

Research article

## Tennis Training Sessions as a Rehabilitation Instrument for Patients after Acute Myocardial Infarction

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### Abstract

The aims of this study were to measure the effects of a cardiac rehabilitation program based on a modification of a sport (tennis) on quality of life, on various laboratory test parameters and on an exercise stress test, and to determine if the results of this novel activity are equivalent to those of traditional programs (i.e., the use of the bicycle ergometer). The sample consisted of 79 patients with a low-risk acute coronary syndrome. They were divided into three groups: two experimental groups and one control group. One of the experimental groups used the bicycle ergometer as its main physical activity, whereas the other received training in a modified form of tennis lesson. By the end of the 3-month program, triglycerides, cholesterol LDL, cholesterol HDL, ( $-25 \text{ mg}\cdot\text{dl}^{-1}$  and  $32.3 \text{ mg}\cdot\text{dl}^{-1}$  final, and  $15.7 \text{ mg}\cdot\text{dl}^{-1}$  and  $23.3 \text{ mg}\cdot\text{dl}^{-1}$  LDL final, respectively) and exercise capacity improved significantly (by 1.1 metabolic equivalents (METs) and 1.2 METs, respectively), in both experimental groups. We conclude that the application of a comprehensive cardiac rehabilitation program in patients with low-risk acute coronary syndrome based on a program of modified tennis improves exercise tolerance and metabolic parameters, as well as certain physical characteristics that reduce cardiovascular risk.

**Key words:** Tennis, exercise, cardiovascular diseases, cardiac rehabilitation, acute coronary syndrome.

### Introduction

Cardiovascular diseases (CVD) are one of the main causes of mortality and morbidity in developed countries (American Heart Association, 2008; WHO, 2008). However, despite the proven effectiveness of cardiac rehabilitation programs (CRP) in patients who have suffered acute coronary syndrome (ACS) (Bogers et al., 2007; Brubaker et al., 2000; Fuster et al., 2005; Gielen et al., 2001; Vanhees et al., 2004), only a small percentage of such patients ever take part in this type of program (Encuesta Sorecar, 2010).

Many studies have focused on measuring the physical demands of high-level tennis players and have shown that mean blood lactate during games is around  $3 \text{ mmol}\cdot\text{l}^{-1}$ , and in prolonged and intense games can reach  $8 \text{ mmol}\cdot\text{l}^{-1}$  (Fernández et al., 2006; 2007; 2008; Kovacs, 2006; 2007; Méndez et al., 2007a; 2007b; 2010; Murias et al., 2007; Reid et al., 2008). However, there has been little work on the physiological demands of tennis in older players. Fernández-Fernández et al. (2009) performed a study of the patterns of activity and physiological demands in older players. They analysed their results in

relation to the recommendations of the American College of Sports Medicine concerning the quality and quantity of exercise recommended for adults to develop and maintain a healthy cardiovascular status. Thus, tennis allows patients to work at a level suitable for achieving cardiovascular improvement, and can be adapted perfectly to the physiological requirements of this patient group, while offering advantages in terms of health: a more favourable lipid profile, less fatty tissue, and an improved aerobic state, all of which contribute to lowering the risk of cardiovascular morbidity (Fuentes et al., 2009).

Several studies have demonstrated a health benefit not only in tennis players who have played all their lives, but also in those who only start to play as adults (Koronas, et al., 2004; Marks, 2006; Pluim et al., 2007; Tournaire et al., 2007), with substantial health benefits on older players (i.e., greater aerobic capacity, reduced percentage of fat, more favourable lipid profile). Thus, it seems to be interesting to incorporate tennis in cardiac rehabilitation programs (Fuentes et al., 2009), following the recommendations concerning the practice of this sport established by the 36th Conference of Bethesda (2005) for low risk cardiac patients: starting by playing doubles, gradually increasing the duration and intensity of play, generally not exceeding 85% of the maximum heart rate ( $\text{HR}_{\text{max}}$ ) obtained during laboratory tests, and encouraging recreational rather than competitive play. The final purpose will be to achieve beneficial effects on cardiovascular health and an adequate level of adherence.

The important connection between obesity and sedentary behaviour is well known (WHO, 2004). In this context, obesity is defined by the Body Mass Index (BMI). Thus according to the criteria of SEEDO (Sociedad Española para el Estudio de la Obesidad), overweight is defined as a BMI between 25 and  $29.9 \text{ kg}\cdot\text{m}^{-2}$ , and obesity is defined as a BMI equal to or greater than  $30 \text{ kg}\cdot\text{m}^{-2}$  (Salas et al., 2007; SEEDO, 2000). Patients are considered sedentary if they do not take physical exercise (i.e., any body movement generated by the skeletal muscles and resulting in an expenditure of calorific energy, and which have measurable characteristics in terms of intensity, duration and frequency). The intensity of exercise must be sufficient to maintain the heart rate (HR) between 60% and 85% of the estimated  $\text{HR}_{\text{max}}$ . If the exercise is of moderate intensity, it must last 30 min on five days a week; if intense, 20 min on three days a week; in each case it proceeds in combination with a twice a week muscle-strengthening exercise (American College of Sport Medicine, 2010).

The main purpose of this study was to analyse and compare the different parameters in groups of patients undertaking a tennis exercise program and patients using a standard bicycle ergometer (BE) program, and a control group.

## Methods

### Selection of patients

The study sample consisted of 79 male patients diagnosed with ACS entering the cardiology ward of our hospital and classified as low risk according to the criteria of the American Association of Cardiovascular and Pulmonary Rehabilitation (1991), with an average age of 55.23 years (DT = 9.60). Being a medical treatment, no patients are excluded from the possibility of participating in this programme. The assignments of the intervention groups (tennis (n = 27) or bicycle (n = 27)) were blindly randomised. 51.9% of the patients in the tennis group suffered from non-ST segment elevation acute coronary syndrome (NSTEMI-ACS), 18.5% had acute coronary syndrome with anterior ST segment elevation (STEMI-ACS) and 29.6% had acute coronary syndrome with inferior ST segment elevation (STEMI-ACS); the control group (n = 25) was 40% NSTEMI-ACS, 32% STEMI-ACS anterior and 28% STEMI-ACS inferior, and the bicycle ergometer group was 37.1% NSTEMI-ACS, 22.2% STEMI-ACS anterior and 40.7% STEMI-ACS inferior. All the patients had suffered an ACS and their systolic function was conserved or only slightly depressed (left ventricular ejection fraction -LVEF >45%). Thus the patients were treated according to the guidelines of clinical practice for ACS and the instructions of the cardiologists in charge of them. Regarding medication, 90% of the patients received beta blockers and all of them received statins.

All the patients were given the opportunity to join the CRP (cardiac rehabilitation program) and were informed of the purpose of the study and associated risks. All participants provided written, informed consent. The experimental protocol was approved by the ethics committee of the hospital and the University of Extremadura, conformed to the recommendations of the Declaration of Helsinki.

### Phases of training

The CRP lasted three months, during which the following activities were undertaken:

1. During hospital admission (3-5 days) the cardiologist took a patient's clinical history (personal data, detailed case history including physical parameters) and explained the program to them. In addition, a general analysis was carried out (i.e., echocardiograms and medical tests needed to assess the treatments and their evolution, as well as implementing possible surgical interventions to deal with cardiac problems (catheterization with implantation of stents...)).

2. Two weeks after the first phase, a stress test was conducted for those patients who were included in the program. Once the stress test was conducted, patients were referred to the rehabilitation physician in order to avoid musculoskeletal or neurologic changes and to re-

ceive detailed information about the program, including phases (i.e., talks, types of activity undertaken), aims and schedule. All patients completed a quality of life questionnaire (Velasco-Del Barrio et al., 1993), which consisted of 44 items defining nine scales: perception of health, sleep and rest, emotional behaviour, future plans, mobility, social relations, awareness of behaviour, communication, leisure time and work.

3. A supervised and individualised physical training consisted on a 1-month general physical conditioning routine (i.e., movement exercises, endurance on a bicycle ergometer, and muscle-strengthening activities). The aim of this phase was to reduce the risk of skeletal muscle problems during the training, given their poor physical state and their lack of experience regarding the tasks involved in the program.

4. Main training program (2 months duration). Subjects were assigned to a bicycle ergometer training and a tennis training, and were trained based on their individual laboratory HR (e.g., Bruce protocol, conducted in a TreadmillSpacelaple Quest 600 ergometer). During training protocols, subjects were required to maintain an intensity of 70-85% HR<sub>max</sub>. The HR was monitored and recorded at 5-second intervals during the exercise (S610, Polar Electro, Kempele, Finland). The data obtained from the HR monitors were downloaded on a portable PC and analysed using specific software (Polar ProTrainer 5TM), in order to adjust the training intensity if necessary. Training consisted of three weekly sessions of 60 min duration (i.e., 10 minutes warm-up, 40 minutes of specific training protocol (bicycle or tennis), and 10 minute cool-down period, including flexibility exercises). The bicycle ergometer training sessions were conducted on a rehabilitation room (San Pedro de Alcántara Hospital (Cáceres, Spain), and supervised by a rehabilitation specialist and a physiotherapist. Tennis training sessions were performed on an indoor tennis court (Faculty of Sport Sciences, University of Extremadura, Spain), and supervised by sports science specialists, a sports science doctor, a cardiologist and a rehabilitation specialist.

In order to control the training intensity (i.e., 70-85% of the HR<sub>max</sub>) during tennis lessons, some modifications were included; for example subjects were allowed to let the ball bounce twice at the beginning, using mainly doubles rather than singles games. In this regard, four different on-court movement intensities were employed (according with the patient's capacity), in order to maintain the effort within the limits of healthy cardiac output (i.e., walking slowly, walking fast, jogging and running) (Fuentes y Díaz, 2010).

5. Parallel to the training programs, an educational program was conducted with the aim of modifying the patient's life style and controlling the coronary risk factors: dietary advice, and basic information about cardiovascular disease.

### Statistical analysis

The age and the results of the biochemical and physiological tests were recorded as quantitative variables. Statistical analysis was performed using SPSS® (Version 15.0 for Windows). The Wilcoxon test for paired samples

**Table 1.** Comparison of the initial characteristics of patients by group according to the occurrence rate of cardiovascular risk factors.

	Control Group	BE Group	Tennis Group
Patients, n	25	27	27
Age, mean ( $\pm$ SD)	55.8 (9.8)	53.5 (9.4)	56.4 (9.8)
<b>Echocardiogram</b>			
FE VI > 50%	100%	92.6%	100%
FE VI 40% to 49%	0%	7.4%	0%
Arterial Hypertension	52%	48.1%	40.7%
Diabetes Mellitus	24%	25.9%	11.1%
Dyslipemia	44%	63%	33.3%
Smoking	76%	96.3%*	66.7%
Obese	92%	74.1%	81.5%
Sedentary	100%	96.3%	92.6%

SD: Standard deviation. LVEF: left ventricular ejection fraction. \*  $p < 0.05$

was used to compare variables before and after undertaking the CRP. Differences between groups were examined by analysis of variance ANOVA (factor: group). Differences between means were rated significant at  $P < 0.05$ . To estimate normality we used the Kolmogorov-Smirnov test. All tests were two-tailed and  $p < 0.05$  was considered statistically significant.

## Results

Table 1 presents a comparison between the groups before the intervention, and shows the homogeneity of the in the analysed variables. The only significant differences ( $p \leq 0.05$ ) are found in the number of (tobacco) smokers in hospital training group compared to tennis group ( $p \leq 0.05$ ) and control group ( $p \leq 0.05$ ).

Table 2 shows significant differences in initial and final BMI between bicycle ergometer group ( $p < 0.01$ ) and tennis group ( $p < 0.01$ ). Regarding quality of life, there are significant postprogram differences in control group ( $p < 0.01$ ), bicycle ergometer group ( $p < 0.001$ ) and tennis group ( $p < 0.001$ ).

In Table 3, control group shows significant differences in HRmax ( $p < 0.01$ ), % HRmax ( $p < 0.01$ ), METs ( $p < 0.01$ ), PSD ( $p < 0.05$ ) and exercise time ( $p < 0.01$ ). Tennis group shows significant differences in HRmax ( $p < 0.001$ ), %HRmax ( $p < 0.001$ ), METs ( $p < 0.001$ ), exercise time ( $p < 0.001$ ) and double product ( $p < 0.01$ ). Bicycle ergometer group shows significant differences in HRmax ( $p < 0.001$ ), %HRmax ( $p < 0.001$ ), METs ( $p < 0.001$ ), exercise time ( $p < 0.001$ ) and double product ( $p < 0.001$ ).

Likewise, Table 4 presents the results of the comparative analysis of different variables at the beginning and the end of the CRP, allowing for comparisons be-

tween the different groups. Differences were primarily observed in final parameters, with significant differences with respect to control group in exercise time (tennis group 1.5 minutes;  $p < 0.05$ ) and functional capacity measured in metabolic equivalents (tennis group 1.19 METs;  $p < 0.05$ ).

On the other hand, Table 5 presents data about the parameters of the lipid profile, comparing the initial data with the final data and finding significant differences in the control group regarding triglycerides ( $p < 0.01$ ), total cholesterol ( $p < 0.05$ ) and cLDL ( $p < 0.05$ ); in the tennis group regarding total cholesterol ( $p < 0.05$ ), cHDL ( $p < 0.001$ ) and cLDL ( $p < 0.01$ ); and in bicycle ergometer group regarding total cholesterol ( $p < 0.01$ ), cHDL ( $p < 0.05$ ) and cLDL ( $p < 0.01$ ).

## Discussion

The main objective of this study is to assess the effectiveness of a cardiac rehabilitation program based on a modification of a sport (tennis) on QL (quality of life), effort capacity and different analytic variables, as well as to check whether the results of the new activity are comparable to those of other traditional programs such as the ergometer bicycle, considering that, as the review by Grima et al. (2011) shows, secondary prevention through physical exercise based on CRPs is the intervention with the most scientific support for reducing the morbidity and mortality of the coronary disease, especially after an acute myocardial infarction (AMI). Therefore, if we compare our CRP with the results of various traditional secondary prevention programs (Plaza et al., 2007; Velasco et al., 2002; 2004), we see that our program achieves results similar to, and sometimes better than these programs for the variables analysed. Thus, with our CRP we aim to suit

**Table 2.** Changes in body characteristics and quality of life. Data are means ( $\pm$ SD).

	Control Group	BE Group	Tennis Group
Initial WT (Kg)	82.0 (12.0)	83.4 (1.0)	82.0 (14.0)
Final WT (Kg)	82.3 (12.0)	81.9 (14.0)	80.6 (14.0)
Initial BMI	29.2 (3.0)	28.9 (5.0)	28.5 (4.0)
Final BMI	29.3 (3.0)	28.4 (5.0) **	28.0 (4.0) **
Initial PE (cm)	100.8 (5.0)	100.2 (12.0)	99.3 (10.0)
Final PE (cm)	100.9 (5.0)	100.1 (12.0)	98.9 (9.0) *
Initial Quality of Life Test	90 (30)	95 (22)	90 (29)
Final Quality of Life Test	81 (26) **	64 (13) ***	65 (19) ***

WT: Weight; BMI: Body Mass Index; PE: Abdominal circumference. \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

**Table 3. Results from the stress tests. Data are means ( $\pm$ SD).**

	Control Group (n=25)		Tennis Group (n=27)		BE Group (n=27)	
	Initial	Final	Initial	Final	Initial	Final
<b>HRmax</b>	125 (17)	141 (15) **	120 (15)	136 (19) ***	125 (15)	142 (15) ***
<b>%HRmax</b>	75 (9)	80 (9) **	73 (8)	83 (11) ***	74 (9)	85 (9) ***
<b>Borg</b>	14 (2)	15 (2)	14 (2)	14 (2)	14 (1)	14 (2)
<b>METs</b>	9 (2)	10 (2) **	9 (2)	11 (2) ***	9 (2)	11 (2) ***
<b>PSS</b>	169 (26)	175 (26)	170 (19)	171 $\pm$ 15	166 (30)	172 (28)
<b>PSD</b>	89 (9)	92 (11) *	90 (8)	90 (12)	87 (9)	87 (11)
<b>T`Test</b>	8 (2)	9 (2) **	8 (2)	10 (2) ***	8 (2)	10 (2) ***
<b>Rest HR</b>	76 (14)	78 (13)	73 (15)	71 (14)	77 (9)	76 (9)
<b>Double Product</b>	19480 (5427)	21163 (3867)	18215 (3595)	20979 (4617) **	18650 (5617)	22008 (4440) ***

HRmax: maximum heart rate achieved in the stress test; Borg: scores obtained in the questionnaire on subjective perception in the Borg stress test; METs: metabolic equivalents; PSS: systolic blood pressure; PSD: diastolic blood pressure; T`Test: test duration in minutes; HR rest: cardiac frequency before the start of the test. \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

**Table 4. Analysis of variance (ANOVA) of the variables in the stress test.**

Comparisons between groups	BE control	Tennis control	ER/ Tennis
Variables	Dif. (n=25)	Dif. (n=27)	Dif. (n=27)
Initial HRmax	-.12	-5.08	4.96
Final HRmax	10.26	4.51	5.74
Initial METS	-.15	-.01	-.15
Final METS	1.09	1.19 *	-.10
Initial exercise T`	-.21	.03	-.24
Final exercise T`	1.42	1.52 *	-.10
Initial HRrest	1.34	-3.32	4.67
Final HRrest	-1.42	-6.90	5.48

HRmax: maximum heart rate achieved in the stress test; METS: metabolic equivalents; T`Test: test duration in minutes; HR rest: cardiac frequency before the start of the test. \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

different motivations and preferences in order to increase the participation in CRPs, which has been proved to be low (García, et al., 2010). On the other hand, focusing on the country in which this study was conducted (Spain), it is particularly necessary to broaden the scope of CRPs. Through the cooperation with other non-hospital institutions (Sport Sciences Faculties), our program helps to reduce infrastructure costs and promotes interdisciplinary work between health and sport sciences professionals. Spain is the European country with fewer CR centres and with the lower participation rate in CR - according to the European Cardiac Rehabilitation Inventory Survey (Bjarnason-Wehrens et al., 2010) only 2-3% of these patients undergo CRP - although there is ample evidence that the cost-effectiveness and cost-benefit ratios of CRPs are nowadays the most favourable among all the treatments and interventions for cardiac diseases (Plaza, 2003). Thus, we believe that it is necessary to devise varied and motivating CRPs in order to foster the unsupervised practice of and the adherence to physical exercise considering that, as Cano (2012) points out, based on the results of different studies the risk of cardiovascular mortality is lower

in physically active cardiac patients, with reductions up to 35%.

As for QL, the analysis of the three groups shows significant differences in favour of tennis and ergometer bicycle groups with respect to control group regarding total score. We consider this improvement in emotional behaviour important because, as Jiménez Muro et al. (1999) note, AMI patients suffer a substantial deterioration in this regard. In the clinical practice, we can observe a clear deterioration in the QL of patients who have suffered an AMI and have recovered from it. The review by Cano et al. (2012) shows that for many patients with heart failure in an advanced stage, QL and the great benefits of the CRP in terms of QL are more important than the estimated life expectancy. Thus, as Laprerie y Trochu (2010) point out, every CRP should include specific components aimed to optimize the cardiovascular risk reduction, promote healthy behaviours and the adherence thereof by means of education programs with the active involvement of the patient in his own treatment, as well as to reduce disability promoting an active lifestyle for patients with CVD. In the study by Jiménez Muro et al. (1999), 85.29 % of the patients saw a reduction in their QL after suffering an AMI, and this reduction was more evident in the Emotional Component (50.38 %) than in the Physical Component (34.90 %) of the patient. It has been demonstrated that, in patients with uncomplicated AMI, overall QL significantly improved from the start to the finish of the program. The data gathered in our study are broadly in line with the results of this study.

Regarding the stress test, we can see that most parameters experienced improvements, primarily in the results of experimental groups. We must take into account that exercise capacity is considered an important prognostic factor in cardiac patients, with both the maximum oxygen consumption and the exercise time during the stress test being powerful predictors of mortality. For

**Table 5. T-tests of results relating to lipid profiles. Data are means ( $\pm$ SD).**

	Control Group (n=25)		Tennis Group (n=27)		BE Group (n=27)	
	Initial	Final	Initial	Final	Initial	Final
<b>Triglycerides</b>	130 (51)	97 (44) **	114 (38)	102 (54)	152 (68)	140 (76)
<b>Total Cholesterol</b>	178 (44)	155 (46) *	158 (33)	140 (32) *	170 (31)	151 (26) **
<b>cHDL</b>	42 (9)	47 (12)	34 (10)	44 (10) ***	38 (10)	42 (13) *
<b>cLDL</b>	110 (37)	88 (36) *	100 (31)	76 (24) **	100 (29)	81 (23) **

cHDL: cholesterol bound to high density lipoproteins; cLDL: cholesterol bound to low density lipoproteins. \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$



every 1 MET increase in exercise capacity, there is a 12% increase in survival (Boraita, 2008). There were improvements in most of the parameters of the stress tests; mainly in the experimental groups. Exercise capacity measured in metabolic equivalents clearly increased in the patients in the active groups (Table 3). This is a general finding in all CRPs (León et al., 2010), and an effect of physical training. Nevertheless, because this is the first time that such training has taken place on its own, and simultaneously within and outside a primary care centre, the results obtained are even more convincing than those obtained previously with patients with similar characteristics (Haykowsky et al., 2007; Kraus et al., 2002; Peterio et al., 2005; Wisloff et al., 2007).

Finally, it may be mentioned that a number of studies (Roberts et al., 2006; Singh et al., 2006) have shown that aerobic exercise at levels of intensity, duration and frequency similar to those in the program we have developed increase cHDL by approximately 5% (Alegria et al., 2008). Of the lipid profile values obtained in our program for the three groups, those of the tennis group are especially striking in that, relative to the reference metabolic values (Alegria et al., 2008), there was a favourable change in each of the values.

## Conclusion

In conclusion, cardiac rehabilitation of low risk patients with acute coronary syndrome based on a program of modified tennis produces an improvement in QL, lipid profiles and in exercise tolerance, as well as favourable changes in various anthropometric parameters related to the reduction of cardiovascular risk. Therefore, we propose the development of programs based on modified versions of various sports. This would complement the available choice of traditional programs of cardiac rehabilitation (ergometer bicycles, treadmills, gymnastic tables...) and suit different motivations and tastes in order to increase the participation of patients in CRPs and the adherence to physical exercise.

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### Key points

- Cardiac rehabilitation of low risk patients with acute coronary syndrome based on a program of modified tennis produces an improvement in quality of life, lipid profiles and in exercise tolerance
- A cardiac rehabilitation program based on a modification of tennis produces favourable changes in various anthropometric parameters related to the reduction of cardiovascular risk
- The development of programs of cardiac rehabilitation based on modified versions of various sports would advantage the adherence to physical exercise.

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