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# Effect of Magnesium Supplementation on Physical Activity of Overweight or Obese Insomniac Elderly Subjects: A Double-Blind Randomized Clinical Trial

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***Abstract***

***Background***: Strategies for weight reduction often promote lifestyle changes like encouraging participation in physical activity. Also there is some evidence suggesting an association between insomnia and physical activity level and probable beneficial effect of magnesium supplementation on insomnia. The objective of this study was to determine the effect of magnesium supplementation on physical activity level in insomniac elderly subjects.

***Materials and Methods***: A double blind randomized clinical trial was conducted in 46 overweight or obese subjects, randomly allocated into the magnesium or the placebo group and received 500 mg magnesium or placebo daily for 8 weeks. Questionnaires of insomnia severity index (ISI), physical activity and sleep-log were completed and serum magnesium measured at baseline and after the intervention period. Anthropometric confounding factors, daily intake of magnesium, calcium, potassium, caffeine, calorie form carbohydrates, fat, protein and total calorie intake, were obtained using 24-hrs recall for 3-days. Statistical analyses were performed using SPSS-19 software.

***Results***: No significant differences were observed in assessed variables between the two groups at the baseline. According to our research magnesium supplementation significantly increased sleep indices and physical activity level, also resulted in significantly decrease of total calorie intake in magnesium group. Although serum magnesium concentration and weight did not show any differences.

***Conclusion***: In the present study magnesium supplementation resulted in improvement of sleep indices and physical activity level in elderly subjects. Although according to our short term intervention no significant beneficial effect was observed on subject`s weight.



## Introduction

Physical activity level is the first index of the health in a society, according to World Health Organization [1]. Obesity has a close relationship with low physical activity level [2]. The study of health in Canada in 2004 revealed that the prevalence of obesity in adults is significantly higher in inactive men (27%) compared to moderately active (20%) and high active (17%) individuals. This was also elevated in inactive (27%) compared to moderately active (21%) and high active (14%) women [3]. The Copenhagen Heart Study also showed that people with a higher BMI, has lower physical activity compared to low BMI individuals and that obesity development occurs subsequent to reduced physical activity [4]. Faltun et al. also reported that moderate and severe physical activity have inverse correlation with BMI and FMI (Fat Mass Index) indices [5]. About 70 percent of individuals older than 60 years are overweight or obese in United States [6] and obesity through its relationship to cardiovascular diseases is considered as the first cause of mortality. Thus given the increasing prevalence of obesity, sedentariness as one of the reasons or a consequence of obesity is highly interested. In addition to mentioned issues, by aging of world population and increment prevalence of chronic diseases in this group, the importance of physical activity become clear as a risk-preventive or risk-reducing factor [7].

The researches performed in Iran revealed that more than 80% of Iran's population is physically inactive [8]. Nejati and Ashayeri showed that the physical activity of 60 years and older elders was 57.01% in women and 77.06% in men, and this value reduces the health related quality of life [9]. Although the importance of active life is well known but encouraging elderly to physical activity is very hard and most of them think that they are too old and fragile for physical activity [10]. Therefore, gradual change of life style toward more active life along with correction of causing factors of inactivity can help to increase physical activity in this age group.

Along with obesity prevalence, the sleep duration is also reduced and in various societies reached to 7.2 hours from 8.5 hours per day [11]. Several studies were evaluated the relationship between these two [12, 13] and found an inverse relation between self-reporting of sleep hours and obesity in men, women, and children [14].

Sleep and physical activity may be considered as separate behaviors which are controlled by different physiologic mechanisms. But there are growing evidences regarding to clinical association between sleep and physical activity [15]. Based on studies, sleep duration is related to physical activity reduction [16]. In addition, insomnia leads to reduced physical activity level through the increase of fatigue and drowsiness during the day [16] and through its relation to depression-like symptoms and anxiety [17].

Besides the usual methods of treating sleep disorders, including medicinal and non-medicinal methods for which there are weak evidences for their positive impact and that they produce significant side effects for patient [18], some studies have evaluated the impact of magnesium supplementation on insomnia and have reported positive results [19, 20]. Evaluation of various studies shows that despite the important physiologic role of magnesium and its beneficial effects, the dietary intake of magnesium is inadequate in different societies [21] and some population groups like elderly and low educated people have low magnesium intake [22].

The existing statistics also show that insomnia as one of the most common sleep disorders of elderly has 40 to 50 percent prevalence in elders older than 60 years [23]. There is little information about insomnia prevalence in Iran. In a study on 224 persons, Arasteh reported no significant relationship between age, gender, and insomnia. In this study the prevalence of insomnia in studied population was reported to be 57.4% [24].

Therefore, regarding to the available information, this hypothesis is formed as whether the increase of magnesium intake through supplementation of a safe amount can lead to physical activity increment, weight loss and reduction of other chronic diseases in insomniac individuals through improving the insomnia as a prevalent disease.

In addition, little numbers of performed studies, especially in underdeveloped countries and WHO recommendations for performing dietary clinical trials in various populations justifies the necessity of this study, and since elders due to the changes in their physics and physiology are more prone to insomnia and also due to their stationary and inactive life style [25].

The purpose of this study is to investigate the impact of supplementation with 500 mg magnesium for 8 weeks on physical activity level of elderly subjects with insomnia in order to correct a changeable factor as the underlying cause of low activity level.

## Materials and Methods

The study was performed in a double-blind randomized placebo-controlled parallel design. Subjects consisted of elder men and women older than 60 years with insomnia. Criteria for inclusion in our RCT included: willing to cooperate, having insomnia according to ISI questionnaire (Insomnia Severity Index), having BMI range of 25-34.9, not having substance or alcohol abuse, dietary intake of magnesium under 75% RDA (Recommended Dietary Allowance); serum magnesium level under 0.95 mmol/L, not receiving loop diuretics, cyclosporine, digoxin, amphotericin and any hormonal treatment, not having renal diseases, acute heart failure, restless leg syndrome, and acute sleep apnea. Reasons for exclusion from the study were: recent stressful life events (e.g. divorce or death of a family member) and taking less than 100 tablets of 120.

Regarding to Held et al. study [19], sample size was estimated to be 23 persons in each group. Insomnia severity index test was taken from the elders who referred to Culture Houses of Tehran's 1, 10, and 14 regions with insomnia complaint (as self-report). When their insomnia has been confirmed by ISI questionnaire (clinically moderate or severe), and their sleep time was registered in Sleep Log questionnaire for 14 days, prior to begin supplementation (Run-in phase). Then for those who were consistent with inclusion criteria and lacked the exclusion criteria of the study, the benefits, the aim, and duration of the study, and mode of intervention were described in a briefing. A written consent form was then obtained from participants. Three persons (2 women and 1 man) were excluded from the study regarding to the exclusion criteria. General information, insomnia severity index, Sleep Log, and physical activity questionnaires were completed and serum magnesium level was measured by atomic absorption method at the beginning and the end of the study. At baseline and end of the intervention period confounding factors including anthropometric measurements, weight, BMI, total energy intake, dietary magnesium, potassium, calcium and caffeine were determined.

Anthropometric measurements were done by trained colleagues, so according to WHO standards, the light cloth worn patients were weighted and their height were measured without shoes with a 0.5 cm accuracy wall meter. Using the weight (in kilograms) divided by height (in meters) square formula, BMI was calculated and the obtained information was recorded in general information questionnaire of patients. Then based on the unique and randomly assigned codes of participants, magnesium and placebo containing packages were distributed among them. Patients in magnesium supplementation group received 500 mg elemental magnesium tablets for 8 weeks while the placebo group received starch containing placebo during the study. Since the study was double-blind, in order to uniform the research executive from packages content, a person outside the study divided the tablets into groups A and B and put them in identical packages.

To prevent undesired gastrointestinal effects, it was suggested to consume the pills along with the main meals (lunch and dinner). During the study any information about weight loss was not given to participants and they continued their normal life except the intake of 500 mg magnesium or the placebo. The dietary information was obtained from 24 hours recall questionnaire (2 usual days and 1 day off) and analyzed with Nutritionist 4 software ($N_4$) and daily total energy, magnesium, calcium, potassium, and caffeine intake of each person was determined at the beginning of the study. Kolmogorov-Smirnov test was used to analyze the distribution mode of the variables. The studied variables were compared at the beginning and the end of the study with paired *t*-test and the studied variables between magnesium supplementation and placebo groups were compared with independent samples *t*-test. The variables were analyzed by SPSS-19 software and *p*-value calculated as two-tailed. The $p< 0.05$ is considered statistically significant.

The subjects were voluntarily entered in the study with full knowledge of design, methods, and materials. They also signed a written consent form and were free to be excluded whenever they had no desire to continue the study.

According to our review, no side effects were seen in consumers of magnesium supplement or starch containing placebo at prescribed dose. However, high dose magnesium-induced diarrhea has been reported in some studies. At the end of the study, as expected by the researchers, any complaints or complications were not reported. The study has been approved by the Medical Ethics Committee of Shahid Beheshti University of Medical Sciences and has been registered in the center of clinical trials registration of Iran.

## Results

Total of 46 persons participating in the study, 2 persons due to not regular consuming of supplement or placebo and one person due to not participating in second turn blood sampling, were excluded from the study. At the end, 43 persons (21 men and 22 women) completed the study. The age, weight, height, body mass index and physical activity level means and standard deviations of contributors were 65±4.6 years, 72.1±9.7 kg, 29.2±3.7 $kg/m^2$ and 2.8±0.7 MET h/day respectively.

The dietary intakes of the study participants at the baseline and end of the study are shown in Table 1. During the study, the dietary intake of individuals in none of investigated micronutrients and caffeine intake showed no significant statistical difference. As seen in Table 2, the results of this study show that sleep time (ST) ($p$=0.002) and sleep efficiency (SE) ($p$=0.03) increased and Sleep onset latency (SOL) ($p$=0.02) decreased, both significantly. However, total sleep time (TST) ($p$=0.37) and early morning awakening (EMA) ($p$=0.08) did not shown a significant difference.

As seen in table 3 total energy intake ($p$=0.02) decreased and physical activity level ($p$=0.02) increased both significantly in magnesium group compared to placebo group. Despite favorable increase of serum magnesium concentration ($p$=0.06) during this study, the related changes in its level were not significant. As researchers expected, volunteers participants in the study did not report any adverse effects and the results of this study showed that daily consumption of supplements as 500 mg magnesium oxide in two doses of 250 mg along with the meal does not lead to any complications in the elders.

## Discussion

In the present study, serum magnesium level in supplement group tended to augment ($p$=0.06), however a significant difference between two groups was not seen at the end of the study. The obtained results from our study are consistent with the study of Hoogerbrugge et al. who investigated the effect of supplementation with 1 gram magnesium oxide for 6 weeks on Lipoprotein (a) level in hypercholesterolemic patients and did not observe a significant difference in serum magnesium increment [26].

Held et al. also, in a study which dealt with magnesium supplementation in 12 healthy persons could not recognize a significant difference between two groups, despite detection of serum magnesium tendency toward increase in the supplementation group [19].

Guerrero and Rodriguez in their study to investigate the effect of magnesium supplement in lowering blood pressure of hypertensive diabetic patients, reported that during 4 month of supplementation with 450 mg/day elemental magnesium, serum magnesium concentration in the intervention group compared to placebo group, increased gradually and reached a significant level at the third month [27].

**Table 1.** Means and standard deviations of dietary confounding factors in magnesium supplementation and placebo groups at baseline

| Variable | Magnesium Supplementation | Placebo | *p*-Value |
|---|---|---|---|
| Dietary magnesium intake (mg/day) | 190±55 | 198±54 | 0.970 |
| Dietary calcium intake (mg/day) | 829±317 | 795±365 | 0.743 |
| Dietary potassium intake (mg/day) | 3006±897 | 2996±772 | 0.970 |
| Dietary caffeine intake (mg/day) | 77±43 | 69±29 | 0.475 |

**Table 2.** Comparison of sleep indices in magnesium supplementation and placebo groups before and after intervention

| Magnesium Supplementation (n=21) | | | | Placebo (n=22) | | |
|---|---|---|---|---|---|---|
| Variable | Before intervention | After intervention | Difference (CI=95%) | Before intervention | After intervention | Difference (CI=95%) |
| Total sleep time (hrs.) | 7.8±1.1 | 7.9±0.6 | 0.1±0.7 | 7.6±0.9 | 7.6±0.8 | -0.03±0.3 |
| Sleep time (hrs.) | 5.1±0.8 | 5.7±0.9 | 0.6±0.7* | 5.0±0.5 | 5.0±0.6 | -0.02±0.3 |
| Sleep onset latency (hrs.) | 1.3±0.2 | 1.1±0.4 | -0.2±0.4* | 1.4±0.2 | 1.4±0.2 | 0.04±0.1 |
| Early morning awakening (hrs.) | 1.04±0.02 | 1.01±0.05 | -0.03±0.05 | 1.03±0.02 | 1.03±0.02 | -0.01±0.01 |
| Sleep efficiency (hrs.) | 0.67±0.07 | 0.73±0.1 | 0.06±0.1* | 0.66±0.04 | 0.66±0.07 | 0.00±0.05 |

$p<0.05$*

Regarding to this study and increment trend of serum magnesium in our study, this is possible that the duration of our study was inadequate to observe a significant difference in serum magnesium alterations. This resistance to change of serum magnesium levels could also be attributed to its important role as a cofactor and the need to precisely regulate its concentration.

The results of our study show that sleep time ($p$=0.002) and sleep efficiency ($p$=0.03) increased and Sleep onset latency ($p$=0.02) decreased, both significantly. Results of the present study about the role of magnesium in sleep regulation are consistent with Dralle and Bodeker study which showed that there is an association between magnesium supplementation and REM (Rapid eye movement), muscle tone, and gross body movements in infants. Results of Dralle and Bodeker also suggested that there is a relationship between serum magnesium level and active sleep, and between serum magnesium level and quiet sleep, and magnesium supplementation increased the quiet sleep and decreased the active sleep [28]. In a study conducted by Held et al. to analyze magnesium supplementation effects on sleep EEG , plasma ACTH (Adrenocorticotropic hormone), cortisol, AVP (Arginine vasopressin), renin, angiotensin II, and aldosterone in elderly, he showed that the most important $Mg^{2+}$ supplementation effect in healthy elderly subjects was SWS (Short Wave Sleep) increment [19]. Beside NMDA (N-methyl-D-aspartate) antagonistic properties, $Mg^{2+}$ also has endocrine effects such as an ATII-antagonistic action [29] and a dampening effect on HPA-system (Hypothalamic-Pituitary-Adrenal Axis) activity [30]. Also, the results of our study are consistent with Rondanelli et al. study which was done to investigate the effects of combined melatonin, magnesium, and zinc supplementation, which showed that the supplementation resulted in total score improvement of Pittsburg questionnaire compared to placebo, and suggested that treatment has beneficial effects on capability of recovering body activities through sleep [20].

Physical activity level in magnesium supplement group was increased significantly compared to placebo group. These results were consistent with study hypothesis that magnesium supplementation may be able to increase physical activity levels of volunteers participating in the intervention through correcting their insomnia problem.

The obtained results were consistent with Chasens and Yang study which suggested that insomnia symptoms were associated with reduction of physical activity level and although the insomnia is a state of brain arousal, the end result of insomnia is increment of fatigue and sedentariness and finally insomnia can lead to reduced levels of physical activity through increment of fatigue and drowsiness during the day [16]. In addition, the results of this study were consistent with Stamatakis and Brownson study which suggested that sleeping time reduction was associated with high-risk behaviors related to weight increase such as physical activity reduction and fruit and vegetable intake reduction [31].

In the present study, total calorie intake and energy intake from carbohydrates show a significant decrease in magnesium group, while in placebo group a significant difference was not observed. Regarding to the results of Nedeltchev et al. study conducted on 11 healthy women and men, sleep deprivation can alter the composition and distribution of human dietary intake and in a favorable environment for obesity, inadequate sleep can facilitate energy intake from snacks further than main dietary meals [32]. The results of Shi et al. study, also confirmed the relationship between sleep time and carbohydrate intake [33]. Also, the results of Weiss et al. study performed on 240 adolescents 17.7±0.4 years old showed that sleeping time reduction led to 2.2% calorie intake increment from fat and 3% calorie intake reduction from carbohydrate. These minor alterations can increase the risk of obesity through the accumulated effect of modified energy intake balance over time [34].

In our study the energy intake from fat showed a significant reduction in magnesium supplementation group, while in placebo group a significant difference was not observed. In addition there was no difference in calorie intake from protein in the studied groups. This was consistent with the results of Shi et al. study conducted on 2828 Chinese men and women which showed a significant relationship between sleep duration and fat and carbohydrate intake. In this study the persons with daily sleep lower than 7 hours had more energy intake from fat in comparison with whom slept 7-9 hours a day [33]. In this relation, several mechanisms can be involved such as, reduced glucose tolerance, reduced sensitivity to insulin, increased sympatho-vagal regulation, increased cortisol level, increased ghrelin level, and reduced leptin level, upregulation of orexin neurons activity, alteration of orexin neurons activity, and appetite regulating hormones which may increase feeling hungry and appetite [35]. In other human studies, reduction of sleeping time was associated with fat intake increment [33] and energy intake increment from snacks [32]. There is no doubt that a strong relationship exists between sleep and obesity, but its mechanism and direction are not known and needs to be further investigated (longitudinal, interventional, or both).

In general, the results of this study show a favorable significant effect of magnesium supplementation on sleep time, sleep efficiency and physical activity level as well as insomnia severity index reduction, sleep onset latency, total calorie intake, calorie intake from fat and calorie intake from carbohydrate in insomniac elderly subjects. However, observing the increasing of serum magnesium level and weight reduction did not cause a significant difference in these variables; this can be the result of the short time of the study.One potential weakness of this study is its short duration which make difficult to opine about those variables which have a slow response to the treatment. Therefore we suggest to perform the future studies of this field in a longer time and to measure the possible effects of intervention on weight reduction in insomniac patients. Also, monitoring the physical activity level using actigraphy can help to increase the accuracy of next studies.

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## Authors' Contributions

All authors had equal role in design, work, statistical analysis and manuscript writing.

## Conflict of Interest

The authors declare no conflict of interest.

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