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The Effects of Bicycle Versus Arm Ergometer Exercise Training on Physical Functions and Lipid Profile in Patients Who Underwent Coronary Artery Bypass Surgery: A Randomized Trial

Koroner Arter Baypas Cerrahisi Geçirmiş Hastalarda Bisiklet ve Kol Ergometresi Egzersiz Eğitiminin Fiziksel Fonksiyonlar ve Lipid Profili Üzerine Etkisi: Randomize Bir Çalışma

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Part of this study was presented as an oral presentation at the 9th International Sports Physiotherapists Congress, 9-11 November 2017, Ankara, Turkey.

ABSTRACT Objective: The aim of this study was to compare the effects on physical functions (PF) and lipid profile (LP) of bicycle and arm ergometer exercises among the patients, who underwent coronary artery bypass graft (CABG) surgery. **Material and Methods:** The study involved 50 patients, who underwent CABG surgery. The patients were randomly divided into 2 groups. After the exclusion of 11 cases, evaluation was performed of 23 patients in the bicycle ergometer group (BEG) and 16 patients in the arm ergometer group (AEG). All the subjects participated in a cardiac rehabilitation program consisting of exercise training with bicycle or arm ergometer exercise for a total of 30 sessions as 5 sessions per week during 6 weeks. Before and after the exercise training, the 6-minute walking test distance (6MWTD), body composition evaluation, and blood lipid levels were recorded. **Results:** Before and after the exercise training, statistically significant positive changes were observed in the BEG including increased 6MWD, and LP parameters containing decreased percentage of body fat, LDL, trigliserid level, and total cholesterol. Statistically significant changes were found in the AEG including increased 6MWTD and LP parameters containing HDL, decreased body fat percentage, BMI, LDL, triglycerides, and total cholesterol. Comparing the values between the groups, it was found that there was a statistically significant increase in the 6MWD in the BEG when compared to the AEG. **Conclusions:** In conclusion, bicycle and arm ergometer exercises had a positive effect on PF and LP after CABG surgery. For improving the functional capacity, the bicycle ergometer training was seen to be more advantageous.

Keywords: Coronary artery bypass; cardiac rehabilitation; ergometry; exercise

ÖZET Amaç: Bu çalışmanın amacı koroner arter baypas cerrahisi geçiren hastalarda bisiklet ve kol ergometresi egzersizlerinin fiziksel fonksiyonlar ve lipid profiline etkisi açısından karşılaştırılmasıdır. **Gereç ve Yöntemler:** Çalışmaya 52-65 yaş aralığında bisiklet ergometresi (BEG) (n=23) ve kol ergometresi grubu (KEG) (n=16) olmak üzere iki gruptan oluşan, toplam 39 olgu (35 erkek, 4 kadın) dahil edildi. Demografik veriler kaydedildikten sonra çalışmaya dahil edilen tüm bireylerin eğitim öncesinde ve sonrasında HDL, LDL, Trigliserid ve Total kolesterol seviyeleri kaydedildi ve 6 dakika yürüme testi mesafesi (6DYTM) ile vücut kompozisyonu analizleri yapıldı. Tüm katılımcılar 6 hafta, haftada 5 seans olmak üzere toplam 30 seans boyunca bisiklet veya kol ergometre egzersiz eğitimi programına katıldı. **Bulgular:** Egzersiz eğitiminin öncesi ve sonrasında BEG'nda 6DYTM'nde artma, vücut yağ yüzdesi, LDL, trigliserid seviyesi ve total kolesterolde azalma gibi lipid profilini içeren parametrelerde istatistiksel olarak anlamlı değişiklikler gözlendi. KEG'da 6DYTM ve HDL'de artış, vücut yağ yüzdesi, VKİ, LDL, trigliseridler ve total kolesterolde azalma gibi lipid profilini içeren parametrelerde istatistiksel olarak önemli değişiklikler bulundu. Gruplar arasındaki değerler karşılaştırıldığında BEG'da 6DYTM'nin KEG'na göre istatistiksel olarak anlamlı şekilde daha yüksek olduğu belirlendi. **Sonuç:** Bu çalışmanın sonuçları bisiklet ve kol ergometre egzersizlerinin koroner arter baypas cerrahisi geçiren hastaların fiziksel fonksiyonlarını ve lipid profilini benzer şekilde iyileştirdiğini gösterdi. Fonksiyonel kapasitenin geliştirilmesinde bisiklet ergometre eğitimi egzersizlerinin daha avantajlı olduğu görüldü.

Anahtar Kelimeler: Koroner arter baypas, kardiyak rehabilitasyon; ergometri; egzersiz

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Coronary artery bypass graft (CABG) surgery has been the gold standard for more than 50 years in the revascularization of cardiovascular patients.[1,2] The main reason for the fact that coronary artery diseases are the leading cause of mortality throughout the world is not the intervention in the acute period, but it arises from the insufficient implementation of secondary protective methods.[3-5] Cardiac rehabilitation (CR), which is the implementation of a personalized planned exercise program for cardiac patients, is a secondary protective method that, as a result of medical evaluations and the determination of risk factors, includes behavior changes according to medical treatment and coronary risk factors and aims to maximize the quality of life from the aspect of physical, physiological, social, and work productivity.[6-8]

Various exercise machines are used in exercise programs in the context of CR. The most commonly used ones are bicycle ergometer, arm ergometer, and treadmill.[9,10] Bicycle ergometer and arm ergometer are preferred since they are portable devices that are inexpensive, quiet, take little room, and can be tailored for each individual. Furthermore, accurate electrocardiograph (ECG) data can be obtained. After rest and warm-up, it is aimed for the patient to reach the maximum exercise performance to the increasing resistance to the pedals in watt units, which is applied mechanically or electronically in ergometer machines. The workload applied with these machines is set using a standard formula that takes the height, weight, gender, and estimated oxygen consumption at rest of the patient into consideration.[11-13]

The first study comparing arm crank and cycle ergometer was carried out by Mitropoulous in 2017. In that study, it was stated that arm ergometer test may be an alternative method for assessing cardiorespiratuar fitness, however, there is lack of evidence for the cut-off values in ACE $V\dot{O}_2$peak for the disease and/or mortality prognosis. Also, future research should be carried out for comparing the protocols in different populations.[14] On the other hand, clinical data obtained during the arm exercise may be equivalent to those reported for treadmill or cycle ergometer exercise.[15,16] After CABG, in the study which used CPET via treadmill, cycle ergometer training was conducted and the increased HDL and decreased LDL level were found.[17]

Although there are studies in literature that have been conducted in this area, there are few comparative studies. It was thought that the more advantageous method could be determined with this study and this could play guiding role in CR. Therefore, the aim of the study was to compare the effect of bicycle and arm ergometer exercises on the physical functions and lipid profile of patients who underwent CABG.

MATERIAL AND METHODS

This prospective, randomized study was carried out in Dumlupinar University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation and Dumlupinar University Kütahya Evliya Çelebi Training and Research Hospital, Department of Cardiopulmonary Rehabilitation. Approval for the study was obtained from the Clinical Research Ethics Committee of Eskişehir Osmangazi University (decision no: 06, dated 2015). Also, the study was carried out in accordance with principles of the Declaration of Helsinki.

PARTICIPANTS

The study involved 50 voluntary participants: Informed consent was obtained from all participants. First, an echocardiography test was applied to the individuals who underwent stable CABG surgery and were present at the cardiology polyclinic. An exercise test consistent with the modified Bruce protocol was applied on the treadmill. Cases in the moderate and low risk group were identified. Randomization was applied according to the order of referral to the rehabilitation unit as single or double figures. Those with single numbers were assigned to the bicycle ergometer group (BEG) and those with double numbers were assigned to the arm ergometer group (AEG) (Figure 1).

Inclusion criteria of the study were a low and moderate risk level according to the evaluation for risk of cardiac event related to exercise (EF>40%-49% and MET value >5), age 18-65 years, and being able to stand independently. Patients were excluded if

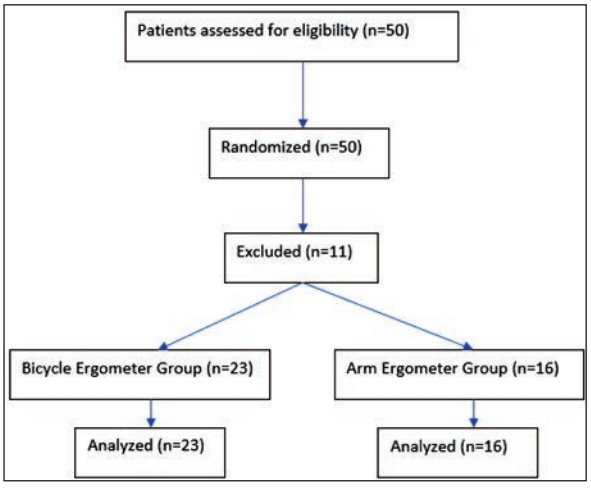

FIGURE 1: Flowchart of the patients

they had a neurological problem, an active infection, an orthopedic problem in the upper or lower extremity preventing bicycle use, if they were a cancer patient receiving radiotherapy or chemotherapy or a psychiatric patient using anti-depressants. A total of 11 patients were excluded, 2 from the AEG who did not wish to continue the training and 9 in the BEG who did not complete the program. Thus, the final evaluation was made of a total of 39 patients, 16 in the AEG, and 23 in the BEG.

EvALuATIONS

All the evaluations were performed before and after the exercise training. Demographic and descriptive data of the patients including age, gender, height, weight, and body mass index were recorded on pre-prepared evaluation forms. The 6MWD was applied to determine functional capacity. At the end of the test, the distance walked in 6 minutes was measured in meters.[18]

Body composition was calculated as body mass index (BMI) and body fat percentage using the bioelectrical impedance method with a Tanita body composition analyzer TBF-300 device. The participants were requested to attend after overnight fasting and measurements were taken barefoot. The bodyweight and body fat percentage values were recorded.[19] Of the serum lipid values, high density lipoprotein (HDL), low density lipoprotein (LDL), triglycerides (TG) and total cholesterol (TC) were examined using laboratory tests before and after the exercise program.[20]

ExERCISE TRAINING

The training was applied in the cardiopulmonary rehabilitation center by a rehabilitation team comprising a cardiologist, a physical therapy physician, a physiotherapist, and a nurse. Exercise training was conducted under the supervision of a multidisciplinary team trained on this subject and training was carried out by keeping basic life support and cardiopulmonary resuscitation equipment ready. Also, hemodynamic responses such as heart rate, blood pressure, oxygen saturation and clinical findings were noted. Before starting the training, a 5-min warm-up period was applied and a 5-min cooling-down period at the end of the session. The cases in both groups received the exercise training program with bicycle or arm ergometer machines for a total of 30 sessions as 5 sessions per week during 6 weeks.

The BEG program was applied using the Ergoline Ergoselect 200, computer-controlled, medical ergometer machine (ergoline 900, ergoline, Bitz, Germany). As the bicycle had a dual adjustment capacity (height and angle), the angle formed by the upper body and the legs were always set to optimum using the gears. The AEG exercise program was applied using the Ergoselect 400 arm ergometer medical machine (ergoline 900, ergoline, Bitz, Germany). The height of the loading unit and the seat were adjusted so that the patient could easily reach the grip bars. The height of the loading unit was adjusted electronically. The training was applied at maximum oxygen consumption of 60%-80% as determined with the cardiopulmonary exercise test with 5-min warm-up period, 30-min on average training duration and 5-min cooling-down period. Bicycle and arm ergometer had the program, in which MET values were converted to Watt values. Therefore, loads were determined using this method.

STATISTICAL ANALYSIS

Data were analyzed using IBM version 20.0 (SPSS Inc., Chicago, IL, USA). Descriptive data were shown as median (minimum-maximum), number, and percentage. Data's conformity to normal distribution was assessed using the Kolmogorov-Smirnov test and it was determined that the data did not have

normal distribution. Therefore, non-parametric statistical methods were used. The data obtained before and after the exercise program were analyzed using the Wilcoxon Signed Rank test. In order to determine the superiority of one exercise program over the other, the differences between the pre and post-exercise values were calculated and compared using the Mann Whitney U-test. For all the statistical test results, the statistical significance was set at $p<0.05$.

RESuLTS

The demographic data of the cases in both groups are shown in Table 1. No statistically significant difference was found between the groups in terms of the demographic data before the exercise program ($p>0.05$).

In the BEG comparisons of the physical functions before and after the training, statistically significant changes were obtained in the walking distance (p=0.000), body fat percentage (p=0.043), LDL (p=0.057), TG (p=0.023), and TC (p=0.000) values. No difference was found in the other values after the exercise program (Table 2).

In the AEG comparisons of the physical functions before and after the training, statistically significant positive changes were determined in the walking distance (p=0.000), body fat percentage (p=0.005), HDL (p=0.027), LDL (p=0.041), TG (p=0.001) and BMI (p=0.001) values. No difference was determined in the other values after the exercise program (Table 3).

In the comparison of the difference in the values of the physical functions between the BEG and AEG, a statistically significant increase in the walking distance was observed in the BEG compared to the AEG (p=0.004). No significant change was observed in the other parameters (Table 4).

TABLE 1: Demographic characteristics of the groups.

Variables	BEG (23) Median (Min-Max)	AEG (16) Median (Min-Max)	p
Age (years)	59 (52-65)	60 (52-65)	0.877
Length (cm)	168 (150-180)	163 (155-187)	0.143
Weight (kg)	79 (61.5-105.5)	81 (65-100)	0.582
BMI (kg/m²)	28.8 (21.8-33.79)	30.12 (18.59-36.05)	0.217
		n (%)	n (%)
Gender	Female	0 (0%)	4 (25%)
	Male	23 (100%)	12 (75%)

BEG: Bicycle Ergometer Group. AEG: Arm Ergometer Group.

TABLE 2: Comparison of the physical functions of bicycle ergometer group before and after training.

Variables		Before training Median (Min-Max)	After training Median (Min-Max)	p
Physical Functions	6MWD (m)	430 (280-564)	580 (410-710)	**0.000 ***
	Body fat Percentage (%)	25.80 (2.10-44.60)	28.40 (16.20-41.60)	**0.043 ***
	HDL	43 (31-53)	40 (25-67)	0.427
	LDL	99 (50-182)	86 (31-254)	**0.057***
	Triglyceride	184 (86-383)	147 (78-331)	**0.023 ***
	Total cholesterol	187 (115-384)	160 (100-273)	**0.000 ***
	BMI (kg/m²)	28.80 (21.38-33.79)	28.88 (19.81-33.89)	0.094

MWD: Minute Walking Distance

TABLE 3: Comparison of the physical functions of arm ergometer group before and after training.

Variables		Before training Median (Min-Max)	After training Median (Min-Max)	p
Physical Functions	6MWD (m)	395 (300-660)	477.50 (370-795)	**0.000 ***
	Body fat percentage (%)	29 (20-328)	28.50 (19.90-41)	0.005*
	HDL	42 (30-60)	43.50 (32.59)	0.027*
	LDL	122 (89-184)	105.50 (79-241)	0.041*
	Triglyceride	182 (61-334)	153 (79-294)	0.001*
	Total cholesterol	199.50 (165-298)	186.50 (148-342)	0.006
	BMI (kg/m²)	30.12 (18.59-36.05)	29.74 (18.30-34.85)	0.001 *

MWD: Minute Walking Distance

DISCuSSION

This study was conducted to compare the effects of bicycle and arm ergometer exercises on physical functions and lipid profile in CABG patients. The results demonstrated that both of bicycle ergometer and arm ergometer exercises contributed to the improvement of the physical functions and lipid profile of the patients. Obtained positive changes were increased 6MWTD, decreased percentage of body fat, LDL,

TABLE 4 Comparison of the delta values of the physical functions between the groups.

Variables		BEG (Δ) Median (Min-Max)	AEG (Δ) Median (Min-Max)	p
Physical Functions	6MWD (m)	140 (40-320)	97.50 (15-200)	**0.004 ***
	Body fat percentage	-1.40 (-12.10-24.90)	-1 (-297-1.20)	0.989
	HDL	-3 (-18-30)	2 (-5-12)	0.239
	LDL	-17 (-45-166)	-8.50 (-99-57)	0.454
	Triglyceride	-20 (-134-89)	-31 (-125-22)	0.507
	Total cholesterol	-21 (-214-18)	-16 (-53-44)	0.329
	BMI (kg/m²)	-0.38 (-1.91-0.54)	-0.68 (-1.20-0.13)	0.544

BEG: Bicycle Ergometer Group. AEG: Arm Ergometer Group, MWD: Minute Walking Distance, Δ: delta.

BMI, triglyceride level, and total cholesterol and increased HDL level. It was also determined that the functional capacity increased with bicycle ergometer exercise training more than arm ergometer exercise training.

It can be seen in literature that bicycle and arm ergometer exercise training machines have been widely used in aerobic exercise training. They are commonly preferred for the implementation of CR.[21-24] Moreover, every patient is different and can benefit from different exercise training methods. In other words, it is very important for effective CR program in terms of patients' motivation. Therefore, these two ergometer exercise machines were chosen for determining their advantages and interchangeability in this study.

Regarding the rehabilitation of coronary heart patients, there is consensus that the active lifestyle and the regular aerobic exercise have positive effects on body fat percentage, blood lipids, and walking distance. A previous study reported that the increased age had a negative effect on functional capacity.[25] Studies in recent years have reported the evidence that patients benefit from CR. Williams et al. reported that CR provides benefits for both young and elderly patients.[26]

A reduction in BMI has been reported to be observed following regular CR applications.[27] In a study of Al-Ajlan and Mehdi on 474 subjects, the participants were classified according to their level of physical activity as low, moderate and high and a negative relationship was found between BMI and activity level.[28] In the present study, the BMI value showed a difference only in the AEG. We thought that this result may have arisen from increased metabolism of the body during arm ergometer exercises.

The 6MWD is a test which is affected by many factors.[29,30] The factors of age, gender, height, and weight have many components such as the mood at the time of the test, mental functions, additional oxygen use, the effort made when walking, the test location, and other diseases.[31] In a study by Trevisan et al., in which bicycle ergometer exercises were compared to aerobic exercises, the walking distance of both groups in the 6MWD was reported to increase. However, the increase in the walking distance of the BEG was determined to be statistically significant.[18] Positive results have also been obtained in studies carried out using ergometer exercises.[32] In another study comparing the bicycle and arm ergometry devices, an increase in the 6MWD in the BEG was determined to be similar to the current study results.[33] An increase in the walking distance was determined in both the BEG and the AEG of the current study, but the increase in the bicycle ergometer group was greater. In our opinion, the reason for this result is that, in the bicycle exercise training method, similar muscle groups are used during walking and in daily life activities. These muscles not only have large muscle mass but also have more oxygen demand regarding the use in arm ergometer exercises. In addition, it was shown that lower body has a critical role during arm ergometer exercises.[34]

Ghrouni et al. investigated the effect of bicycle ergometer exercise on body fat percentage after CABG surgery, and the authors reported no significant difference.[19] However, some other studies have reported a decrease in body fat percentage.[35-37] Similarly, in the current study, while a significant decrease was determined in body fat percentage at the end of both ergometer exercise training programs, no superiority of one over the other was observed.

Impairments in blood lipid metabolism in patients, who underwent CABG, cause an increase in

the likelihood of recurrence and mortality.[38] After aerobic training period in many studies related to blood lipids, it has been determined different results. While Mahović determined that blood TG level decreased, TC level reduced or did not change in some patients, HDL increased and LDL decreased.[39] In another study carried out by Lakusic et al., the published CR results were seen to be similar to those reported in another study, in which TC, TG, and LDL levels decreased and HDL increased, whereas Bilinska et al. reported no change in HDL, LDL, TC, and TG levels at the end of 6 weeks.[17,20-24]

The results of the current study show a similarity to previous results in literature. In the evaluation of the pre and post-training program, while positive changes were seen in the LDL, TG and TC values of the BEG, in the AEG, there was a change observed in the HDL, LDL and TG values. However, no difference was determined between the two ergometer exercise programs in terms of the HDL, LDL, TG, and TC values. There was no superiority of one exercise over the other parameters. In our opinion, in result of each planned and regular exercise method these effects may be obtained.

When compared to other studies in literature, the present study examined several parameters at the same time after CABG surgery and, as one of the few studies that have compared two types of exercise with the involvement of a multidisciplinary team, it can be considered as a guiding study in this area. However, our study had some limitations or ignored factors that might have affected the physical and psychosocial functions of patients after CABG surgical intervention such as time spent after CABG surgery and medications. Also, for all participants, CPET was performed using treadmill. In order to standardize all patients in terms of CPET, we used the same test procedure with treadmill because there were no evidence cut-off values for arm ergometer tests. Future studies could take these recommendations into consideration.

CONCLuSION

In conclusion, according to the results of this study, it was determined that bicycle and arm ergometer exercises improved the functional capacity, had a positive effect on body composition and blood lipids, and reduced BMI. But 6-week training period in our study may be a limitation. Future studies should be planned for at least 8 weeks, as training duration may affect training outcomes. In addition, bicycle ergometry was observed to be more effective than arm ergometry in terms of improving functional capacity and reducing total cholesterol. Both ergometer exercise methods used in this study can be used in CR. Moreover, it should not be forgotten that they can be used as alternatives to each other in CR according to the needs and motivation of the patient.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: Design: *Elif Dilara Durmaz, Betül Taşpınar, Orçin Telli Atalay, Yasemin Özkan, Gül Kulan Soykan, Taner Şen;* ***Control/Supervision:*** *Elif Dilara Durmaz, Yasemin Özkan, Gül Kulan Soykan, Taner Şen, Betül Taşpınar;* ***Data Collection and/or Processing:*** *Elif Dilara Durmaz; Betül Taşpınar;* ***Analysis and/or Interpretation:*** *Betül Taşpınar, Ferruh Taşpınar, Elif Dilara Durmaz, Orçin Telli Atalay;* ***Literature Review:*** *Elif Dilara Durmaz, Betül Taşpınar;* ***Writing the Article:*** *Elif Dilara Durmaz, Betül Taşpınar, Orçin Telli Atalay, Ferruh Taşpınar;* ***Critical Review:*** *Betül Taşpınar, Orçin Telli Atalay, Ferruh Taşpınar;* ***References and Fundings:*** *Yasemin Özkan, Gül Kulan Soykan, Taner Şen, Betül Taşpınar;* ***Materials:*** *Yasemin Özkan, Gül Kulan Soykan, Taner Şen.*

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