# The Effect of Aerobic Exercise on Hand Strength and Dexterity of Patients with Coronary Artery Disease

## Aerobik Egzersizin Koroner Arter Hastalığı Olan Hastaların El Kavrama Kuvveti ve Becerisi Üzerine Etkisi

Feray SOYUPEK*, Nesrin BÖLÜKBAŞI**, Z. Rezan YORGANCIOĞLU***, Figen GÖKOĞLU***
**Süleyman Demirel Üniversitesi Tıp Fakültesi, Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, Isparta*
***Gazi Üniversitesi Tıp Fakültesi, Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, Ankara*
****Ankara Eğitim ve Araştırma Hastanesi, 1. Fiziksel Tıp ve Rehabilitasyon Kliniği, Ankara*

### Summary

**Objective:** To examine the immediate effect of aerobic exercise training on hand muscle strength and dexterity.
**Materials and Methods:** Forty subjects with coronary heart disease were included. They were divided into two groups as exercise and control groups. The exercise group underwent exercise based cardiac rehabilitation program. Hand grip strength and hand dexterity were assessed just before and 5 minutes after the exercise session. In the control group the grip strength and dexterity were assessed as baseline and after 35 minutes. Hand grip strength was measured by Jamar hand dynamometer. The Purdue Pegboard test was used for evaluating hand dexterity.
**Results:** Grip strength of both hands increased significantly five minutes after aerobic training session when compared to pre-exercise values in the exercise group ($p<0.05$). There were significant differences in all stages of the Purdue pegboard test between pre and post-training ($p<0.001$) in the exercise group. The scores of Purdue pegboard dexterity test at post training were higher than pre-training scores.
**Conclusion:** Aerobic exercise of 30 minutes duration had an immediate improving effect on muscle strength and dexterity of the hand. *Turk J Phys Med Rehab 2006;52(2):72-75*
**Key Words:** Aerobic exercise, hand, dexterity, muscle strength

### Özet

**Amaç:** Aerobik egzersizin el kas gücü ve becerisi üzerine olan erken dönem etkisini incelemek.
**Gereç ve Yöntem:** Çalışmaya koroner arter hastalığı olan 40 hasta dahil edildi. Egzersiz ve kontrol olmak üzere iki gruba ayrıldı. Egzersiz grubu egzersiz bazlı kardiyak rehabilitasyon programına dahil edildi. El kavrama kuvveti ve becerisi egzersiz seansından hemen önce ve seanstan 5 dakika sonra değerlendirildi. El kavrama gücü Jamar el dinamometresi ile değerlendirildi. Kontrol grubunda el kavrama kuvveti ve becerisi başlangıçta ve 35 dakika sonra değerlendirildi. El becerisini değerlendirmede Purdue Pegboard testi kullanıldı.
**Bulgular:** Egzersiz grubunun aerobik egzersiz sonrası her iki el kavrama kuvvetleri egzersiz öncesi değerlere göre anlamlı olarak artmıştı ($p<0.05$). Egzersiz grubunda Purdue Pegboard testinin tüm basamaklarında egzersiz öncesi ve sonrası arasında anlamlı fark vardı. Purdue Pegboard beceri testinin egzersiz sonrası skorları egzersiz öncesi skorlara göre yüksekti.
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**Anahtar Kelimeler:** Aerobik egzersiz, el, beceri, kas gücü

## Introduction

Impaired exercise tolerance is a major problem in patients with coronary artery disease (CAD) and often results in functional disabilities. Patients with CAD limit their physical activities because of exercise intolerance. This pattern results in a cycle of inactivity and physical deconditioning and consequently, daily activities, and quality of life (QOL) are reduced (1,2) Diminished muscle strength and perceived fatigue are frequently associated with exercise intolerance and may be responsible for these limitations (1).

Aerobic exercise training is an integral and significant com-

**Yazışma adresi:** Dr. Feray Soyupek, Süleyman Demirel Üniversitesi, Tıp Fakültesi, Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, 32300 Isparta
Tel: 0-246-2112518, Faks: 0-246-2371762, E-posta: feraysoyupek@yahoo.com **Kabul Tarihi:** Nisan 2006

ponent of the second phase of cardiac rehabilitation. Aerobic exercises such as walking have been shown to improve the functional capacity of the patients (3), reverse the decline in muscle strength (4,5), stimulate the release of endogenous opiates (6), increase the general sense of well being and help to reduce anxiety depression and neuroticism (7,8). By promoting the general fitness, strength and health habits, it increases the functional reserve of persons concerning daily activities (9).

Numerous studies have reported that exercise training improves overall physical fitness, especially muscle strength (10,11) and also improves dexterity by increasing motor performance and muscle strength (12,13). Exercise increases the conduction velocity of both muscle fibers and peripheral nerves via the elevation of temperature (14). The other effect is on the excitability of the motor cortex (15). Chmura et al. (16) reported that the effect of exercise on the motor processes may be mediated via the noradrenergic system. Because of all these effects of exercise on motor cortex, peripheral nerves and muscle, we aimed to examine aerobic exercise training on hand muscle strength and dexterity in this study.

## Materials and Methods

After having filled an informed consent, forty-two patients with coronary heart disease were included in this prospective observational study. The subjects' age, educational and marital status, type of treatment as coronary artery bypass grafting (CABG) and percutaneous transluminal coronary angioplasty (PTCA) and dominant hand were recorded. Subjects were excluded if they had pain or stiffness of the thumb, evidence of wasting in hand muscles or neuromuscular disease, were regularly using any medication likely to affect muscle function or motivation (17,18), or had pulmonary disease. According to these criteria, we excluded 2 subjects because of tremor and carpal tunnel syndrome.

The patients were divided into two groups as exercise and control groups. Patients who were participating in the exercise based cardiac rehabilitation program were included in the exercise group. In the control group, exercise training program was not performed.

In the exercise group, the subjects underwent maximal exercise tolerance test on treadmill by Bruce protocol. The test was terminated according to the criteria of American College of Sports Medicine (19). Two days after the exercise tolerance test, submaximal (heart rate 70-85% of maximum heart rate achieved during exercise tolerance test) exercise training program was initiated. Each exercise session had a duration of 30 minutes including warm-up and cool-down periods. Hand grip strength and hand dexterity were assessed just before and 5 minutes after the exercise session. In the control group, neither exercise test nor exercise training program were performed and we assessed the hand dexterity and grip strength at baseline and after 35 minutes.

Hand grip strength was measured in the dominant and non-dominant hand using Jackson, MI 49203 USA Jamar hand dynamometer. The subject's arm was positioned according to the American Society of Hand Therapist's recommendations with the shoulder adducted and neutrally rotated, elbow flexed at 90º, forearm and wrist neutrally positioned when subject was sitting (20,21). After the subject was positioned appropriately, subjects were instructed to squeeze the handle as hard as they could to produce maximal grip contraction for 2-5 second. Attention was paid to a possible Valsalva effect. This procedure was repeated three times with 30 second periods between trials for both hands (22). The mean of three scores was recorded on each hand score table.

For evaluating fine coordination and dexterity of the hand, the Purdue Pegboard test was used. Five subtests comprise the test; right hand (RH), left hand (LH), both hands (BH) and assembly. The test board consists of a board with four cups across the top and two vertical rows of 25 small holes down the center. Each of the two outside cups contains 25 pins; the cup immediately to the left of center contains 40 washers; and the cup immediately to the right of center contains 20 collars. For the performance of the RH and LH subtests, participants use their right hand (dominant) and then left hand (non-dominant) to place as many pins as possible down the respective row within 30 seconds. The score of each subtest is the total number of pins placed by each hand in the allowed time. The BH subtest is a bimanual test where the participants use their right and left hand simultaneously to place as many pins as possible down both rows in 30 seconds. The score for this subtest is the total number of pairs of pins placed in 30 seconds. The assembly subtest requires that both hand work simultaneously while performing different tasks for 60 seconds. The score of this subtest is the total number of pins, washers and collars placed in 60 seconds. Each stage of the test is administered three times (23). All stages are performed when the subject learns how to administer the test.

The data was analyzed using SSPS statistical package program 11.0 for windows program. Non-parametric Wilcoxon test was used to analyze significant differences between the factors recorded at pre-training and post-training period. Mann Whitney- U test were used to analyze significant differences of parameters between the groups.

## Results

Forty patients were assessed as two patients were excluded. The mean ages of the exercise and control group were 53.50±7.49 and 53.05±4.98 years, respectively. Ages, educational and marital status, type of treatment are demonstrated in Table 1. All subjects were right handed.

**Assessment of hand grip strength:** According to baseline hand grip strength values there were no significant differences between the groups ($p>0.05$). In the control group, there were no significant differences in both dominant and non-dominant hand grip strengths between baseline and after 35 minutes ($p>0.05$). In the exercise group, hand grip strength increased significantly five minutes after aerobic training session when compared to pre-exercise values ($p<0.05$). Comparison of hand strength between dominant and non-dominant hands revealed no significant differences in neither pre-training nor post-training periods ($p>0.05$). The statistical analysis of hand grip strength is demonstrated in Table 2.

**Assessment of hand dexterity:** There were significant differences in all stages of the test between pre and post-training scores in the exercise group. The post-training scores were higher than the pre-training scores. At pre-training period, score of the dominant hand was higher than the non-dominant hand score ($p=0.006$). We found the same result in post-training period

scores (p= 0.001). In the control group, we did not find significant differences in any stage of the test between baseline and 35 minute scores. At pre-training period, score of the dominant hand was higher than the non-dominant hand score (p<0.001). The baseline scores of all stages of control group were significantly higher than exercise group except assembly subtest. We could not detect any significant differences between the groups at baseline assembly subtest but according to 35 minute assembly subtest scores, the score of the exercise group was significantly higher than the control group. The statistical analysis of hand dexterity is demonstrated in Table 3.

**Table 1: The characteristics of the subjects.**

| | Exercise group (n: 20) | Control group (n: 20) |
|---|---|---|
| Mean age (years) | 53.50±7.49 | 53.05±4.98 |
| Gender | | |
| Male | 14 (70%) | 15 (75%) |
| Female | 14 (70%) | 5 (25%) |
| Education Year | | |
| >12 years | 3 (15%) | 4 (20%) |
| <12 years | 17 (75%) | 16(80%) |
| Marital status | 20 (100%) | 20 (100%) |
| Type of Treatment | | |
| CABG | 12 (60%) | 11 (55%) |
| PTCA | 2 (10%) | 2 (10%) |
| Medical | 6 (30%) | 7 (35%) |
| Dominant hand-Right | 20 (100%) | 20 (100%) |

## Discussion

To our knowledge, this is the first study that has evaluated the immediate effect of aerobic exercise training program on hand grip strength and dexterity. We found an improvement on hand strength and dexterity immediately after aerobic exercise.

The previous studies showed the effects of long term aerobic exercise on hand strength. Izawa et al. (10) evaluated the impact of 8 week cardiac rehabilitation on physiological outcomes and health-related quality of life (HRQOL) of patients with acute myocardial infarction. They found that exercise had specific effects on improvement in HRQOL and muscle strength. The results of our study are similar to the muscle strength findings reported by Izawa et al. (10). Adams et al. (11) evaluated the effects and safety of a program of high intensity muscle training combined with aerobic and resistance training in 61 phase II cardiac rehabilitation patients and found that the training resulted in an increase in muscle strength of approximately 17%. We did not combine aerobic training with muscle strength and resistance training. We only evaluated the aerobic exercise training effects. Contrary to these studies, a study showed no change in upper extremity strength after an 8 week aerobic exercise program (24).

**Table 2: The comparison of hand grip strength.**

| | Exercise group (n=20) | Control group (n=20) | p value |
|---|---|---|---|
| Hand grip strength | | | |
| **Dominant hand** | | | |
| Baseline | 31.88±11.42 | 33.97±7.49 | 0.448 |
| 35 minute | 33.17±12.44 | 33.98±7.50 | 0.675 |
| P value | 0.008* | 0.131 | |
| **Non-dominant** | | | |
| Baseline | 30.74±10.81 | 32.27±8.14 | 0.372 |
| 35 minute | 32.66±11.03 | 32.29±8.11 | 0.892 |
| p value | 0.010 | 0.350 | |

**Table 3: The analyses of Purdue Pegboard test for dexterity.**

| | Exercise group (n=20) | Control group (n=20) | p value |
|---|---|---|---|
| **Purdue PT-dom** | | | |
| Baseline | 13.44±1.81 | 15.85±2.25 | 0.002 |
| 35 minute | 14.84±1.80 | 15.85±2.25 | 0.249 |
| p value | 0.001 | 0.058 | |
| **Purdue PT-n.dom** | | | |
| Baseline | 12.59±1.21 | 13.60±1.50 | 0.036 |
| 35 minute | 14.03±1.25 | 13.60±1.50 | 0.480 |
| p value | p<0.001 | | |
| **Purdue PT-BH** | | | |
| Baseline | 10.01±1.33 | 12.40±1.18 | P<0.001 |
| 35 minute | 12.45±1.82 | 12.60±1.36 | 0.065 |
| p value | p<0.001 | 0.152 | |
| **Purdue PT-Assembly** | | | |
| Baseline | 27.50±5.89 | 27.80±4.20 | 0.403 |
| 35 minute | 31.77±7.48 | 27.94±4.25 | 0.016 |
| p value | p<0.001 | 0.776 | |

Beniamini et al. (25) evaluated the effects of a 12 week cardiac rehabilitation program on muscle strength and suggested that increases in muscle strength were associated with an improved HRQOL and enhanced self efficacy. A previous study suggested that changes in mood were mediated by self efficacy rather than actual physical performance (26). The consequence of the heightened muscular strength was associated with an increased ability to perform activities of daily living resulting in an improvement in quality of life (5). In our study, these outcomes were not assessed specifically. It is the main weakness of our study. As a general knowledge aerobic exercise stimulates the release of endogenous opiates. It increases the general sense of well being and helps to reduce anxiety, depression and neuroticism (7,8). By promoting the general fitness, strength and health habits, it increases the functional reserve of persons going about daily activities (9). We consider that improvement in well-being experienced in our cardiac rehabilitation group is a general effect of aerobic training. Releasing of endorphine by aerobic exercise may have enhanced the ability of coronary patients' performance of squeezing the Jamar dynamometer.

Purdue pegboard is one of the best methods that evaluate fine dexterity and coordination of hand. In the test, memory and learning are important. Remembering the steps of the subtest immediately influences the scores, especially in the assembly subtest. In vitro experiments indicate that endorphin stabilizes the kinetics of dopamine-receptor interactions. The dopaminergic mechanism forms the basis for fortifying the emotiogenic memory system, promoting the facilitation of retrieval (27). In experiments on rats the authors demonstrated the influence of endogenous opioids beta-endorphin and the analogue of leu-enkephalin dalargin on the processes of memory (28). In this study, the HRQOL and beta-endorphin level were not assessed so we could not determine whether self efficacy was a factor in increasing the hand dexterity and strength after training. The relation between improved HRQOL and exercise performance requires further study.

Enander (13) reported even relatively mild thermal stress may affect human performance and noted that tasks requiring manual dexterity and muscular strength were impaired by low body temperature. Enander's study might suggest that improvement in dexterity would be expected after exercise, since exercise raises body temperature (13). Hancock and Hockey (29), however, reported that dynamic changes in body temperature produced decrements in motor skills. Another study supported these results and reported that the elevation of body temperature would increase the conduction velocity of both muscle fibers and peripheral nerves (14). Chmura et al. (16) reported that the effects of exercise on the motor processes may be mediated via the noradrenergic system. The release of cathecolamines during a submaximal exercise could be responsible for the effects of exercise. The results of our study support the conclusion of these studies.

As a conclusion, aerobic exercise training in cardiac rehabilitation program improved the muscle strength and dexterity of hand. Long term follow-up is needed to evaluate whether these benefits will continue over time.

## References

1. Ades PA. Cardiac rehabilitation and secondary prevention of coronary heart disease, N Engl J Med 2001;345:892-901.
2. Neill WA, Branch LG, DeJong G, Smith NE, Hogan CA, Corcoran PJ, et al. Cardiac disability the impact of coronary heart disease on patient's daily activities, Arch Intern Med 1985;145:1642-7.
3. Gossard D, Haskell WL, Taylor CB. Effects of low and high intensity home exercise training on functional capacity in healthy middle-aged men. Am J Cardiol 1986;57:446-9.
4. Fragnoli-Munn K, Savage PD, Ades PA. Combined resistive-aerobic training in older patients with coronary artery disease early after myocardial infarction. J Cardiopulm Rehabil 1998;18:416-20.
5. Ades PA, Savage PD, Cress ME, Brochu M, Lee NM, Poehlman ET. Resistance training on physical performance in disabled older female cardiac patients. Med Sci Sports Exer 2003;35:1265-70.
6. Schwartz L, Kindermann W. Changes in beta endorphin levels in response to aerobic and anaerobic exercise. Sports Med 1992;13:25-36.
7. Martinsen EW. Benefits of exercise for the treatment of depression. Sports Med 1990;9:380-9.
8. Morgan WP. Affective beneficence of vigorous physical activity. Med Sci Sports Exerc 1985;17:94-100.
9. Buschbacker RM, Porter CD. Deconditioning, conditioning and benefits of exercise. In; Braddom RL, editor. Physical Medicine and Rehabilitation. Philadelphia: W. B. Saunders; 2000, p. 702-23.
10. Izawa K, Hirano Y, Yamada S, Oka K, Omiya K, Iijima S. Improvement in physiological outcomes and health-related quality of life following cardiac rehabilitation in patients with acute myocardial infarction. Circulation J 2004;68:315-20.
11. Adams KJ, Barnard KL, Swarnk AM, Mann E, Kushnick MR, Denny DM. Combined high-intensity strength and aerobic training in diverse phase II cardiac rehabilitation patients. J Cardiopulm Rehabil 1999;19:209-15.
12. Waldron EM, Anton BR. Effects of exercise on dexterity. Percept Mot Skills 1995:80;883-9.
13. Enander AE. Effects of thermal stress on human performance. Scand J Work Env Health 1989;97:27-33.
14. Van Der Hoeven JH, Lange F. Supernormal muscle fiber conduction velocity during isometric exercise in human muscle. J Appl Physiol 1994;77:802-6.
15. Samii A, Wassermann EM, Ikoma K, Mercuri B, Hallet M. Characteristization of postexercise facilitation and depression of motor evoked potentials to transcranial magnetic stimulation. Neurology 1996;46:1376-82.
16. Chmura J, Nazar K, Kaciuba- Uscillo H. Choice reaction time during graded exercise in relation to blood lactate and plasma catecholamine threshold. J Sports Med 1994;15:172-6.
17. Phillips SK, Rook KM, Siddle NC, Bruce SA, Woledge RC. Muscle weakness in women occurs at an earlier age than in men, but strenght is preserved by hormone replacement therapy. Clin Sci 1993;84:95-8.
18. Phillips SK, Bruce SA, Newton D, Woledge RC. The weakness of the old age is not due to failure of muscle activation. J. Gerontol Med Sci 1992:47:M45-M49.
19. Hanson P. Clinical exercise testing. In: Blair SN, Painter P, Pate RR, Smith LK, Taylor CB, editors. Resource for guidelines for exercise testing and prescription. Philadelphia: Lea & Febiger; 1988, p. 205-22.
20. Mathiowetz V, Weber K, Volland G, Kashman N. Reliability and Validity of grip and pinch strength evaluations. J Hand Surg 1984;9A:222-6.
21. Mathiowetz V, Rennells C, Donahoe L Effect of the elbow position on grip and key pinch strength. J Hand Surgery (Am) 1985;10A:694-7.
22. Heinslein DM, Harris BA, Jette AM. A strength training program for postmenopausal women. A pilot study. Arch Phys Med Rehabil 1994:75:198-204.
23. Buddenberg LA, Davis C. Test-retest reliability of the Purdue Pegboard Test. Am J Occup Ther 2000;54:5:555-8.
24. Hung C, Daub B, Black B, Welsh R, Quinney A, Haykowsky M. Exercise training improves overall physical fitness and quality of life in older women with coronary artery disease. Chest 2004;26(4):1026-31.
25. Beniamini Y, Rubenstein JJ, Zaichkowsky LD, Crim MC. Effects of high- intensity strength training on quality of life parameters in cardiac rehabilitation patients. Am J Cardiol 1997;80:841-6.
26. Stewart KJ, Kelemen MH, Ewart CK. Relationships between self-efficacy and mood before and after exercise training. J Cardiopulm Rehabil 1994;14:35-42.
27. Il'iuchenok RIu, Dubrovina NI, Podgornaia EK. The mechanisms of the emotiogenic regulation of memory. Vestn Ross Akad Med Nauk 1998;9:24-9.
28. Kruglikov RI, Getsova VM, Orlova NV, Riga TN. Serotonin excess in the brain modifies the effect of beta-endorphin and dalargin on the processes of learning and memory. Zh Vyssh Nerv Deiat Im I P Pavlova 1990;40(2):310-7.
29. Hancock PT, Hockey HF. The effects of stress on human performance. Belmont: California University; 1984. p. 18-21.