ORIGINAL ARTICLE

The effects of magnesium supplementation on thyroid hormones of sedentars and Tae-Kwon-Do sportsperson at resting and exhaustion

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Abstract

The effect of magnesium on thyroid hormones of sedentars and sportsperson in Tae-Kwon-Do, has been investigated in a 4-weeks training program.
Group 1 consisted of sedentars receiving 10 mg/kg/day Mg for 4 weeks. Group 2 consisted of subjects receiving magnesium (Mg) supplement and practicing Tae-Kwon-Do for 90–120 min/day, for five days a week. Group 3 consisted of subjects practicing Tae-Kwon-Do but receiving Mg supplements.
TSH levels increased with training and Mg supplementation ($p<0.05$). Mg increased FT_3 values. ($p<0.05$). TT_3 values of groups reduced in all groups ($p<005$). After supplementation, group 1 had higher TT_4 values than groups 1 and 3 and the group 2 had higher TT_4 values than the third group ($p<005$).
Results of this research show that training until exhaustion causes reduction in thyroid hormone activity in sedentars and sportsperson. It has been established that Mg supplementation however, prevents reduction in thyroid hormone activity in sedentars and sportsperson.

INTRODUCTION

Exercising changes homeostasis by creating stress. Autonomic nervous system and hypothalamus-pituitary-adrenal-axis jointly form a protection system to ensure physical and homeostasis coherence by participating in the reaction (Mastorakos and Pavlatou, 2005). During exercise, physiological and psychological systems combined together in order to determine the intake of energy. Leptin and stokins affect cortisol, and growth and thyroid hormone secretions (Hackney *et al.*2003; McMurray and Huckney, 2005). Many studies, which investigate the relation between exercise and hormones, present different results (Duma *et al.* 1998; Huang *et al.* 2004; Rosolowska-Huszcz, 1998). It was reported that treadmill exercise had increased thyroid hormones activity during post exercise period (Huang *et al.*, 2004). Similarly, in a research on professional footballers, it was determined that training increased thyroid hormones activity (Bosco *et al.*, 1996).

Magnesium is an important cofactor for many enzymes, required in several biochemical events and for energy metabolism (Lukaski *et al.*, 1983; Lukaski and Nielsen, 2002). It has been suggested that there is a positive correlation between magnesium levels and the physical performance (Mastorakos and Pavlatou, 2005; Bohl and Volpe, 2002). Through high-energy diets, athletes usually receive sufficient essential minerals including magnesium. This is not the case with subjects under a diet restricted or reduced to maintain or limit their body weight, which might be the cause of insufficient magnesium intake leading to decreased physical performance (Keen *et al.*, 1987; Keen *et al.*, 1987; Viru *et al.*, 1998). At the same time, magnesium affects the serum concentration of thyroid hormones by regulating hepatic type 5' deiodinated (5'D-I) activity (Eder *et al.*, 1996).

In this study, the effect of supplementation of magnesium on the action of thyroid hormones of sedentars and sportsperson practicing Tae-Kwon-Do has been investigated.

MATERIALS AND METHODS

Subjects

Thirty healthy subjects of ages between 18–22 years voluntarily participated in the study. Before the start of the research protocol, all the participants gave their consent for participation after the purpose of the study had been explained to them. The participants were divided into three groups of ten subjects each, kept under distinct regimens for four weeks as follows:

Group 1. Sedentars receiving 10 mg Mg (as magnesium sulfate) per kg body weight, per day. **Group 2.** Subjects received the Mg supplement and practiced the Tae-Kwon-Do exercise for 90 – 120 min per day, for five days a week. **Group 3.** Subjects training as those in Group 2, but without Mg supplements.

Blood samples were drawn from all participants before and after the experimental period at rest and after exhaustion. Serum TSH, FT_3, FT_4, TT_3 and TT_4 values were determined by standard clinical laboratory procedures.

Exhaustion measurements

To create exhaustion, the participants underwent a 20m shuttle run test prior to blood sampling. The test was performed at the Training and Sports Academy, Selcuk University. The test starts with a slow running speed (8 km/h) in which the subject runs on a 20m track following a signal. The subject should run to the end of the track and touch the finish line with one foot before the signal to return sounds again. The subject is allowed to continue the test if one signal is missed, but dismissed if he has difficulty in following the signal or if he is 3 meters far from the finish line in two consecutive cycles. At this point, the running speed is increased up to 0.5 m/min. Every minute is counted as a grade point. The result of the test is the number of accumulated points, which is taken as the indicator of endurance. The duration of the test depends on the individual's ability and strength (Zorba, 2001).

Analyses of hormones

Two ml blood samples were drawn into EDTA tubes and used to determine the thyroid hormones activity at the Medical Faculty Laboratory of Selcuk University. Free T_3 (pg/ml) (Lot No: 519799), Free T_4 (ng/dl) (Lot No: 521371), TSH (Mikroünite/ml) (Lot No: 520005), Total T_3 (ng/dl) (lot no: 515869), and Total T_4 (μgr/dl) (Lot No:518030) levels were determined by using Access Immunoassay system test kit in Unicel DXI 800 otoanalyser.

Statistics

The statistical analysis was performed with the SPSS statistical program. The results were expressed as mean ± SD. The Kruskal-Wallis analysis of variance was used for comparison between groups and the Mann-Whitney U-test was applied to those with $p<0.05$.

RESULTS

TSH values for each study group are given in Table 1. When these values were compared between groups it was observed that before supplementation, relaxation and exhaustion values were not different. When parameters after supplementation were examined it was determined that TSH was higher in the training and exercise group during relaxation ($p<0.05$). In addition, following Mg supplementation, exhaustion values in the second and the third groups were higher than in the first group ($p<0.05$). It was also established that values after exhaustion were higher than values during relaxation period in all groups ($p<0.05$).

FT_3 values for each study group are given in Table 2. On evaluation, it was determined that exhaustion values reduced considerably than relaxation values before and after Mg supplementation ($p<0.05$). An inter group comparison revealed that Mg supplementation increased FT_3 value during relaxation and exhaustion periods ($p<0.05$). The highest increase was seen in the first group. When FT_4 values were examined for the three groups, it was observed that exhaustion values (before and after supplementation) were lower than relaxation values (Table 3, $p<0.05$). Examination of inter-group values inferred that Mg supplementation had no effect on FT_4 levels. When TT_3 levels between groups were compared a reduction was noticed due to exhaustion, for this parameter in all groups (Table 4, $p<0.05$). This increase in the values for the group supplemented with Mg (Group 1) was the highest than in other groups (Table 4, $p<0.05$).

TT_4 values for each study group are given in Table 5. There were not any differences among groups before research. However, exhaustion values were found considerably lower than relaxation values before supplementation only in the second group ($p<0.05$). Exhaustion values were found lower than relaxation values after supplementation in all groups ($p<0.05$). Following supplementation inter-group relaxation levels showed that the first group had a higher TT_4 value than the second and the third groups and the second group had a higher TT_4 value than the third group ($p<0.05$). The evaluation of exhaustion values after supplementation, though revealed the first group was at the highest level, did not find any differences in terms of statistics.

DISCUSSION

The results of this research were evaluated and it was determined that TSH levels increased with exercise and Mg supplementation ($p<0.05$). Similarly, it was seen that Mg supplementation also increased FT_3 value. When TT_3 levels were compared it was determined that in all groups, exhaustion caused reduction within this parameter ($p<0.05$) TT_4 values increased with Mg supplementation ($p<0.05$) Exercise affected homeostasis by creating stress, which plays a role in the development of physical fitness and homeostasis by responding to nervous system and hypothalamus-hypophysis adrenal axel (Mastorakos and Pavlatou, 2005). Magnesium level must be maintained in the body up to a certain level to continue optimal physiologic functions essential for a healthy life. Work performance and energy metabolism in a steadfast way depends on the existence of certain amounts of magnesium (Golf *et al.*, 1998). But, findings related to a better of performance by magnesium must be discussed (Clarkson, 1991). Different results were obtained in studies carried out on this subject using varied parameters. Nevertheless during previous researches it was usually the effects of short intensive exercises on thyroid hormone activity which were investigated (Huang *et al.*, 2004; Rosolowska-Huszcz, 1998). Researches that examine the effects of supplementation of magnesium with exercise were almost lacking. Earlier it was established that insufficient Mg affected marathon athletes' performance. However, our 4-week long study supplying 365 mg/day Mg had no effects during 42 km of marathon race on athletes' performance (Terblanche *et al.*, 1992).

Table 1. TSH (μU/ml) at Rest and Exhaustion, Before* and After** Supplementation with Magnesium

	Group 1	Group 2	Group 3
Rbs	1.45±0.91^{c}	1.51±0.52^{c}	1.45±0.65^{c}
Ebs	1.92±0.32^{a}	1.86±0.12^{ab}	1.90±0.32^{a}
Ras	1.59±0.21^{by}	1.66±0.35^{abx}	1.46±0.98^{cy}
Eas	1.90±0.15^{ay}	1.99±0.31^{ax}	1.97±0.79^{ax}

Rbs - Resting values before supplementation, Ebs - Exhaustion values before supplementation, Ras - Resting values after supplementation, Eas- Exhaustion values after supplementation
^{a} Values at exhaustion higher than at rest ($p<0.05$)
^{x} Group 2 values higher than groups 1 and 3 at Ras ($p<0.05$),
^{x} Group 2 and 3 higher than group 1 at Eas ($p<0.05$).
$^{a, b, c}$; Different letters in the same column are important.
$^{x, y, z}$; Different letters in the same line are important.

Table 2. FT_3 (pg/ml) at Rest and Exhaustion, Before and After Supplementation with Magnesium

	Group 1	Group 2	Group 3
Rbs	3.91±1.40^{a}	3.95±1.52^{a}	3.84±1.75^{a}
Ebs	3.71±1.42^{b}	3.64±1.16^{b}	3.57±1.65^{ab}
Ras	3.87±1.35^{ax}	3.84±1.62^{ax}	3.70±1.71^{aby}
Eas	3.70±1.42^{bx}	3.61±1.57^{bxy}	3.50±1.38^{by}

^{b} Levels at Ebs lower than Rbs ($p<0.05$)
^{x} Group 1 and 2 significantly higher than group 3 at Ras and Eas ($p<0.05$).
$^{a, b, c}$: Different letters in the same column are important.
$^{x, y, z}$; Different letters in the same line are important.

Physical activity has been associated to the reduction of response to pituitary–adrenal activity. Chronicle exercise also affected thyroid axle. Thyroid hormones provide a condition similar to entropic condition as a response to chronicle exercise by decreasing thyroid hormones at periphery which was reported to cause oppression at T_3 and increase at rT_3 (Duma *et al.*, 1998; Mastorakos and Pavlatou, 2005). Our research showed a significant decrease in FT_3 and TT_3 values after exercise which corresponds to the results of aforementioned studies. It has been suggested that since T_3 depends on 5' deiodinated gene expression so oppression of the enzyme activity is the cause of this reduction (Mastorakos and Pavlatou, 2005). It was hypothesized that a one-week exercise could increase thyroid hormones activity, which can be associated with the response to cold having no effects on THS values but on T_3, T_4 values that increased due to vasoconstriction (Castellani *et al.*, 2002). A research reported that levels of TSH and FT_4 did not change during exercise because of an important role of muscle methaboreseptors which is effective for hormonal control during muscle activity (Hackney *et al.*, 2003). In another research it was investigated whether exercise affects thyroid hormones activity significantly. This study showed an increase in T_3 and T_4 values following exercise, which returned to normal values at exhaustion (Mastorakos and Pavlatou, 2005). In our research however, as in the preceding study, exercising to exhaustion did not affect TSH at a considerable pace. Evaluation of after supplementation values turned up with the increase of Mg^+ arising only from the supplementation of Mg.

In a research on short supramaximal exercise it was found that there was increase in all thyroid hormones types (TSH, FT_3, FT_4, TT_3 ve TT_4) which may be conducive to activation of hypophysis-thyroid by exhaustion.

In contrast to the preceding research our study showed that exhaustion caused oppression. We hypothesized that it might depend on the period of training and its style. Likewise, in another research it was established that different sports had different effects on thyroid hormones activation.

In a study on weight lifters, it was observed that exercise did not affect T_3 but T_4 values which increased after exercise (McMurray and Hackney, 2005). In a study on swimmers, it was showed that exercise done at different temperatures caused different results. For example, at 20 °C TSH and FT_4 values increased whereas they decreased at 32 °C and there is no change at 26 °C (Deligiannis *et al.*,1993). These temperature differences however, did not affect the T_3 levels very much. Contrarily gymnastic women at intensive training program had reduced T_3 values (Jahries *et al.*, 1991).

In Sedentars, cycling exercise increased T_3 value but did not affect T_4 level. Moreover, for sportsperson, 10–15 km running did not affect T_3 level but T_4 level which was decreased. It was also observed that regular exercises increased T_3 values (Limanova *et al.*, 1983). Changes in the temperature of the environment and the body during exercises may affect these parameters in different ways.

In studies on test animals, exercises in hot weather decreased Mg, T_3 and T_4 levels of the body. On the other hand, completely opposite results were found for exercises that were done during cold weather (Vezyraki *et al.*, 2000). Once again, this study showed that there was an inverse relation between Mg and T_3 levels. In an experiment on rats, it was reported that exercise decreased T_3 and T_4 values (Eder *et al.*, 1996). In the same study, it was determined that hepatic 5' deiodinated activity was not affected during exercises.

These studies showed that different exercise types and periods affected thyroid hormones activity in different ways. In addition, when we examined the existing literature, there was no study that had earlier examined the relation between exercise and Mg supplementation. Our research showed that the 4-week exercise program and Mg supplementation caused changes in thyroid hormones activity. Especially, a decrease in their activity due to exhaustion was suppressed by Mg supplementation, which is the most imported finding of our study.

Table 3. FT_4 Levels (ng/dl) at Rest and Exhaustion, Before and After Supplementation with Magnesium

	Group 1	Group 2	Group 3
Rbs	$1.64±0.75^{a}$	$1.71±0.82^{a}$	$1.68±0.65^{a}$
Ebs	$1.48±0.69^{b}$	$1.45±0.68^{b}$	$1.53±0.79^{ab}$
Ras	$1.63±0.88^{a}$	$1.50±0.92^{b}$	$1.58±0.91^{ab}$
Eas	$1.41±0.74^{b}$	$1.47±0.79^{b}$	$1.44±0.87^{b}$

No significant differences between groups before and after supplementation.
[b] Levels at Ebs lower than Rbs ($p<0.05$)
[a, b, c]; Different letters in the same column are important.

Table 4. TT_3 at (ng/dl) Rest and Exhaustion Before and After Supplementation with Magnesium

	Group 1	Group 2	Group 3
Rbs	$129.80±21.15^{a}$	$130.60±24.18^{a}$	$127.50±31.19^{a}$
Ebs	$121.90±35.41^{b}$	$122.90±31.14^{b}$	$121.10±28.24^{b}$
Ras	$131.70±27.15^{ax}$	$123.50±29.10^{by}$	$126.50±24.75^{ay}$
Eas	$125.40±25.40^{abx}$	$121.50±22.44^{by}$	$120.10±29.86^{by}$

[b] Values at Exhaustion (Ebs) lower than at rest ($p<0.05$)
[x] Group 1 higher than groups 1 and 3 at Ras and Eas ($p<0.05$),
[a, b, c]; Different letters in the same column are important.
[x, y, z]; Different letters in the same line are important.

Table 5. TT_4 at (µg/dl) Rest and Exhaustion, Before and After Supplementation with Magnesium

	Group 1	Group 2	Group 3
Rbs	$8.50±2.32^{ab}$	$8.29±3.72^{a}$	$8.42±3.82^{a}$
Ebs	$7.66±2.20^{b}$	$7.53±2.98^{b}$	$7.98±2.95^{a}$
Ras	$8.85±2.10^{ax}$	$8.21±3.65^{ay}$	$7.97±3.07^{az}$
Eas	$7.83±2.87^{b}$	$7.72±3.05^{b}$	$7.73±3.56^{b}$

[b] Values at exhaustion lower than at rest (Rbs) ($p<0.05$)
[x] Group 1 higher than groups 1 and 3 at Ras ($p<0.05$),
[y] Group 2 higher than group 3 at Ras ($p<0.05$).

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