

Influences of acute resistance and aerobic exercises on plasma homocysteine level and lipid profiles

[Akut dirençli ve aerobik egzersizlerin plazma homosistein ve lipid profili üzerine etkisi]

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[Received: 05 May 2008; Accepted: 12 January 2009]

Kayıt Tarihi: 05 Mayıs 2008; Kabul Tarihi: 12 Ocak 2009

ABSTRACT

Purpose: The aim of the present study was to compare the effects of two different types (aerobic and resistance) of acute exercise on plasma homocysteine level and lipid profiles.

Material and methods: 51 students were included. Resistance exercise group (n=20) performed moderate resistance and aerobic exercise group (n=18) performed sub-maximal aerobic exercise for one session. Control group (n=13) did not join any exercise. The plasma homocysteine level and lipid profiles were measured.

Results: Two-way ANOVA with repeated measures yielded a significant time by group interaction for homocysteine level. Homocysteine level in aerobic exercise group was statistically different from the control group (p=0.04). We found that the increase for plasma homocysteine level in aerobic exercise group was higher than the percentage of biological variation of the plasma homocysteine (p<0.05). Acute exercises did not considerably change lipid profiles (p>0.05).

Conclusion: Our findings indicate that although the acute moderate aerobic exercise increases plasma homocysteine level the acute resistance exercise does not. Independently from the type of exercise, acute exercises do not considerably change lipid profiles.

Key Words: Homocysteine, lipids, exercise.

ÖZET

Amaç: Bu çalışmanın amacı farklı iki akut egzersiz çeşidinin (aerobik ve dirençli) plazma homosistein ve lipid profili üzerindeki etkisini karşılaştırmaktır.

Gereç ve yöntemler: 51 öğrenci çalışmaya dahil edildi. Dirençli egzersiz grubu (n=20) orta şiddetli dirençli, aerobik egzersiz grubu (n=18) sub-maksimal düzey egzersizleri bir seans yaptı. Kontrol grubu (n=13) hiç bir egzersiz yapmadı. Plazma homosistein düzeyi ve lipid profili incelendi.

Bulgular: Tekrarlı ölçümlerde iki yönlü varyans analizi sonucunda homosistein düzeyinde anlamlı bir grup zaman etkileşimi olduğu görüldü. Aerobik egzersiz grubunun homosistein düzeyi kontrol grubundan anlamlı olarak farklıydı (p=0.04). Aerobik egzersiz grubundaki artışın plazma homosistein düzeyi için belirlenen biyolojik varyasyon yüzdesinden fazla olduğu bulundu (p<0.05). Akut egzersizlerden sonra lipid profili değişmedi (p>0.05).

Sonuç: Bulgularımız; akut orta şiddetli aerobik egzersizin plazma homosistein düzeyini artırdığını fakat akut dirençli egzersizin değiştirmediğini göstermektedir. Egzersiz çeşidinden bağımsız olarak, akut egzersizlerden sonra lipid profili değişmemektedir.

Anahtar Kelimeler: Homosistein, lipitler, egzersiz.

Introduction

Homocysteine (Hcy) is a nonessential sulphur-containing amino acid and an intermediate in the metabolic pathway of the essential amino-acid methionine (1-3). High Hcy levels may increase the risk of cardiovascular disease and possible mechanisms such as ability of Hcy leading to endothelial cell injury, stimulate vascular smooth muscle cell growth, increase platelet adhesiveness, enhance LDL-cholesterol (LDL-c) oxidation and deposition in the arterial wall, and may directly activate the coagulation cascade (1-7).

Hyperhomocysteinemia is a commonly accepted independent risk factor for cardiovascular, neurodegenerative and other diseases (8-10). Increased physical activity especially in sedentary individuals positively affects well known risk factors for cardiovascular disease, including decreases in blood pressure, circulating levels of serum cholesterol and plasma insulin and increases cardio-respiratory fitness (3,6,9).

Quite a lot of studies investigated the effects of exercise on cardiovascular risk factors such as high triglyceride, total cholesterol and blood pressure, whereas few studies have addressed the potential for different type of exercises to modify plasma Hcy levels in sedentary individuals (3,11-14). Yet, there is still equivocal information about whether plasma Hcy level can be changed with exercise.

The two possible mechanisms were defined between physical activity and plasma Hcy levels. One of the possible links between Hcy metabolism and physical activity depends on the formation of the universal methyl group donating substance S-adenosylmethionine for proper energy production by converting guanidinoacetate to creatine. Creatine phosphate is utilized within the skeletal muscles for storing high-energy phosphate bonds. It has been supposed that these alterations in the creatine synthesis may affect the Hcy levels, because the formation of S-adenosylhomocysteine (the precursor of Hcy) from adenosylmethionine is thought to be enhanced by high creatine synthesis (11,13,14).

During the anaerobic alactacid metabolism, the creatine turnover is elevated. Physical activity effects on plasma protein metabolism and turnover and consequently the concentration of certain amino acids, including methionine (11, 14).

The other possible mechanism between exercise and Hcy might be that the increase in the nitric oxide production in endothelial cells by effecting vasoregulation causes a decrease in Hcy (5, 15).

Recent studies have pointed out the type and intensity of the exercise and it seemed to be that the effect of exercise on the level of Hcy could change depending on the intensity and frequency of the training (8,11,13,14,16,18). There are a lot of studies which interest in the training effect on the plasma Hcy level in the literature (4,

8,11,14,17,19) whereas a few of the studies investigate the acute effects of the exercises on the Hcy level (5,11,18).

There are contradictory information for the training intensity and type in the recent studies about the effects of acute exercises on Hcy levels. DeCree et al. (20), and Konig et al. (11) reported that the intense acute exercise increased the plasma Hcy. In contrast, De Cree et al. (21) declared that plasma Hcy levels were not affected by acute submaximal exercise and this result was confirmed by Wright et al. (18) by using an intensity of 70% of maximal heart rate for 30 minute.

We examined the effects of acute aerobic exercise on plasma Hcy level and lipid profile in the first part of our research. We found that the plasma Hcy level was increased after sub-maximal acute aerobic exercise but lipid profile did not change (22). In the second part of the study; our aim was to investigate not only the effects of the resistance exercises on plasma Hcy level and lipid profiles but also to compare the effects of two different types (aerobic and resistance) of exercises on these parameters.

Methods

Subjects

Fifty one healthy subjects, aged 21.76 ± 2.73 years old, were included the present study. Subjects who are smokers, have Hcy level higher than 20 micromole/L, total-cholesterol (Total-c) level higher than 200 mg/dL, systolic blood pressure (SBP) and diastolic blood pressure (DBP) higher than 140 and 100 mmHg, have history of injury related to lower extremities and have performed regular exercise for the last 6 months were excluded in this study.

Approval was obtained from University of Dokuz Eylul, Human Ethics Committee (B.30.2.DEU.0.01.00.00/970) before commencing this study, and the written consent was taken from all subjects.

The subjects underwent a submaximal cycling test to determine their aerobic capacity indirectly. A computerized Monark 839 cycle ergometer including its own heart rate monitor was used for the tests (22). Aerobic capacities of all subjects were described as "low" according to Astrand's classification (23).

Study Design

This study was a non-randomized controlled trial. The subjects were divided into three groups (n=20 for each group). None of them had participated in sporting activities on a regular basis or regular completion of a specific exercise program for the prior 6 months. The Hcy analysis was done at the same time and subjects who did not match the inclusion criteria according to normative values were excluded from the study. Aerobic exercise (AE) group included 18 sedentary subjects and control (CT) group included 13 subjects were examined in the

first part of the study (22). Resistance exercise (RE) group (20 sedentary subjects) was added to complete the second part of our research. RE program was done at the same time in the morning as previously done. Blood Pressure (mmHg) was measured on the upper right arm (over the brachial artery) using a standard mercury sphygmomanometer, before and immediately after exercises (22). Before the study, subjects were given instructions on how to exercise. Furthermore, all the subjects were told not to take any vitamin B supplements such as vitamin B6, vitamin B12 or folate before a week to participate in this study.

Aerobic exercise procedure; including warm-up, sub-maximal aerobic exercise and cool-down was performed as Gelecek et al.'s study (22).

Resistance exercise procedure; was performed as 5 minute warm-up, 30 minute exercise and cool-down. Resistance exercise program consisted of the completion of three sets of 10 repetitions, with 60 s of rest between each set, performed at 80% of each subject's predetermined one-repetition maximum (1-RM), respectively.

Resistance bands were used for: Abdominals, biceps, flexor, extensor, abductor, adductor muscles of the hip. The resistance machines were used for: Chest press, latissimus row, seated triceps, seated quadriceps, hamstring curl (25,27).

Laboratory Assessments; In RE group; blood samples were taken before and immediate post-exercise as it was previously done (22). To eliminate the possible effect of the hormonal status on Hcy, we arranged the assessments considering the menstrual period.

The blood samples were collected between 8-9 a.m. following a 12-h overnight fasting. Lipid analyses were studied in sera samples immediately after collection. Also, for Hcy measurement, blood samples were collected in EDTA-containing tubes and they were centrifuged within the 10-20 minutes at 4°C, 4000 ×g for 10 minutes. Blood samples were stored on ice until centrifugation. The plasma fractions were kept at -20°C until measurements. Plasma Hcy levels were measured by the competitive immunoassay method (Intra-assay CV % = 0.98 %, Inter-assay CV % = 1.60 %) (DPC Immulite, Los Angeles, USA) (7).

Total-c, triglyceride (TG), HDL-cholesterol (HDL-c), LDL-cholesterol (LDL-c) levels were measured with colorimetric/enzymatic method by a chemistry auto analyzer (Roche, DP Moduler System, Tokyo, Japan). When the TG level was lower than 400mg/dL, LDL-c calculated using the Friedewald formulae: $\{Total-c\} - \{(TG/5) + HDL-c\}$ (28). All methods were daily controlled by internal quality system and were certified by NEQAS external quality control system.

Statistical Analysis

All variables were normally distributed. Therefore, arithmetic mean and standard deviation were used for

descriptive statistics. Demographic and investigational variables which are Hcy levels, together with Total-c, HDL-c, LDL-c and TG levels were put into a database within the SPSS 13.0 data managements system and analyzed by using this system. Potential baseline differences for demographic variables of the participants among the groups were analyzed using One-way ANOVA. Two-way analysis of variance (ANOVA) with repeated measures with time (within) and treatment groups (between) as factors was used to test for time by exercise effects on subjects' Hcy, Total-c, HDL-c, LDL-c and TG levels for each variable. When significant changes were observed in ANOVA tests, Tukey's post hoc test was applied to locate the source of significant difference. The level of significance was set at $p=0.05$.

Results

All subjects in the groups were similar respect to both descriptive and biochemical variables at the baseline (One-way ANOVA) ($p>0.05$). The descriptive and anthropometric characteristics of the subjects are outlined in Table 1.

We used the repeated measures ANOVA test to determine the group and time effect for all biochemical analyses. When significant differences detected in ANOVA tests, Tukey's post hoc test was applied.

Table 2 shows the biochemical variables of all groups at baseline and second measurements, and absolute changes of each variable were added.

The changes in Total-c ($F=0,13$, $p=0,88$), HDL-c ($F=0,23$, $p=0,80$) and LDL-c ($F=0,59$, $p=0,56$) were not statistically different among three groups.

The repeated measures ANOVA yielded a significant time by group interaction for Hcy level ($F=10,39$, $p=0,00$). Hcy level increased in both exercise groups whereas there was a reduction in Hcy level of control group (Table 2). The control and resistance exercise groups were compared and no significant difference was found ($p=0,60$). Similarly there was no significant difference between resistance and aerobic exercise group ($p=0,95$). Hcy level in aerobic exercise group was statistically different from control group ($p=0,04$). This increasing in aerobic group for Hcy level was higher than the percentage of biological variation of the plasma Hcy (<http://www.westgard.com/biodatabase1.htm>).

According to the results of the Two-way ANOVA analysis there was no significant time by group interaction for TG level ($F=0,16$, $p=0,85$) whereas time effect were significant ($F=7,48$, $p=0,01$). There was a 6.5 reduction in the TG level percentile of the aerobic exercise group and control group decreased by 3.8 percentiles and the difference between the two groups was significant ($p=0,04$). However this alteration of TG level was related to its biological variation (<http://www.westgard.com/biodatabase1.htm>).

Table 1. The descriptive and anthropometric characteristics of the subjects

Variable	RE group n=20	AE group n=18	CT group n=13	
Gender	Female	10	8	p
	Male	9	5	
Age, years	22.00±3.21 (20-34)	21.50±2.28 (19-29)	21.75±2.67 (20-28)	0.86
Height, cm	168.30 ± 7.84 (155-183)	168.05 ± 7.43 (156-178)	168.05 ± 7.43 (157-181)	0.30
Body mass, kg	62.80 ± 9.48 (50-85)	61.16 ± 7.87 (48-76)	58.17 ± 5.70 (51-72)	0.28
BMI, kg/m ²	22.19 ± 2.04 (18-26.5)	22.0 ± 1.99 (19.20-26.0)	21.50 ± 1.42 (19-23.5)	0.23

RE: Resistance exercise; AE : Aerobic exercise; CT :Control; BMI, Body mass index, Values are means ± standard deviations.

(The values of AE and CT groups are from Gelecek et al. Influences of Acute and Chronic Aerobic Exercise on the Plasma Hcy Level. Ann Nutr Metab. 51:53–58, 2007)

Table 2. Biochemical variables of the groups

	Resistance Exercise	Aerobic Exercise	Control Group
Hcy (µmol/L)			
Pre	9.34±3.88	9.40±2.48	8.63±1.63
Post	9.59±4.20	10.15 ±2.58 §	8.10 ±1.67
Δ	0.25 ±0.79 (% 6.5±5.3)	0.76 ±0.66 † (% 9.9±5.2)	-0.53±0.83 (% 7.9±6.1)
TG (mg/dL)			
Pre	78.85±32.91	90.16±39.06	80.66±23.70
Post	75.70±28.97	88.11±37.05 §	79.41±23.07
Δ	-3.15 ±6.02 (% 5.8±4.3)	-2.06± 8.05 (% 6.5±6.3)	-2.25 ±2.34 (% 3.8±2.8)
Total-c (mg/dL)			
Pre	152.10±29.37	150.38±29.03	155.91±20.57
Post	150.95±29.48	149.44±38.39	154.08±20.47
Δ	-1.15 ±4.79 (% 2.4±1.8)	-0.94 ±5.58 (% 3.0±1.6)	-1.83 ±2.89 (% 1.7±1.3)
HDL-c (mg/dL)			
Pre	59.40±12.77	54.61±11.05	62.50±9.37
Post	59.60±12.29	55.11±11.16	61.70±10.25
Δ	0.20 ±1.77 (% 1.8±2.3)	0.50 ±1.58 (% 2.7±1.8)	0.17 ±1.19 (% 1.3±1.4)
LDL-c (mg/dL)			
Pre	76.95±26.97	73.11±25.60	81.33±18.16
Post	76.90±27.73	71.88±25.92	78.91±16.80
Δ	-0.05 ±4.84 (% 4.3±3.0)	-1.22 ±3.80 (% 3.9±2.5)	-1.42 ±2.50 (% 2.3±1.9)

Δ, absolute changes in the variables from baseline to second measurements. Percentiles were showed in the parenthesis. Values are means ± standard deviations.

† Different from control group at $p < 0.05$.

§ Different from the first measurement to second measurement at $p < 0.05$.

(The values involved with initial and second measurements of aerobic exercise group and control group are from Gelecek et al Influences of Acute and Chronic Aerobic Exercise on the Plasma Hcy Level. Ann Nutr Metab. 51:53–58, 2007)

Discussion

Our study aimed to compare the effects of acute aerobic and acute resistance exercises on plasma Hcy level and lipid profile. The present data demonstrate that sub-maximal acute aerobic exercise increases Hcy level considerably whereas acute resistance exercise makes a little difference on this level.

It is hard to commit a clear explanation for relation between exercise and Hcy level since there is equivocal information about the effect of acute exercise on plasma Hcy level. Nygard et al. reported that there was a negative relation between plasma Hcy level and physical activity in Hordaland Hcy study. In this study, researchers declared that the plasma Hcy level was lower in the subjects who performed moderate and heavy training compared with the sedentary subjects (2).

De Cree et al. found an increase in plasma Hcy levels following exhaustive exercise in women, although the results were depend on the menstrual cycle (20). For this reason we aimed to eliminate the possible effect of the hormonal status on Hcy level, therefore we arranged the assessments considering the menstrual period.

There are studies investigating the effects of acute exercise on plasma Hcy level. De Cree et al. found that plasma Hcy level increased post-immediate acute moderate exercise, whereas brief exhaustive training did not change this level (20). Wright et al. determined that exercise at moderate or intermediate intensity is probably not adequate to induce an increase in plasma Hcy level (18). Hermann et al. reported that endurance exercise may induce a considerable plasma Hcy level increase, which varies between different disciplines and determined by the duration and intensity of exercise (8). They indicated that the possible reason for increased Hcy levels after endurance exercise might be the exercise-related hemoconcentration. And they explained their findings with this mechanism. The exercise-related non-energetic metabolic demand possibly exerts an increased turnover of many of methylated molecules (e.g., acetylcholine, creatine and DNA) which are fundamental for physical exercise. Regeneration of these molecules is accompanied by a sufficient stimulation of the methionine metabolism. If this stimulation exceeds a distinct level, the steady state between Hcy production and its degradation by remethylation and transsulfuration may be disturbed in favor of the production. These results support our previous findings that plasma Hcy level increases after acute aerobic exercise due to plasma volume shifts during exercise (22).

König et al. reported that intense acute exercise increased plasma Hcy level in young healthy men aged 24-39 (11). In contrast, De Cree et al found that plasma Hcy levels were not affected by acute sub-maximal exercise and this result was confirmed by Wright et al by using an intensity of 70% of maximal heart rate for 30 minute (5,18). In the first part of our research, we found

that acute aerobic exercise (intensity of 70% of maximal heart rate) increased plasma Hcy level (22).

We expected that the plasma Hcy level would increase after the resistance exercise according to the hypothesis that creatine synthesis may affect the Hcy levels. In addition, Hudson et al. suggested that acute resistance exercise protocols elicited a blood oxidative stress in a time-dependent fashion (29). But our results showed that acute resistance exercise did not affect the Hcy level.

Hernandez-Torres et al. found that TG level did not change with acute aerobic exercise whereas Total-c and HDL-c level increased at the end of both continuous and intermittent aerobic exercises (30). In our study we found that TG level decreased after acute aerobic exercise, however its alteration was related to its biological variation. We also found that levels of Total-c and LDL-c, HDL-c did not change immediately after both acute resistance and acute aerobic exercise.

Conclusions

Our findings indicate that acute moderate aerobic exercise increases plasma Hcy level and acute resistance exercise not. Independently from the type of exercise, acute exercises do not considerably change lipid profiles.

References

- [1] Ganji V, Kafai MR: Third National Health and Nutrition Examination Survey. (2001) Demographic, health, lifestyle, and blood vitamin determinants of serum total Hcy concentrations in the third National Health and Nutrition Examination Survey, 1988-1994. *Am J Clin Nutr.* 77: 826-33.
- [2] Nygard O, Vollset SE, Refsum H, Stensvold I, Tverdal A, Nordrehaug JE, Ueland M, Kvale G. (1995) Total plasma Hcy and cardiovascular risk profile. The Hordaland Hcy Study. *JAMA.* 274: 1526-33.
- [3] Silaste ML, Rantala M, Sampi M, Alfthan G, Aro A, Kesaniemi YA. (2001) Polymorphisms of key enzymes in Hcy metabolism affect diet responsiveness of plasma Hcy in healthy women. *J Nutr.* 131: 2643-7.
- [4] Graham, I.M., Daly, L.E., Refsum, H.M., Robinson, K., Brattstrom, L.E., Ueland, P.M., Palma-Reis, R.J., Boers, G.H., Sheahan, R.G., Israelsson, B., Uiterwaal, C.S., Meleady, R., McMaster, D., Verhoef, P., Witteman, J., Rubba, P., Bellet, H., Wautrecht, J.C., de Valk, H.W., Sales Luis, A.C., Parrot-Rouland, F.M., Tan, K.S., Higgins, I., Garcon, D., Andria G, et al. Plasma Hcy as a risk factor for vascular disease. (1997) The European Concerted Action Project. *JAMA.* 277: 1775-81.
- [5] Hankey, G.J. and Eikelboom, J.W. (1999) Hcy and vascular disease. *Lancet* 354: 407-13.
- [6] Kuller, L.H. and Evans, R.W. (1998) Hcy, vitamins, and cardiovascular disease. *Circulation.* 196-9.
- [7] Mennen, L.I., de Courcy, G.P., Guillard, J.C., Ducros, V., Bertrais, S., Nicolas, J.P., Maurel, M., Zarebska, M., Favier, A., Franchisseur, C., Hercberg, S. and Galan P. (2002) Hcy, cardiovascular disease risk factors, and habitual diet in the French Supplementation with Antioxidant Vitamins and Minerals Study. *Am J Clin Nutr.* 76: 1279-89.

- [8] Herrmann, M., Wilkinson, J., Schorr, H., Obeid, R., Georg, T., Urhausen, A., Scharhag, J., Kindermann, W. and Herrmann, W. (2003) Comparison of the influence of volume-oriented training and high-intensity interval training on serum Hcy and its cofactors in young, healthy swimmers. *Clin Chem Lab Med.* 41: 1525-31.
- [9] Gaume, V., Mouglin, F., Figard, H., Simon-Rigaud, M.L., N'Guyen, U.N., Callier, J., Kantelip, J.P. and Berthelot, A. (2005) Physical training decreases total plasma Hcy and cysteine in middle-aged subjects. *Ann Nutr Metab.* 49: 125-31.
- [10] Kuo HK, Yen CJ, Bean JF. (2005) Levels of Hcy are inversely associated with cardiovascular fitness in women, but not in men: data from the National Health and Nutrition Examination Survey 1999-2002. *J Intern Med.* 258: 328-35.
- [11] König, D., Bisse, E., Deibert, P., Muller, H.M., Wieland, H. and Berg, A. (2003) Influence of training volume and acute physical exercise on the Hcy levels in endurance-trained men: interactions with plasma folate and vitamin B12. *Ann Nutr Metab.* 47: 114-8.
- [12] Nygard, O., Refsum, H., Ueland, P.M. and Vollset, S.E. (1998) Major lifestyle determinants of plasma total Hcy distribution: the Hordaland Hcy Study. *Am J Clin Nutr.* 67: 263-70.
- [13] Randeve, H.S., Lewandowski, K.C., Drzewoski, J., Brooke-Wavell, K., O'Callaghan, C., Czupryniak, L., Hillhouse, E.W. and Prelevic, G.M. (2002) Exercise decreases plasma total Hcy in overweight young women with polycystic ovary syndrome. *J Clin Endocrinol Metab.* 87: 4496-501.
- [14] Streenge, G.R., Verhoef, P. and Greenhaff, P.L. (2001) The effect of creatine and resistance training on plasma Hcy concentration in healthy volunteers. *Arch Intern Med.* 161: 1455-6.
- [15] Hayward, R., Ruangthai, R., Karnilaw, P., Chicco, A., Strange, R., McCarty, H. and Westerlind, K.C. (2003) Attenuation of Hcy-induced endothelial dysfunction by exercise training. *Pathophysiology.* 9: 207-214.
- [16] Pisciotta, L., Cantafora, A., Piana, A., Masturzo, P., Cerrone, R., Minniti, G., Bellocchio, A., Reggiani, E., Armani, U. and Bertolini, S. (2003) Physical activity modulates effects of some genetic polymorphisms affecting cardiovascular risk in men aged over 40 years. *Nutr Metab Cardiovasc Dis.* 13: 202-10.
- [17] Vincent, K.R., Braith, R.W., Bottiglieri, T., Vincent, H.K. and Lowenthal, D.T. (2003) Hcy and lipoprotein levels following resistance training in older adults. *Prev Cardiol.* 6: 197-203.
- [18] Wright, M., Francis, K. and Cornwell, P. (1998) Effect of acute exercise on plasma Hcy. *J Sports Med Phys Fitness.* 38: 262-5.
- [19] Francis, K.T. (1996) Physical activity in the prevention of CVD. *Physical Therapy.* 76: 456-68.
- [20] De Cree, C., Malinow, M.R., van Kranenburg, G.P., Geurten, P.G., Longford, N.T. and Keizer, H.A. (1999) Influence of exercise and menstrual cycle phase on plasma homocyst(e)ine levels in young women--a prospective study. *Scand J Med Sci Sports.* 9: 272-8.
- [21] De Cree, C., Whiting, P.H. and Cole, H. (2000) Interactions between Hcy and nitric oxide during submaximal exercise in adults male. *Int J Sports Med.* 21: 256-62.
- [22] Gelecek N, Teoman N, Ozdirenc M, Pinar L, Akan P, Bediz C, Kozan O. (2007) Influences of Acute and Chronic Aerobic Exercise on the Plasma Hcy Level. *Ann Nutr Metab.* 51: 53-58
- [23] Astrand PO, Rodahl K. (1986) *Textbook of Work Physiology*, p. 355-356, McGraw-Hill Company, New York.
- [24] Holly RG, Shaffrath JD. (2001) *ACSM's Resource Manual for Guidelines For Exercise Testing and Prescription* 4th ed, p. 456-60, Williams and Wilkins, Philadelphia.
- [25] Colberg SR, Parson HK, Nunnold T, Herriott MT. (2006) Effect of an 8-week resistance training program on cutaneous perfusion in type 2 diabetes. *Microvasc Res.* 71(2): 121-7.
- [26] Ramalho AC, Lima AL, Nunes F, Cambui Z. (2006) The effect of resistance versus aerobic training on metabolic control in patients with type-1 diabetes mellitus. *Diabetes Res Clin Pract.* 72(3): 271-6.
- [27] Henry JB. (2001) *Clinical diagnosis and management by laboratory methods.* p.233-36, 12 ed., Saunders Company, Philadelphia.
- [28] De Bree A., Verschuren W.M., Blom H.J., Kromhout, D. (2001) Lifestyle factors and plasma Hcy concentrations in a general population sample. *Am J Epidemiol.* 154: 150-4.
- [29] Hudson MB., Hosick PA., McCaulley GO., Schrieber L., Wrieden J., McAnulty SR., Triplett NT., McBride JM., Quindry JC. (2008) The effect of resistance exercise on humoral markers of oxidative stress. *Med Sci Sports Exerc.* 40(3): 542-8.
- [30] Hernández-Torres RP., Ramos-Jiménez A., Torres-Durán PV., Romero-Gonzalez J., Mascher D., Posadas-Romero C., Juárez-Oropeza MA. (2008) Effects of single sessions of low-intensity continuous and moderate-intensity intermittent exercise on blood lipids in the same endurance runners. *J Sci Med Sport.* 12(2): 323-31.

Acknowledgments

We thank Department of Scientific Research Project of Dokuz Eylül University for funding, and Lamia Pınar, PT, Mehtap Malkoc, PT, Omer Kozan M.D., Cem S. Bediz M.D. for assistance with our research. And we also thank Gazanfer Aksakoğlu, MD, for statistical advices.