Effect of A period of Magnesium Supplementation on Muscle Strength and Resistance of Bodybuilders

Abstract

Objective: The purpose of this study is to determine the effect of magnesium supplements on the muscular strength of active men.

Materials and Methods: Samples were matched into two groups. Magnesium supplements (containing 47 mg of calcium and 250 mg of magnesium oxide produced by al-Hawi Company) were given to the experimental group and the placebo that was completely similar to the supplements for the control group. The tablets are given to every other subject individually and they performed strength training. Supplements were ingested before strength training in the gym and the supplements were consumed with a glass of water. The statistical population of the study included male bodybuilders' athletes who are regularly excising three days a week in Shahre Kord sports clubs. 40 subjects were selected from people who were interested to participate in the research. After selecting the samples, they are randomly divided into two groups A and B (double-blind method). The strength of the athletes was measured by the CPR machine based on the 1-RM and their resistance by more repetition of bench press with a standard device using 1-RM by 0.5 Kg in the gym.

Results: The results of Wilks' lambda test showed that there is a significant difference between the experimental and control groups in one of the measurements related to arms muscle strength and chest muscle strength, while there is no a significant difference between the two groups in measurements related to muscle strength and resistance of the upper body, which means that magnesium supplementation for 8 weeks has had a significant effect on the strength of the hands and chest muscles of the bodybuilders 'athlete.

Conclusion: magnesium supplementation can affect the strength of upper body's muscles of men.

Keywords: Sports nutrition, Ergogenic aids, Resistance training, Magnesium

Introduction

In recent years, athletes and nutritionists use different methods to improve athletic performance, such as dietary supplements. The use of mineral supplements is also considered among athletes, such as zinc and magnesium supplements. Nutritional supplements have several roles, such as creating energy, effects on general health and also increasing muscle mass [1-4]. Among the supplements is magnesium, which is a rare mineral material and plays a key role in cell replication [2]. Magnesium also serves as a physiological regulator of membrane stability and in neuromuscular, cardiovascular, immune, and hormonal function. Magnesium can be considered as a restricted component in performance [4-7]. Previous studies have shown that magnesium supplementation can increase aerobic power and strength [8]. Conducting a research on the effects of rare components on endurance and muscle strength is important considering the need for informing about the use of supplements, especially mineral supplements for the coaches and athletes. Lukaski [3] reported that magnesium supplementation improves strength in healthy athletes. However, it is unknown whether these results are due to its drug effect or because of the

improvement of nutritional disorders. Magnesium supplementation reduces cortisol during the exercises, which may be due to a reduction in the catabolism.

Brilla and Conte [9] performed a study on students to assay the effect of magnesium supplementation on the resistance training time and exhaustion of physical education students. Subjects after ingesting 8 mg of the magnesium oxide supplement (for each one kilogram of body weight) per day for 2 weeks showed a significant increase in endurance performance and decreasing oxygen intake during exercises. In a study that was conducted by [10], the subjects ingested 387 mg of magnesium supplement per day for 2 weeks, that ultimately a significant increase was observed in the total body magnesium and in the red blood cell magnesium. This difference can be due to the use of the sensitive analysis method compared to the previous studies.

The studies done by [11] and [12] showed that the low supplementation (116 mg / day) compared to high supplementation (372+122) had no significant effect on the performance and this study indicated that magnesium supplementation had no effect on aerobic and anaerobic performance of the subjects. Also, [13] investigated the effect of magnesium deficiency on calcium, iron, copper, zinc, manganese, selenium status of the red blood cells in Wistar rats. It was found that a diet with low magnesium leads to increase calcium, iron, copper, zinc, and manganese of red blood cells, but no significant change was observed in selenium.

In another study [14], assayed the effect of magnesium supplements on the performance and duration of recovery for active women. In this study, the subjects ingested 212 mg of magnesium oxide or placebo per day for 4 weeks. The result showed that the level of magnesium ion was increased in the supplementation group compared to the placebo group, but there was no significant effect on the performance and the rest period.

Therefore, the purpose of this study is to determine the effect of magnesium supplements on the muscular strength of active men.

Research Method

The purpose of this study was to investigate the effect of a period of the magnesium supplementation on muscular strength and endurance of male bodybuilders and it is an applied study and quasi-experimental research. In the quasi-experimental research, the subject is alive and the variables in the field of research cannot be fully controlled.

Statistical population of the study

The selected subjects of the current study as the statistical population were active men at sports clubs in Shahr-e-kord, who had to have sports activities (physical fitness) a frequency of three times per week, and all of them were physically healthy. For this purpose, with the collaboration of Shahr-e-kord physical education department, among the active men, those were considered who had sporting experience, at least for six months prior exercises in sports clubs, for this study. In the next step, 40 people were randomly selected using a distributed questionnaire among statistical population who expressed their satisfaction with the research. Subjects were randomly matched into two experimental (magnesium supplement recipients) and control (without magnesium supplements) groups and 20 subjects were placed in each group.

Variables of the study

In the current study, muscular endurance and strength and muscle strength scale of athletes were assayed as dependent variable and the different treatments by the magnesium supplements and performing strength and endurance training (designed by researcher) as independent variable [14].

Machines used for exercises

In this study, two machines were used, including a chest press machine for chest muscles and a rowing machine for back muscles and arms' bender.

- **Chest press machine**: In this study, this machine has been used to strengthen the muscles of the subject's chest. Subjects tighten their shoulders on the table of the machine after getting the barbell and fixing their hands on its bar and they push back their hips with a slight curve of the waist. The barbell bar is lifted from the pedestal and it is vertically fixed on the direction of the shoulder joints and then the barbell is slightly brought down to the chest, and after a little touch on the chest surface and a little pause, the barbell bar is again brought up.
- **Rowing machine:** In this study, this machine is used to strengthen the wide back muscles and arms' bender. The subject holds the handle at arms-length in front of him/herself, keeping your knees bent, shins vertical, core tight, and chest leaning slightly forward. He/she begins the drive movement by pressing his/her heels into the pads, then leaning back as his/her legs finish straightening. Subject complete the stroke by pulling the handle to his/her chest. For the return, he/she reverses the movements. First straighten his/her arms, then leans forward, and bends your knees as possible.

Information Collection Method

After designing a questionnaire (containing personal information including height, weight, illness history, etc.), the researchers described the purpose of the research and its implementation for those who were interested to participate in this research. 40 subjects were randomly selected after filling in the questionnaire by the statistical population. The exercise included 8 weeks of strength and endurance training, along with magnesium supplementation, to reveal the effect of supplementation on muscle strength and endurance. Of course, before starting and after finishing the strength training, warm-up exercises were used for warming and cooling the body for 10-15 minutes.

Strength training program for subjects

The subjects perform the researcher-made strength training program for 8 weeks, when this program was conducted three days for per week (even days). In these days, subjects engaged to perform the strength training with the help of bodybuilding machines. Before the start and after the end of 8-week course of strength training, two sessions were devoted to the determination of RM-1 training weights, and a session for taking blood sampling.

Initially, after calculating and measuring the maximum power of the subjects through formula (1), a specific training program was set up by the researcher based on the percentage of maximum repetition of the subjects [15-17].

$$1RM = \frac{\text{weight}}{[1.0278(\text{Number of repetitions before fatigue} \times 0.0278)]}, \quad (1)$$

The subjects warmed up for 10-15 minutes using the warm-up exercises and then began to perform the endurance and strength training for their upper body using the scheduled training program. It should be noted that, the principles of training programs have been observed, including the reduction of courses from high to low, reducing repetitions from high to low, reducing the rests intervals and increasing the intensity of the load (16).

The endurance training program of the athletes: "the endurance means the ability to endure the fatigue process arising from the hard activities and fast recovering to the initial condition. Endurance has a close relationship to other factors of physical readiness. When one gets tired or loses his/her endurance, other components of the physical readiness will also decrease such as strength, coordination, reaction time, and so on, as a result the performance of the subjects is weakened by the fatigue. The endurance is measured by the unit of measure for time and the maximum of the repetition of a contraction or the maximum of the time of a contraction is static. In fact, muscular endurance is to perform repetitive contractions for an indefinite period, for example, using a dumbbell and too much repetitive elbow flexion. Accordingly, athlete's endurance is performed by using 1-RM squat 0.50 and more repetition of the chest press and flowing exercises in the gym by a standard machine, as a result, the number of more repetitions is a criterion for more endurance of the athlete.

Statistical method

The statistical tests and t test were used at a significant level less than P< 0.05 in addition the use of the Tables and Charts as well as central indicators and dispersion of descriptive statistics, in order to answer the research hypotheses. Parametric statistical assumptions were also controlled before applying the parametric tests. It should be noted that data analysis was performed using SPSS software (VER – 24).

Results and Discussion

The mean and standard deviation of the subjects' personal characteristics of the active male bodybuilders in the Shahr-e-Kord sports clubs that are divided into control and experimental groups and the results of comparing these characteristics are shown in Table 1 (Shapiro-Wilk test was used to ensure that the data are normal and then the T-test was used for comparison).

Table 1: Comparison of the characteristics of the subjects in the two groups at the start of the study

Variable	Group		t statistics	P-Values
	Experimental	Control		
Age	28 ± 2.81	29.8 ±3.27	-1.867	**0.07**
Height (cm)	170.2 ± 5.76	171.5 ± 4.39	-.797	**0.43**

Weight (kg)	74.71 ± 5.72	71.44 ± 5.87	1.783	**0.083**
BMI (kg/m2)	25.92 ± 2.97	24.35 ± 2.35	1.847	**0.073**
FFM (kg)	56.34 ± 10.25	62.78 ± 12.35	-1.795	**0.081**
FM (kg)	26.19 ± 10.66	21.97 ± 9.9	1.301	**0.201**
LBM	64.42 ± 7.52	60.83 ± 6.2	1.648	**0.108**

Based on the results of Table 1, the two groups did not differ significantly in terms of age, height, weight, BMI, FFM, FM and LBM (P< 0.05). This indicates that homogenization has been carried out in the two groups in terms of the variables of the study in Table 1.

After ensuring that the data were normal, the results of t-test were placed in the Table 2 using the Shapiro-Wilk test to compare the average of magnesium and serum calcium concentration of the groups at the start of the study, and 4-8 weeks after magnesium supplementation (Al-Hawi Company magnesium tablets containing 47 mg calcium and 250 mg Magnesium oxide) for the experimental group and placebo for the control group.

Table 2: Comparison of mean and standard deviation of magnesium and serum calcium in the start of the study and 4-8 weeks after magnesium supplementation in the experimental group and placebo in the control group

Variable	Step	Group		t statistics	P-Values
		Experimental	Control		
Serum magnesium concentration (mg/dl)	start	2.76 ± 0.43	2.86 ±0.81	-0.507	**0.616**
	4 weeks	3.41 ± 0.58	2.87 ±0.67	2.761	**0.009**
	8 weeks	3.58 ± 0.74	2.84 ±0.51	3.688	**0.001**
Serum calcium concentration(mg/dl)	start	9.77 ± 0.28	9.89 ±0.42	-1.087	**0.288**
	4 weeks	9.88 ± 0.14	9.76 ±0.23	2.194	**0.036**
	8 weeks	10.14 ± 0.22	9.86 ±0.44	2.57	**0.016**

According to the results of Table 2, there is no significant differences in the serum magnesium (P = 0.616) and calcium (P = 0.288) concentration between the two experimental and control groups at the start of the study, but with starting magnesium supplementation in the experimental group, the level of serum magnesium and calcium increased gradually in this group and there is a significant difference in the serum magnesium and calcium level in the control and the experimental groups 4-8 weeks after the magnesium supplementation (P <0.05).

Also, the results of repeated measures in this study show that (Table 3) the group has a significant role for the difference in the serum magnesium level of the subjects (P = 0.001) at the start of the study, and 4 and 8 weeks after the magnesium supplementation and taking the placebo, but, the role of the group is negligible in the difference of the serum calcium level of the subjects (P = 0.101) at the start of the study, and 4-8 weeks after, the magnesium supplementation and taking the placebo, and 27% of the changes in serum magnesium level of the subjects were measured in three stages and only 6.9% of the occurred changes in the calcium level of the subjects can be attributed to the variable in three stages of measures.

189 Table 3: The results of the repeated measures test

Variable	Source	Type III Sum of Squares	df	Mean Square	F	P-Values	Partial Eta Squared
Serum magnesium concentration (mg/dl)	Group	4.630	1	4.630	14.077	.001	.270
	Error	12.498	38	.329	-	-	-
Serum calcium concentration (mg/dl)	Group	.276	1	.276	2.833	.101	0.069
	Error	3.709	38	.098	-	-	-

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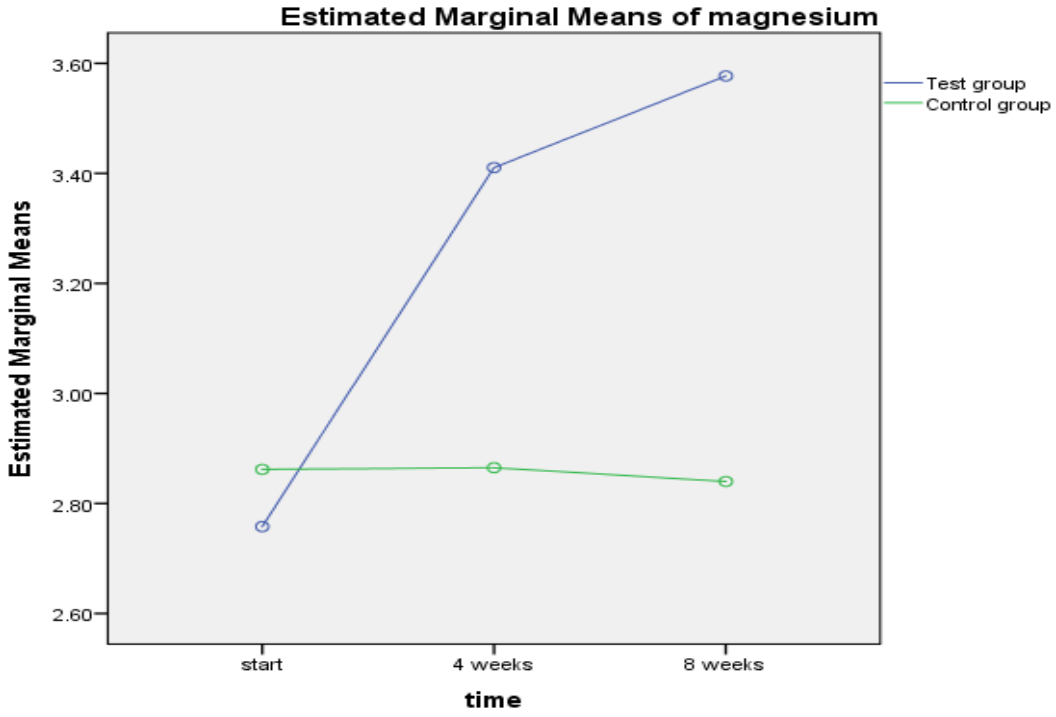

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193 Chart 1: Changes of the serum magnesium level in three measurement steps

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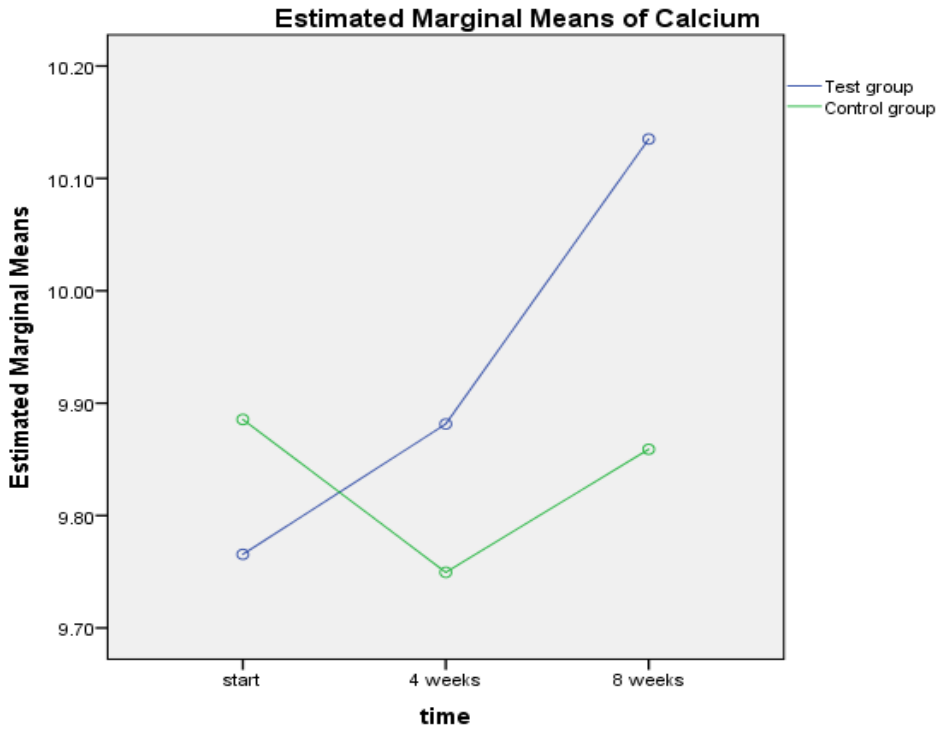

Chart 2: Changes of the serum calcium level in three measurement steps

In the following using multivariate analysis of covariance, the use of mineral supplements such as magnesium and its effect on the strength and endurance of upper body muscles of the male athletes will be discussed.

Table 4: Mean and standard deviation of muscular strength and endurance of the subjects in the start of the study and 4-8 weeks after the magnesium supplementation in the experimental group and taking the placebo in the control group

Variable	Stage	Group	
		Experimental	**Control**
Arms muscle strength	start	60.25 ± 5.28	**60.71 ± 8.18**
	4 weeks	70.61 ± 7.59	**64.01 ± 6.2**
	8 weeks	72.57± 6.93	**68.56 ± 6.59**
Back muscle strength	start	53.14± 4.1	**54.25 ± 6.36**
	4 weeks	61.49± 6.11	**57.86 ± 6.41**
	8 weeks	62.75 ± 6.66	**61.09 ± 8.31**
Chest muscle strength	start	42.6 ± 5.71	**45.62 ± 5.8**
	4 weeks	50.36 ± 4.56	**46.96 ± 4.6**
	8 weeks	53.14± 4.5	**47.97 ± 5.49**
Endurance of the upper body	start	66.9 ± 15.86	**73.34 ± 12.32**
	4 weeks	79.52 ± 9.67	**71.95 ± 12.45**
	8 weeks	79.61± 10.38	**78.27 ± 8.12**

In the following, the assumptions of multivariate analysis of covariance will be examined in order to study the goals of the research.

Table 5: Assumptions of the normalization of data

Variable	Stage	Group	Shapiro-Wilk		
			Statistic	df	P-Values
Arms muscle strength	start	Experimental	.913	20	.073
		Control	.956	20	.467
	4 weeks	Experimental	.951	20	.376
		Control	.911	20	.066
	8 weeks	Experimental	.901	20	.055
		Control	.968	20	.709
Back muscle strength	start	Experimental	.959	20	.515
		Control	.956	20	.460
	4 weeks	Experimental	.967	20	.697
		Control	.956	20	.460
	8 weeks	Experimental	.949	20	.349
		Control	.935	20	.195
Chest muscle strength	start	Experimental	.962	20	.587
		Control	.966	20	.674
	4 weeks	Experimental	.949	20	.353
		Control	.970	20	.757
	8 weeks	Experimental	.976	20	.864
		Control	.950	20	.367
Endurance of the upper body	start	Experimental	.966	20	.665
		Control	.969	20	.737
	4 weeks	Experimental	.978	20	.910
		Control	.980	20	.940
	8 weeks	Experimental	.989	20	.997
		Control	.956	20	.472

Based on the results obtained in Table 5, the distribution of all variables is normal (P> 0.05).

The results of the homogeneity analysis of variances using the Levene's test in the multivariate analysis of covariance are shown in Table 6:

Table 6: Analysis of Homogeneity assumption of error variance

Variable	Stage	Levene's Test of Equality of Error Variances			
		F	df1	df2	P-Values
Arms muscle strength	4 weeks	.753	1	38	.391
	8 weeks	.050	1	38	.825
Back muscle strength	4 weeks	.065	1	38	.800
	8 weeks	1.456	1	38	.235
Chest muscle strength	4 weeks	.011	1	38	.919
	8 weeks	1.248	1	38	.271

Endurance of the upper body	4 weeks	.792	1	38	.379
	8 weeks	.993	1	38	.325

Based on the results obtained in Table 6, homogeneity assumption of error variance is accepted (P> 0.05).

Finally, the results of the homogeneity of the covariance matrix study using the Box test in the multivariate analysis of covariance are shown in Table 7:

Variable	Box's Test of Equality of Covariance Matrices			
	F	df1	df2	P-Values
Arms muscle strength	.270	3	259920	.847
Back muscle strength	1.492	3	259920	.214
Chest muscle strength	.468	3	259920	.705
Endurance of the upper body	.785	3	259920	.502

Based on the results obtained in Table 7, the homogeneity assumption of the covariance matrix is accepted for (P> 0.05).

In general, Wilks' lambda test was used for significance determination of the group effect on strength and endurance components, the gained results are reported in Table 8:

Table 8: Results of the Wilks' lambda Test

Variable	Effect	Value	F	Hypothesis df	Error df	P-Values	Partial Eta Squared
Arms muscle strength	group	.761	5.642	2	36	.007	.239
Back muscle strength	group	.863	2.869	2	36	.070	.137
Chest muscle strength	group	.758	5.738	2	36	.007	.242
Endurance of the upper body	group	.857	2.998	2	36	.062	.143

The results of Wilks' lambda test showed that there is a significant difference between two groups, at least for one of the measurements related to arm muscle strength (P <0.05, F (2.36) = 5.642) and chest muscle strength (P <0.05, F (2.36) = 5.738)., While there is no significance difference between the two groups in the measurements related to back muscle strength (P> 0.05, F (2.36) = 2.869) and endurance of the upper body (P> 0.05, F (2.36) = 2.998), which means that magnesium supplementation for 8 weeks has a significant effect on the arms and the chest muscle strength of the male athlete's body. In this regard, the group variables explain 23.9% and 24.2% of the variances of the arms and chest muscles strength of the male bodybuilder athletes respectively, while the results of the present study indicate that magnesium supplementation for 8 weeks

cannot affect the back muscles strength and endurance of the upper body of the male bodybuilder athletes, and the group variable explains only 13.7% and 14.3% of the back muscles strength and the endurance of the upper body of the male bodybuilder athletes variances respectively.

Conclusion

In this paper, the effect of magnesium supplementation on muscle strength of active men was investigated. The statistical population of the study included active male bodybuilder's athletes in sports clubs in Shahr-e-Kord, who regularly exercise three days for a week and they were healthy physically. The magnesium supplementation, (magnesium tablets containing 47 mg of the calcium and 250 mg of the magnesium oxide) was given to the experimental group and the placebo that was completely similar to the supplements for the control group. The tablets are given to every other subject individually and they performed strength training. 40 subjects were selected from people who were interested to participate in the research. The strength of the athletes was measured by CPR machine based on the 1-RM and their resistance by more repetition of bench press with a standard machine using 1-RM by 0.5 Kg in the gym. Based on the results, there were no significant differences in the serum magnesium and calcium levels at the start of the study between the two experimental and control groups, but, by magnesium supplementation, the serum magnesium and calcium levels increased gradually in the experimental group. The results of the Wilks' lambda test showed that there is a significant difference between the control group and experimental group, at least in one of the measurements related to arms muscle strength and chest muscle strength, while there is no significant difference in the measurements related to back muscle strength and endurance of the upper body in the two groups, which means that magnesium supplementation for 8 weeks has had a significant effect on the strength of the arms and chest muscles strength for the male bodybuilder's athletes.

Disclaimer regarding Consent/Ethical Approval:

As per university standard guideline participant consent and ethical approval has been collected and preserved by the authors.

References

[1] Speich, M., Pineau, A., & Ballereau, F. (2001). Minerals, trace elements and related biological variables in athletes and during physical activity. *Clinica Chimica Acta*, *312*(1-2), 1-11.

[2] König, D., Weinstock, C., Keul, J., Northoff, H., & Berg, A. (1998). Zinc, iron, and magnesium status in athletes--influence on the regulation of exercise-induced stress and immune function. *Exercise immunology review*, *4*, 2-21.

[3] Lukaski, H. C. (1995). Micronutrients (magnesium, zinc, and copper): are mineral supplements needed for athletes?. *International Journal of Sport Nutrition*, *5*(s1), S74-S83.

[4] Gleeson, M., Nieman, D. C., & Pedersen, B. K. (2004). Exercise, nutrition and immune function. *Journal of sports sciences*, *22*(1), 115-125.

[5] Cinar, V., Mogulkoc, R., Baltaci, A. K., & Polat, Y. (2008). Adrenocorticotropic hormone and cortisol levels in athletes and sedentary subjects at rest and exhaustion: effects of magnesium supplementation. *Biological trace element research*, *121*(3), 215-220.

[6] Cinar, V., Mogulkoc, R., Baltaci, A. K., & Nizamlioglu, M. (2007). Effect of magnesium supplementation on some plasma elements in athletes at rest and exhaustion. *Biological trace element research*, *119*(2), 97-102.

[7] Lukaski, H. C. (2000). Magnesium, zinc, and chromium nutriture and physical activity. *The American journal of clinical nutrition*, *72*(2), 585S-593S.

[8] Wilborn, C. D., Kerksick, C. M., Campbell, B. I., Taylor, L. W., Marcello, B. M., Rasmussen, C. J., ... & Kreider, R. B. (2004). Effects of zinc magnesium aspartate (ZMA) supplementation on training adaptations and markers of anabolism and catabolism. *Journal of the International Society of Sports Nutrition*, *1*(2), 12.

[9] Brilla, L. R., & Conte, V. (2000). Effects of a Novel Zinc-Magnesium Formulation on Hormones and Strength. *Journal of Exercise Physiology Online*, *3*(4).

[10] Williams, M. H. (2005). Dietary supplements and sports performance: minerals. *Journal of the International Society of Sports Nutrition*, *2*(1), 43.

[11] Van Loan, M. D., Sutherland, B., Lowe, N. M., Turnlund, J. R., & King, J. C. (1999). The effects of zinc depletion on peak force and total work of knee and shoulder extensor and flexor muscles. *International journal of sport nutrition*, *9*(2), 125-135.

[12] Nielsen, F. H., & Lukaski, H. C. (2006). Update on the relationship between magnesium and exercise. *Magnesium research*, *19*(3), 180-189.

[13] Carvil, P., & Cronin, J. (2010). Magnesium and implications on muscle function. *Strength & Conditioning Journal*, *32*(1), 48-54.

[14] Newhouse, I. J., & Finstad, E. W. (2000). The effects of magnesium supplementation on exercise performance. *Clinical Journal of Sport Medicine*, *10*(3), 195-200.

[15] Wilborn, C. (2008). Nutritional supplements for strength power athletes. In *Nutritional Supplements in Sports and Exercise*(pp. 321-368). Humana Press.

[16] Krotkiewski, M., Gudmundsson, M., Backström, P., & Mandroukas, K. (1982). Zinc and muscle strength and endurance. *Acta Physiologica Scandinavica*, *116*(3), 309-311.

[17] Brilla, L. R., & Haley, T. F. (1992). Effect of magnesium supplementation on strength training in humans. *Journal of the American College of Nutrition*, *11*(3), 326-329.

[18] Lukaski, H. C. (2004). Vitamin and mineral status: effects on physical performance. *Nutrition*, *20*(7-8), 632-644.

[19] Dominguez, L. J., Barbagallo, M., Lauretani, F., Bandinelli, S., Bos, A., Corsi, A. M., ... & Ferrucci, L. (2006). Magnesium and muscle performance in older persons: the InCHIANTI study–. *The American journal of clinical nutrition*, *84*(2), 419-426.