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Review Article

Effect of Chromium Supplementation on Body Weight and Body Fat: A Systematic Review of Randomized, Placebo-controlled Trials

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ABSTRACT

Background: Obesity is a public health and various methods are used to manage this health issue. The aim of this review was to investigate the possible effects of Chromium supplementation on body composition and body weight.

Methods: Databases such as PubMed, EMBASE, The Cochrane Library, Scopus, and Web of Science were searched for human studies in English using keywords of body weight, body mass index (BMI), fat mass, adipose tissue, total body fat, obesity, overweight, ideal body weight, weight loss, weight reduction, and chromium supplementation.

Results: Totally, 345 articles were enrolled. The effect of 400 mcg/day intervention was more pronounced when compared to 200 mcg/day. Later, in 1998, the role of physical activity was illustrated and as a result, a significant change in body composition was seen. Volpe *et al.* found a slight relationship between 400 mcg/day of chromium supplementation and decrease in body fat mass (mean=1.78%/max=7.54%). Liu *et al.* reported no significant changes in BMI, fat mass, and fat-free mass. Moreover, Yazaki *et al.* investigated the effect of 1000 mcg supplementation. Still, no change was seen in BMI neither in the first 12 weeks nor whole 24 weeks of the study. It might have slightly positive effects on decreasing body fat and increasing lean body mass.

Conclusion: The undertaken studies mostly showed better and stronger results for the effect of chromium supplementation on body weight or fat mass when physical activity was included or higher doses were consumed.

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Introduction

Obesity and overweight are considered the main risk factors of chronic diseases worldwide (1, 2). Obesity is a condition in which a person gains more energy than the calories expended through the day (3). There are some indicators helping dietitians and therapists to define whether a person is obese or overweight and also measure the level and the severity of it. Body mass index (BMI) is the most common measure for both clinical and population scale (4), and other indicators include Fat Mass (FM), Fat Free Mass (FFM), and other anthropometric indices such as: Waist Circumference (WC), Hip Circumference (HC), Waist to Hip Ratio (WHR), Waist to Height Ratio (WHtR), etc. (5, 6). Obesity can affect health outcomes and cause various complications including type 2 diabetes and cardio vascular diseases (7) and is also associated with metabolic abnormalities such as dyslipidemia, insulin resistance, and hypertension (8).

Although there have been a lot of progress through controlling body weight gain, efforts have not yet to be prosperous. Over the last three and half decades, its prevalence have had a rise near to 100 percent over the world (4). Since 1980 until 2013, the prevalence rate of obesity and overweight conditions have elevated 27.5% in adults and 47.1% in children and the total population was 2.1 billion individuals worldwide (9). In 2014, about 11% of male and 15% of female adults were obese and in 2013, the population of children less than 5 years who had reached overweight percentile cutoff point had been more than 42 million (4).

As it was mentioned, the most important cause of obesity is energy imbalance between dietary intake and physical activity. However, direct and indirect genetic effects are accused to be the risk factors for obesity as well. Gene-environment interactions and social determinants of health are other possible risk factors (4). Many scientific ways have been adverted since now such as designing a food regime based on reducing or at least balancing ones daily intake to his/her Total Energy Expenditure (TEE). Along with these dietary interventions, nutritionists have come up with some of new trivial, but effective supplementary or complementary interventions to boost or ease or accelerate the process of losing weight.

Chromium (III) or trivalent chromium, is a trace element widely distributed in the human diet, and food sources including meat, nuts, cereal grains, molasses, and brewer's yeast, that provide abundant sources. It is estimated that around 1% to 2% of ingested chromium is absorbed from the diet, and current dietary recommendations suggest a daily intake range between 25 and 45 μg/d for adults (8). Possible roles of chromium in the body include its association with carbohydrate and lipid metabolism, where it may be important in promoting the action of insulin in the control of blood glucose, regulating eating behavior and food cravings, suppressing appetite, stimulating thermogenesis, enhancing resting energy expenditure, and improving insulin sensitivity (8).

This trace element could possibly regulate insulin action and facilitate glucose transfer into cells. Much lower amounts of the hormone are required, since chromium increases insulin efficiency (7). Chromium could potentiate the action of insulin. It was claimed that chromium, when bound to a low molecular weight oligopeptide, can potentiate the actions of insulin at its receptor, increase insulin binding receptor number, or improve insulin internalization (10). Besides stimulating glucose-uptake, amino acid uptake is also stimulated by insulin and chromium can potentiate this process which could result in a higher amino-acid uptake. This anabolic effect of chromium has been reported to result in an increase of lean body mass and a lowering of FM (11).

The results are controversial and do not represent consensus neither advocating nor opposing the effect of chromium on body weight. One meta-analysis of 19 studies with 1316 participants concluded that chromium supplementation was associated with some improvements in body weight and body fat percentage and the clinical relevance stayed uncertain (8). Another meta-analysis of 20 randomized controlled trials (RCTs) with 1038 participants concluded that chromium supplementation makes noticeable decline in body weight and percentage of body fat statically, but the magnitude is small and the clinical correlation is not certain (10). Hence, according to the possible effects of chromium on body weight and due to the controversial results considering its effects on body weight and body fat, we aimed to assess the effects of chromium supplementation on these indicators in this updated systematic review to better elucidate its exact effects.

Materials and Methods

Literature Search

Literature published until February 2021 that described the effect of chromium supplementation on obesity and FM were systematically identified by searching PubMed, EMBASE, The Cochrane Library, Scopus, and Web of Science databases. The following keywords and MeSH terms were used: body weight, body mass index, fat mass, adipose tissue, total body fat, obesity, overweight, ideal body weight, weight loss, weight reduction, and chromium supplementation.

Study Selection

Two reviewers independently assessed potentially relevant articles for eligibility after eliminating duplicates. The selection of articles underwent three stages including selection based on titles, followed by abstract consideration, and finally by assessing the full text. Disagreements were resolved through discussion. Inclusion criteria for this review were (i) primary research of randomized controlled trial

(RCT), (ii) studies conducted on adult obese or overweight or any condition related to obesity of any health or nutritional status, and (iii) studies assessing the effects of chromium on total FM, FFM, weight or any other markers representing ones obesity level. Exclusion criteria included studies that (ii) did not use chromium as the sole or main source of nutrients, (ii) involved supplementation of other nutrients than chromium, and (iii) involved animal or were review articles or dissertations. This review also was limited to published and available full articles in the English language

Results

Totally, 345 articles were found through systematic search in online databases (PubMed, EMBASE, The Cochrane Library, Scopus, and Web of Science databases). First, 150 records were deleted as duplicates. In the next level, the 195 remaining articles were screened according to the title and abstract and as a result, 177 articles were excluded since they did not correlate with our study. Finally, after full text screening, 7 records remained out of all (Figure 1). Study characteristics were shown in Table 1. As shown in Table 1, all of the included studies were double-blind randomized placebo controlled clinical trials and on human studies using chromium supplements as intervention (11-17). Five of them were conducted in the United States of America (11, 13, 15-17) one in The Netherlands (12) and one in France (14). Mostly, studies investigated the effect of chromium on anthropometric parameters in short-term (between 10 to 24 weeks) except for one study in The Netherlands with 16 months of duration (12). Two studies used 400 mcg/day (11, 16) and two studies 200 mcg/day (12, 17) of Chromium supplements as an intervention and all of them used chromium picolinate form of supplement except for one study which was in the guanylate form (14).

Kaats *et al.* (15) first conducted a trial in 1996 using both 200 and 400 mcg/day of supplement and resulted in no significant effect of chromium on body composition. Effect of 400 mcg/day intervention was more pronounced. In this study, they innovated an index named body composition improvement (BCI) to calculate the FM loss and lean mass gain simultaneously. As it was mentioned, comparison of the BCI between the 200 mcg group and the 400 mcg group revealed a larger BCI change in the group with the higher dose, but the difference failed to reach statistical significance. Later, in 1998 they

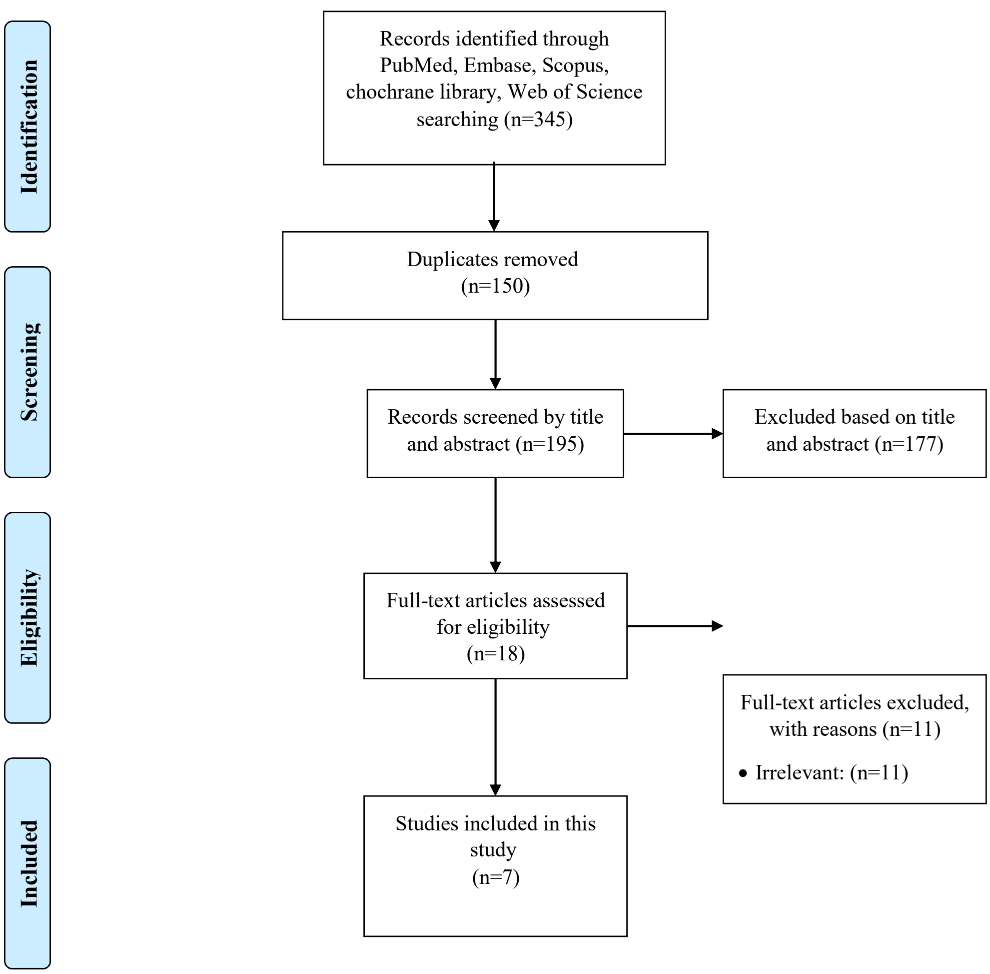

Figure 1: Flow diagram of the study selection process.

Table 1: Characteristics of included studies.

Study/Year	Region	Study design	Intervention groups sample size	Dosage/Type	Duration	Study population	Age range (mean±SD)	Parameters	Result
Volpe *et al.* (2001) (11)	USA	RCT	44	400 mcg/day (Chromium picolinate)	3 months	Female participants, with BMI between 27 to 41 kg.m^{-2} following exercise plan	42.6±6.5	Body composition, RMR, body, weight, BMI, WC, Body fat, LBM, FM	There were no significant change except for decrease in body FM and increase in LBM
Pasman *et al.* (1997) (12)	The Netherlands	RCT	33	200 mcg/day (Chromium picolinate)	16 months	Female obese with BMI 31.2±3.7 kg.m^{-2} following a low calorie diet	34.8±7.0	BW, body composition, energy intake, body fat	No differences in body composition were found, No differences in body fat percentage was found
Yazaki *et al.* (2010) (13)	USA	RCT	80	1000 mcg/day (Chromium picolinate)	6 months	Healthy, overweight adults with abdominal adiposity (WHR=0.9±0.1)	25–75	BMI, central adiposity, body fat	No change was seen in BMI neither in 12 weeks (p=0.07) nor 24 weeks (p=0.81),
Liu *et al.* (2015) (14)	France	RCT	62	1.25 mg/day (Chromium guanylate)	4 months	Overweight (31.4±3.1) adults (both gender)	25-65	BW, BMI, FM, FFM	Baseline characteristics did not differ such as BMI, FM, FM
Kaats *et al.* (1996) (15)	USA	RCT	219	400 and 200 mcg/day (Chromium picolinate)	72 days	No specific characteristic (both genders)	Men (mean=45.7) Women (mean=46.5)	BW, BMI, FM, BCI, FFM	No significant differences on any of the body composition variables, BCI between the 200 mcg group and the 400 mcg group revealed a larger BCI change in the 400 mcg group, but not significant
Kaats *et al.* (1998) (16)	USA	RCT	122	400 mcg/day (Chromium picolinate)	90 days	Physically active men and women	Mean=42.3	BW, Body fat	The group receiving the active treatment had a significant reduction in scale weight (p<0.001), Percent of body fat (p<0.001) and FM (p<0.001)
Clancy *et al.* (1994) (17)	USA	RCT	36	200 mcg/day (Chromium picolinate)	9 wks	Members of the University of Massachusetts football team	______	Body fat, LBM,	No increase in lean body mass, a decrease in percent of body fat

RCT: Randomized controlled trial; RMR: Resting metabolic rate; BMI: Body mass index; WC: Waist circumference; LBM: Lean body mass; FM: Fat mass; BW: Body weight; FFM: Fat-free mass; BCI: Body composition improvement.

implicated an extension and replication of previous study with a difference of considering the role of physical activity by recruiting participants from a variety of fitness and athletic clubs and monitoring them by instructor (16) that showed a significant change in body composition which may be due to the physical activity.

Further, in 2001, Volpe *et al.* (11) found a slight relationship between 400 mcg/day of chromium supplementation and decrease in body FM. However, in another study with similar characteristics of participants (middle-aged overweight females) conducted in the Netherlands considering 200 mcg/day supplementation of chromium, there was no change in body FM (12). Liu *et al.* (14) conducted a study among 62 overweight (31.4±3.1) adults. As a result, no significant change was seen and baseline characteristics did not differ such as BMI (p=0.79), FM (p=0.026), and FFM (p=0.020). Moreover, Yazaki *et al.* (13) performed a trial with a greater dosage than other studies (1000 mcg). They investigated the results in both the first half and whole of the study duration. Similarly, no change was seen in BMI neither in the first 12 weeks (p=0.07) nor whole 24 weeks (p=0.81) of the study. Variation in body fat and central adiposity did not affect any outcome measures (13).

The shortest duration was considered in a study by Clancy *et al.* (17) among the members of the University of Massachusetts football team. After 9 weeks, the 200 mcg/day of chromium supplementation found to be ineffective in bringing about changes in body composition and no increase in lean body mass was seen either. However, a decrease in the percent of body fat was noticed which may be due to the exercise and practice plan followed by the participants (17). Almost all of the studies investigated in this systematic review could not yet find any prominent effect of chromium on anthropometric parameters or body composition. However, involving physical activity or higher doses could possibly change the results.

Discussion

The aim of this systematic review was to investigate the effects of chromium supplementation on anthropometric parameters such as body weight, BMI, FM, and lean body mass. Considering the effects of chromium on the metabolism of carbohydrate and lipid, it could be effective in promoting insulin activity and sensitivity that can improve blood glucose control. Also, it is an important trace element affecting eating behavior and food carvings. Moreover, it can regulate thermogenesis and enhance resting energy expenditure that can possibly affect weight management (8).

Due to the beneficial effects of chromium on body weight and body composition through its possible effects on potentiating the process of glucose- and also amino acid uptake, it could possibly result in an increase in anabolism. By this effect, chromium has been reported to result in an increase in lean body mass and lowering FM (12), and due to the dire consequences of obesity, we considered to investigate the relationship between chromium supplementation and body weight or body composition.

Obesity is characterized by increased body weight and body FM and decrease in fat free or lean body mass. As discussed in this investigation, not too many clinical trials have been conducted on this topic but among the seven RCTs, we have found accordingly no significant effect on body fat and body weight by chromium supplementation. Although, there was a slight effect of chromium on body FM decline in female participants; but the same result was not seen in other studies (11, 12).

Undoubtedly, exercise and physical activity have prominent effects on controlling body weight and preventing obesity. As mentioned, in two studies in which the participants were physically active, noticeable reductions in body FM were reported (16, 17). Kaats *et al.* in the first research in 1996 compared 200 and 400 mcg chromium and showed that although the effects of both doses were non-significant, the intervention with 400 mcg of chromium had greater effects on BCI score (15). Two years later, after considering the role of physical activity, they found more chances of reductions in body weight, percent of body fat, and FM (16).

Dosage of supplementation among the seven studies differed. There may be a probability that the higher the dosage is, the more changes could be seen. To investigate this factor, we compared two studies almost similar in duration and region and participant characteristics; but different in dosage. Hence, it seems that dose of supplementation could possibly have much greater effect when using higher doses. Yazaki *et al.* (13) used 1000 mcg of chromium supplement and Volpe *et al.*, which was almost a similar study considering the region and duration, used 400 mcg supplement (11). Both of them did not show any prominent change in BMI.

In another study, both 200 and 400 mcg was investigated and compared with each other. Kaats *et al.* (15) in their 1st trial in 1996 compared 200 and 400 mcg/day supplementation. Although it resulted in no significant effect of chromium on body composition, but the effect of 400 mcg/day intervention was more pronounced. Thus, 400 mcg was more effective. However, no studies comparing 1000 mcg to other dosages was found and it is not possible to have a firm conclusion on its superiority above lower dosages.

The most common form of chromium supplement recommended by practitioners or dietitians is the picolinate form. However, we wondered whether other forms effect is stronger or not. In order to investigate the role of supplementation form, one study using 1.25 mg/day chromium guanylate was considered. Similarly, baseline characteristics did not change after supplementation (such as: BMI, FM, FFM). This study had some limitations and strengths. One of the main limitations of the current study was related to the fact that due to the previous analysis done in this issue and due to the heterogeneity among studies, we could not conduct a meta-analysis and sub-group analysis on the included studies. However, as a main strength, we searched all databases to find all relevant articles in this regard.

Conclusion

Although views on chromium's role in regulating blood sugar and carbohydrate and lipid metabolism is more defined and also it could have promising effects on thermogenesis and eating behavior, it might have slightly positive effects on decreasing body fat and increasing lean body mass. Studies mostly showed better and stronger results for chromium supplementation and body weight or FM when physical activity was included, too. It seems that including physical activity in the daily programs of those supplemented with chromium can potentiate the effects of chromium on thermogenesis and weight loss synergistically. Moreover, it seems that the effects of chromium on body weight and composition are mostly dependent on the dose of supplementation. However, further studies are warranted to better elucidate the exact effective dose of chromium supplements for improving body weight and body composition. Moreover, evidences are still few for defining conclusion and further investigations, especially clinical trials, are needed to better define the exact effects of chromium on body weight and composition and to clarify the mechanisms of action.

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Conflict of Interest

None declared.

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