Physical Activity and Health

Effects of a tennis training program adapted for cardiac rehabilitation of patients with low risk acute coronary syndrome

Díaz, C. [1], *Fuentes, J.P.* [1], *Menayo, R.* [1], *Barca, J.* [2], *Gómez, J.J.* [3]

[1] Faculty of Sports Science of Caceres. University of Extremadura.
[2] School of Nursing and Occupational Therapy of Caceres. University of Extremadura.
[3] Cardiology Unit of the Hospital San Pedro de Alcantara in Caceres.

Contact details
Cesar Díaz Casasola: cdiaz@titulados.unex.es
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ABSTRACT

At present, slightly healthy ways of life (sedentary lifestyle, unhealthy food, stress, etc.) prevail in our society. Concurrently, rates of cardiovascular diseases causes alarm since they constitute the first cause of death in developed countries. Considering this social problem, we have conducted a study that aims to define the effects of a cardiac rehabilitation training program, based on the practice of tennis, in patients with acute coronary syndrome. Our objective was to determine the technical level achieved after the training program and to specify if improvements were made regarding accuracy comparing the pre-test and the post-test.

The sample consisted of a group of six patients, of average age 53.57 ± 4.68. Systematic observation was used as an assessment tool. The shot technique and accuracy achieved were filmed and subsequently analysed with the help of observational grids previously validated. The statistical analysis of the results showed significant differences (p =.001 and p =.005) in both shot technique and shot accuracy after the training program.

Key words: Adaptive tennis, technique, cardiac rehabilitation, acute coronary syndrome.

INTRODUCTION

Cardiovascular diseases together represent the leading cause of death in developed countries, being cardiac ischemia the first cause of death among men and the second among women (Villar, Benegas, Rodríguez and Rey, 1998). For that reason, intervention strategies should be developed aiming to reduce cardiovascular morbimortality, improve patient's quality of life and accelerate work resumption. These strategies should be effective in terms of prevention as well as treatment of cardiovascular diseases.

At the present time, the multidisciplinary training program developed by the Cardiac Rehabilitation Unit (URC) is the recommended practice to achieve the maximum benefit (Balady, Williams, Ades, Bittner, Comoss, Foody et al., 2007).

However, the meagre number of patients participating in cardiac rehabilitation programs in Spain is around 2% and 4% of the total patients eligible for this treatment, and there are only twenty centres that provide this type of therapy in the country (Márquez-Calderón, Villegas, Briones, Sarmiento, Reina and Sainz, 2003). By contrast, patients' participation in other countries with similar socioeconomic levels oscillates between 30% and 50% (Marquez et al., 2003). Physical activity is essential in most of these programs, but the variety of exercises is limited and the training programs are fairly stereotyped (Marquez et al., 2003).

In 10 out of the 12 Spanish units mentioned patients exercise by following an exercise routine (90.9%), while in nine of them (81.2%) they use the static bicycle and light barbells. Aerobic exercise such as walking, slow running or running on the treadmill is less frequent (only 45.5% of the units for each of the three disciplines) (Marquéz et al., 2003).

For all these reasons, our research follows the guidelines set by previous studies, substituting the physical activities included in them for tennis, a sport that both involves heart healthy exercise and has an appropriate intensity to achieve health benefits (Plaza, Villar, Mata, Pérez, Maiquez, Casasnovas, Banegas, Tomás, Rodríguez and Gil, 2000; American College of Sport Medicine, 2006; Boraita, 2008). The tennis program we have designed for this population group aims to achieve not only health benefits in the patient, that have been previously supported by literature references such as Marks (2006), Pluim et al (2007) and Fernández et al (2009), but also an improvement in their technical skills that will further lead to the mastering of this sport, enhancing their access to exercise in an autonomous, healthy and sustainable manner. Conversely to other programs currently recommended in Spain, our program assures that patients will be able to resume the training program in normal conditions after our intervention, guaranteeing an appropriate and autonomous execution of the exercises.

Picture 1. Sample participant

METHODS

Sample: The sample comprises six patients (N=6) with acute myocardial infarction. The age range was from 48 to 63 years (M = 53.57 ± 4.68). None of the participants had any previous experience with tennis. In order to corroborate that all the subjects had the same technique and accuracy level in early stages, an analysis of intersubject variance was conducted with the technique and accuracy data recorded in the initial test. Important differences were not found in the recorded variables ($p \geq .000$) after this analysis[1]. Considered as low risk patients after the cardiovascular infarction, all the participants were admitted to the Cardiac Rehabilitation Unit at Hospital San Pedro de Alcantara in Caceres. All the patients admitted to this unit were eligible for the study. All of them agreed to participate in the training program by signing a consent form, while the program was concurrently approved by the Hospital ethics committee.

Material: An observational analysis of the various shots performed during the training program was con-

[1] The variables used for analysing patient's technique were the following: flat forehand and backhand, forehand and backhand lift, forehand and backhand volleys and flat serve. The variables for analysing patient's accuracy were the same, taking into account straight down the line and cross-court shots.

ducted in order to record the data on technique and accuracy (Gorospe, Hernández, Anguera and Martínez, 2003; Gil, 2003). A technical description of tennis shots (figure 1), adapted from Fuentes and Menayo (2009), was used to describe each category in technical terms and to elaborate an observation grid.

FOREHAND FLAT Name and Surname: Date:	CORRECTLY PERFORMED	NON-PERFORMED	UNCERTAIN
1. Ready position			
Player awaits the ball with knees slightly bent and legs slightly wider than shoulder width			
Appropriate grip (right in this case)			
The other hand holds the racket by the heart of the racket			
2. Body position and approach			
Before moving, torso turns sideways towards the ball			
Steps are correctly adjusted to the point in which the racket is going to contact the ball			
3. Preparation for the hit			
Knees are slightly bent and the body weight is transferred into the back leg			
After the arm and racket are taken backwards, the head of the racket is approximately at shoulder height			
4.- Movement and contact			
Weight is transferred from the forward leg into the back leg			
Racket is taken forward parallel to the floor while approaching the ball			
Racket remains slightly in front of the body when it contacts the ball			
5.- Follow-through and completion			
Arm and racket follow the ball. Afterwards, the arm remains bent at shoulder height, with the head of the racket between head and shoulder height			
Back to ready position			

Figure 1. Observation grid sample designed for analysing technique. Flat forehand (adapted from Fuentes and Menayo, 2009).

Technical tests were recorded with two video cameras (Sony DCR – HC20E PAL) installed in the court (figure 2).

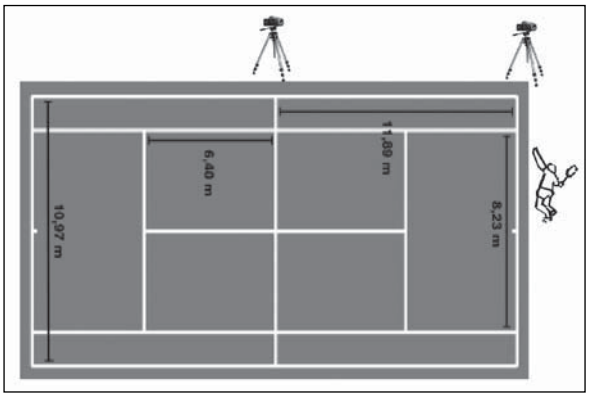
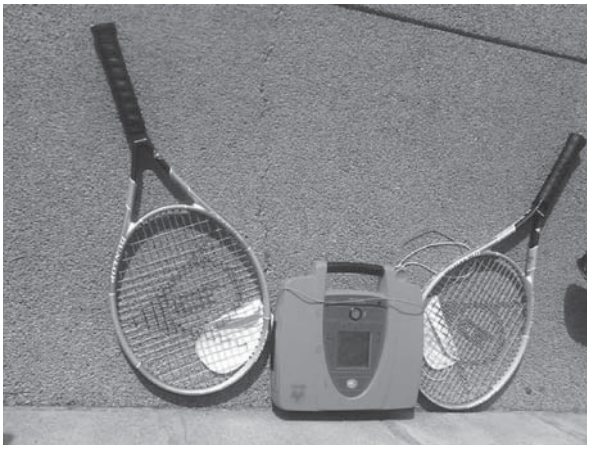


Figure 2. Location of the cameras on the tennis court.

Procedure: The practice sessions took place three times a week during a two-month time period in an indoor tennis court. The exercise program consisted of 28 sixty-minute sessions (Sosa et al, 1993). Patients performed low intensity tennis exercises, monitored with personal heart rate monitors (Polar s610i). The patient's performance varied depending on the results he/she obtained in the ergometric analysis previously conducted (approximately 70%-85% of the heart rate recorded) (American Heart Association, 1971). Heart rate was recorded during the entire session. Data recorded was stored in a USB drive for later analysis and subsequently transferred to a computer by means of an Irda adaptor. Following this procedure, a continuous monitoring of the training intensity during each session was guaranteed, and the individual analysis carried out afterwards assured that every patient was exercising while maintaining his/her optimum heart rate.

Each session had the following structure: 10-minute warm up, 35-minute moderate intensity aerobic activity, 5-minute active rest to reduce heart rates and 10 minute dynamic stretching of upper and lower muscles. Shot technique and accuracy were videotaped at the beginning and the end of the program, by installing two video cameras located 3m behind the baseline and the sideline of the patient's dominant hand (fig. 2). The following shots were analysed in detail: Forehand lift, backhand lift, flat forehand, flat backhand, forehand volley, backhand volley and flat serve.

After videotaping the shots and before analysing the results, three observers were trained to record the patient's technique by using Sanz's method (Sanz (2003)). Firstly, observers, who held a postgraduate degree in Tennis awarded by the Caceres University School of Sports Science, were taught the categories they should observe, and afterwards they practiced for 6 thirty-minute sessions, analysing the videos



Picture 2. Materials

previously selected at random by the researcher and writing down their observations in the technical assessment grid aforementioned. The training was considered completed when the observers achieved an intraobserver and interobserver reliability rate above 80%. A different shot was assessed in each session and the results of the various observers were registered. Furthermore, an analysis of the intraobserver/interobserver reliability was conducted in each session, in order to verify that the observations among the various observers regarding the technical assessment of the shots concurred. The Bellack's formula (Bellack, 1966 (in Anguera 1988)) was used for this purpose. This analysis showed a reliability rate of 86.83%, that represented 211 out of 243 coincidences in the technical assessment of the shots.

Variables: Shot technique and accuracy in the shots aforementioned were analysed as dependent variables after the completion of the tennis training program. The tennis training program adapted to the population group with low risk acute coronary syndrome was the independent variable.

Statistical analysis: Data analysis was conducted by using SPSS 17.0 software. In order to ensure data homogeneity, the Kolgomorov-Smirnov test was carried out in advance. The test outcomes showed the adequacy of using nonparametric statistics when analysing technique while parametric statistics was more suitable when analysing accuracy. Afterwards, a Wilcoxon's Z-test for repeated measures was conducted, facilitating the comparison of the technique data recorded in the initial and final test, while a T-test was carried out for repeated measures in accuracy.

FINDINGS

Analysis of the shot technique

Table 1 reports the results in the technical performance achieved by the sample. The sum of all the items corresponding to each shot in the grid is calculated in the said table (Fuentes and Menayo, 2009). It is remarkable that the number of items that are correctly performed in the case of flat forehands is significantly higher at the end of the training (146 points in the initial test compared to 551 in the final test). Both uncertain items (from 244 points in the initial test to 112 in the final test) and non-performed items (from 1356 points in the initial test to 339 in the final test) considerably decrease.

The forehand lift shows the same tendency, the number of correctly performed items increasing after the training from 105 points in the initial test to 446 in the final test. However, uncertain items swell from 94 points in the initial test to 112 in the final test.

Regarding both flat backhand and lift, they show the same results than those obtained in the flat forehand and lift. Comparatively, the behaviour observed in flat forehand and in flat backhand is similar to this in forehand and backhand volleys, as well as with the serve, where correctly performed items rise after the training period, while uncertain and non-performed items shrink.

Table 1. Results of the summed scores obtained for each item in the initial and final (Dif = final test– initial test).

		Initial Test	Final Test	
	N	Sum	Sum	Dif.
Correctly performed flat forehand	120	146	551	405
Uncertain flat forehand	120	244	112	-132
Non-performed flat forehand	120	1356	339	-1017
Correctly performed forehand lift	120	105	466	361
Uncertain forehand lift	120	94	112	18
Non-performed forehand lift	120	1704	594	-1110
Correctly performed flat backhand	120	107	433	326
Uncertain flat backhand	120	220	82	-138
Non-performed flat backhand	120	1509	738	-771
Correctly performed backhand lift	120	76	402	326
Uncertain backhand lift	120	84	90	6
Non-performed backhand lift	120	1806	819	-987
Correctly performed forehand volley	70	58	273	215
Uncertain forehand volley	70	56	42	-14
Non-performed forehand volley	70	1002	378	-624
Correctly performed backhand volley	90	23	255	232
Uncertain backhand volley	90	40	24	-16
Non-performed backhand volley	90	1491	819	-672
Correctly performed backhand serve	120	150	476	326
Uncertain backhand serve	120	74	52	-22
Non-performed backhand serve	120	1599	654	-945

Table 2 shows remarkable results obtained after analysing technique, comparing the performance achieved in initial and final tests. The table contains the sum of the data recorded for each of the same 12 items considered for the analysis of technique, divided into three further variables: "correctly performed", for cases in which the item has been properly performed, "uncertain", for cases in which the performance is not clear and "non-performed ", for cases in which the item has not been performed.

Table 2. Results of technique scores after the comparison of results in initial and final test (Dif. =initial test – final test).

		Initial test		Final test				
	N	*M*	*DT*	*M*	*DT*	Dif.	*Z*	*p*
Correctly performed flat forehand	120	1.22	1.01	4.59	1.41	3.38	-9.347	.000
Uncertain flat forehand	120	2.03	2.20	0.93	1.42	-1.10	-3.881	.000
Non-performed flat forehand	120	11.30	3.90	2.83	4.27	-8.48	-9.078	.000
Correctly performed forehand lift	120	0.88	1.17	3.88	2.01	3.01	-8.130	.000
Uncertain forehand lift	120	0.78	1.63	0.93	1.70	0.15	-0.473	.636
Non-performed forehand lift	120	14.20	4.29	4.95	5.84	-9.25	-8.044	.000
Correctly performed flat backhand	120	0.89	1.08	3.61	1.87	2.72	-8.806	.000
Uncertain flat backhand	120	1.83	2.41	0.68	1.12	-1.15	-3.954	.000
Non-performed flat backhand	120	12.58	3.88	6.15	5.46	-6.43	-7.442	.000
Correctly performed backhand lift	120	0.63	0.76	3.35	2.03	2.72	-8.332	.000
Uncertain backhand lift	120	0.70	1.18	0.75	1.30	0.05	-0.438	.661
Non-performed backhand lift	120	15.05	2.88	6.83	5.57	-8.23	-8.580	.000
Correctly performed forehand volley	70	0.83	1.68	3.90	2.01	3.07	-6.972	.000
Uncertain forehand volley	70	0.80	1.10	0.60	1.20	-0.20	-0.882	.378
Non-performed forehand volley	70	14.31	5.09	5.40	5.15	-8.91	-7.219	.000
Correctly performed backhand volley	90	0.26	0.61	2.83	1.96	2.58	-7.901	.000
Uncertain backhand volley	90	0.44	0.89	0.27	0.68	-0.18	-1.414	.157
Non-performed backhand volley	90	16.57	2.12	9.10	5.85	-7.47	-7.609	.000
Correctly performed backhand serve	120	1.25	1.84	3.97	2.33	2.72	-8.513	.000
Uncertain backhand serve	120	0.62	0.96	0.43	1.30	-0.18	-1.344	.179
Non-performed backhand serve	120	13.33	5.50	5.45	6.88	-7.88	-8.422	.000

Forehand and flat backhands showed similar results, with meaningful differences among the three categories. Correctly performed items mount while uncertain and non-performed shrink. Similarly, correctly performed items considerably increase while non-performed items decrease in the rest of the shots. However, significant differences in uncertain shots are not found at the end of the training, as was the case for forehand and flat backhands.

Analysis of the shot accuracy

Figures 3, 4, 5 and 6 show results with significant differences in the accuracy of the various shots before and after the training program. In order to analyse this variable, both the number of balls that landed inside the delimited area and the balls that landed outside were compared before and after the training period.

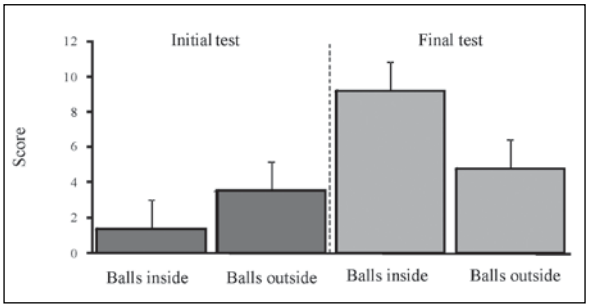


Figure 3. Results for accuracy in flat backhands down the line that showed meaningful differences in initial and final test (p≤.05)

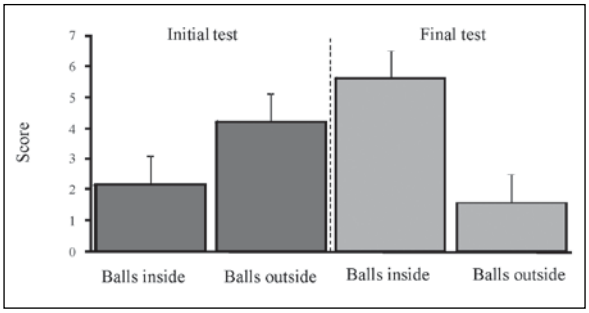


Figure 4. Results for accuracy in forehand volley down the line that showed meaningful differences in initial and final tests (p≤.05).

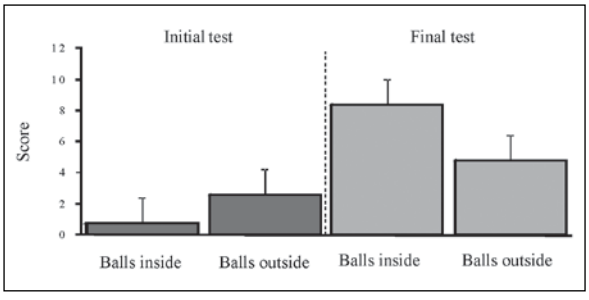


Figure 5. Results for accuracy when serving into the T area that showed meaningful differences (p≤.05)

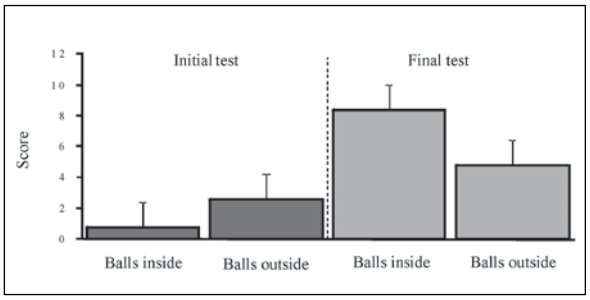


Figure 6. Results for accuracy when serving into the "cross" area that showed meaningful differences (p≤.05)

All the charts report that accuracy, understood as the number of balls that landed inside the delimited area, significantly increased in the final test concerning flat backhands down the line, backhand volleys down the line and serves to the "cross" and the T area. Concerning the lack of accuracy, which was understood as balls that landed outside these areas, it is remarkable that erroneous flat backhands down the line and erroneous serves increased, in contrast with erroneous forehand volleys that decrease after the training.

DISCUSSION

This research primarily aimed to determine the effects of a tennis training program for cardiac rehabilitation in patients with low risk acute myocardial infarction. The program designed for this purpose was based on the improvement of the shot technique and accuracy.

Unfortunately, literature addressing the issue is scarce. Only 93 articles can be found among the search results matching the cross reference "tennis and observation" in the Sport-Discus database. However, they mainly focus on topics such as learning (Jackson, 2003; Liao and Masters, 2001), or norm compliance (Hanegby and Tenenbaum, 2001). In the Pro-Quest database, that gathers various databases, only 3 results that match the same words are found and, in fact, the articles do not really address this issue.

Results showed a remarkable improvement in shot technique and accuracy. Such improvement will enhance patient's adherence to tennis practice since their skill level will provide them the desired level of autonomy. Therefore, patients will be able to practice on their own at similar intensity levels and frequency to those of our training program, thus enabling them to enjoy the sport of tennis in their daily lives without the assistance of a coach.

The marginal shrinking of errors concerning both technique and accuracy is outstanding. It is important to note that the increase in the number of balls that landed outside the delimited areas may be attributed to the patients' technical improvements, since they may assume more risks in an effort to improve the accuracy of their shots. Nevertheless, as it was mentioned above, the number of balls that landed inside the delimited areas is higher to those that landed outside after the duration of the training program.

The results obtained are especially relevant due to the characteristics of the sample. Considering that the sample consisted of a special group population, other colleagues and therapists will be able to further implement this program for similar purposes. Moreover, tennis coaches will be able to apply the observational assessment system developed in this study in order to analyse the technical performance of their players.

BIBLIOGRAPHIC REFERENCES

ACC/AHA (1998). *Guidelines for Exercise Testing.* Barcelona: Medical trends.

ACSM (2006). *Guidelines for Exercise Testing and Prescription.* Séptima edición. Estados Unidos: Editorial Lippincott Williams & Wilkins.

Anguera, M.T. (1988). *Observación en la Escuela.* Barcelona: Graó.

Balady, G.J., Williams, M.A., Ades, P.A., Bittner, V., Comoss, P., Foody, J.M. et al. (2007). Core Components of Cardiac Rehabilitation/Secondary Prevention Programs: Update A Scientific Statement From the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism, and the American Association of Cardiovascular and Pulmonary Rehabilitation. *Circulation, 115*, 2675-2682.

Bellack, A., Kliebard, H., Hyman, R. y Smith, F. (1966). *The Language of the Clasroom*. New York: Teachers College, Columbia University Press.

Boraita, A. (2008). Ejercicio, piedra angular de la prevención cardiovascular. *Rev Esp Cardiol. 61* (5), 514-528

Emery, C.F., y Gatz, M. (1990). Psychological and cognitive effects of an exercise pr ogram for community-residing older adults. Gerontologist, 30 (2), 184-188.

Espinosa, J.S. y Bravo, J.C. (2002). Rehabilitación CardíacaandAtención Primaria. Madrid: Editorial Médica Panamericana S.A.

Espinosa Caliani, S.(2004). Rehabilitación cardíaca postinfarto de miocardio en enfermos de bajo riesgo. Resultados de un programa de coordinación entre cardiologíaandatención primaria. Revista Española de Cardiología 57 (1), 53-59.

Fernández-Fernández, J., Sanz-Rivas, D., Sanchez-Muñoz, C., Tiemessen, I., Pluim, B.M., Méndez-Villanueva, A. (2009). A comparison of the activity profile and physiological demands between advanced and recreational veteran tennis players. *J Strength Cond Res, 23*, 604–610.

Fletcher, G.R. (1992). Estado actual de la rehabilitación cardíaca. *Current problems in cardiology,* 4-207.

Florido Mancheño, E. (1996). Los centros de tecnificación. La planificación de la preparación fisica. Apunts, 44-45, 71-75.

Fuentes, J.P.,andMenayo, R. (2009). Los golpes del Tenis. De la Iniciación al Alto Rendimiento. Wanceulen: Sevilla.

Hanegby, R. and Tenenbaum, G. (2001). Blame it on the racket: norm-breaking behaviours among junior tennis players. *Psychology of sport and exercise, 2* (2), 117-134.

Jackson, R.C. (2003). Evaluating the evidence for implicit perceptual learning: a re-analysis of Farrow and Abernethy (2002). *Journal of sports sciences, 21* (6), 503-509.

Kellermann, J.J. (1998). Cardiac rehabilitatión as a secundary prevention measure. End points. Adv Cardiol, 31, 134-137.

Liao, C.M. and Masters, R.S.W. (2001). *Analogy learning: a means to implicit motor learning. Journal of sports sciences, 19* (5), 307-319.

Marks, BL. (2006). Health benefits for veteran (senior) tennis players. *Br J Sports Med 40,* 469–476.

Márquez-Calderón S., Villegas Portero, R., Briones Pérez de la Blanca E, Sarmiento González-Nieto, V., Reina Sánchez, M., Sáinz Hidalgo, I., et al. (2003). Implantación and características de los programas de rehabilitación cardíaca en el Sistema Nacional de Salud español. *Rev Esp Cardiol, 56,* 775-782.

Marsh, H.W. and Sonstroem, R.J. (1995). Importance ratings and specific components of physical self-concept: Relevance to predicting global components of self-concept and exercise. Journal of Sport and Exercise Psychology, 17 (1), 84-104

Molloy, D.W., Beerschoten, D.A., Borrie, M.J., Crilly, R.G. and Cape, R.D.T. (1988). Acute effects of exercise on neurological function in elderly subjects. Journal of the American Geriatrics Society, 36, 29-33.

Plaza, I. (2003). Estado actual de los programas de prevención secundaria and rehabilitación cardiaca en España. Rev Esp Cardiol 56 (8) ,757-760.

Plaza, I., Villar, F., Mata, P., Pérez, F., Maiquez, A., Casasnovas, J.A., Banegas, J.R., Tomás, L., Rodríguez, F. y Gil, E. (2000). Un instrumento para la prevención cardiovascular. *Revista Española de Cardiología 53*, 815-837.

Pluim, B.M., Staal, J.B., Marks, B.L., Miller, S., and Miley, D. (2007). Health benefits of tennis. *Britain Journal of Sports and Medicine, 41,* 760-768.

Pollock, M.L., Miller, H.S. and Linneroud, A.C. (1975). Frequency of training as a determinant for improvement in cardiovascular function and body composition in middle aged men. Arch Phys Med Rehabil, 78, 141-145.

Serra, J.R. y Prat, T. (1995). Efectos del entrenamiento físico. Revista española de cardiología, 48 (1), 8-12.

Sosa, V., Ubiera, J.M., Alonso, M., Martinez, E., Cantalapiedra, J.L., Almazán, A. et all. (1993). La rehabilitación cardíaca tras infarto agudo de miocardio en la década de los noventa. Monocardio 34, 55-70.

Velasco, J.A. (2000). Guías de práctica clínica de la Sociedad Española de Cardiología en prevención cardiovascular y rehabilitación cardiaca. Rev Esp Cardiol 53, 1095-1120.

Villar, F., Benegas, J.R., Rodríguez Artalejo, F., Rey J. (1998). Mortalidad cardiovascular en España y sus comunidades autónomas (1975- 1992). Med Clin 110, 321-327.

Ward, A., Malloy, P., Rippe, J. (1987). Pautas para prescripción de ejercicio en sujetos normales y en cardiópatas. Hanson P, editoriales. Mexico D.F. Clinicas Cardiovasculares Norteamericanas, 211-225.

Wellard, I. (2002). Men, sport, body performance and the maintenance of 'exclusive masculinity. *Leisure Studies, 21* (3/4), 235-247.

World Health Organization. Technical Report Series 270 (1964). Rehabilitation of patients with cardiovascular diseases. Ginebra: Report of WHO Expert Committee.