World Journal of Cardiology

Online Submissions: http://www.wjgnet.com/1949-8462office
wjc@wjgnet.com
doi:10.4330/wjc.v3.i7.248

World J Cardiol 2011 July 26; 3(7): 248-255
ISSN 1949-8462 (online)

REVIEW

Phase Ⅰ of cardiac rehabilitation: A new challenge for evidence based physiotherapy

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Author contributions: de Macedo RM and Guarita-Souza LC performed the literature review; de Macedo RM, Faria-Neta JR, Costantini CO, Casali D, Muller AP and Costantini CR developed and discussed the paper; de Macedo RM, de Carvalho KAT and Guarita-Souza LC reviewed the paper.

Supported by CAPES

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Received: April 19, 2011 Revised: May 16, 2011
Accepted: May 23, 2011
Published online: July 26, 2011

Abstract

Cardiac rehabilitation protocols applied during the in-hospital phase (phase Ⅰ) are subjective and their results are contested when evaluated considering what should be the three basic principles of exercise prescription: specificity, overload and reversibility. In this review, we focus on the problems associated with the models of exercise prescription applied at this early stage in-hospital and adopted today, especially the lack of clinical studies demonstrating its effectiveness. Moreover, we present the concept of "periodization" as a useful tool in the search for better results.

Key words: Cardiac rehabilitation; Exercise physiology; Physical therapy

Peer reviewer: Ehud Goldhammer, Professor, Head Cardiac Rehabilitation Center, Department of Cardiology, Bnai Zion Medical Center, 35 Golomb Str., Haifa 31048, Israel

de Macedo RM, Faria-Neto JR, Costantini CO, Casali D, Muller AP, Costantini CR, de Carvalho KAT, Guarita-Souza LC. Phase Ⅰ of cardiac rehabilitation: A new challenge for evidence based physiotherapy. *World J Cardiol* 2011; 3(7): 248-255 Available from: URL: http://www.wjgnet.com/1949-8462/full/v3/i7/248.htm DOI: http://dx.doi.org/10.4330/wjc.v3.i7.248

INTRODUCTION

There are different levels of physical aptitude, and they are directly related to the functional capacity of each individual. The same person presents different levels of physical aptitude in different phases of one's life. Physical aptitude is determined by two different components: musculoskeletal and cardiopulmonary. The improvement of both is achieved with regular training (physical activity) and is associated with better exercise tolerance. On the other hand, physical aptitude can deteriorate due to disuse[1]. Bed rest significantly decreases the cardiovascular tolerance for exercise in normal subjects and contributes to physical debility[2-4].

The main components of physical aptitude include body composition, cardio-respiratory aptitude, muscle strength and flexibility[5]. All of them are directly compromised by bed restriction. The human body works like a fine-tuned gear system involving the respiratory, cardiovascular and musculoskeletal systems[6]. The first is responsible for capturing atmospheric oxygen and distributing it into the blood stream through diffusion. The second is responsible for the systemic distribution of oxygenated blood which depends on the pumping function of the left heart. The third system (musculoskeletal) is responsible for capturing and extracting molecular oxygen from the blood stream and transforming it into energy through intracellular biochemical reactions, in order to generate movement[7].

The whole system improves as the individual exercises and the organism develops physiological adaptations[8]. In many individuals one or more of these gears can be pathologically compromised either by clinical disease, surgical intervention and/or by being bedridden. Patients with respiratory diseases tend to have difficulty in capturing and diffusing oxygen, as a result of alterations in their pulmonary volumes and capacities, interfering directly in their exercise tolerance[9]. Patients with decreased left ventricular function present a reduction in the ejection fraction and decrease in the amount of systemic oxygen, consequently reducing exercise tolerance[10,11].

When cardiopathies and pneumopathies coexist in the same patient, the results of such physiopathological alterations can be a reduction in muscle strength due to disuse induced by lower tolerance to exercise or due to the lower level of physical aptitude[12,13]. When such a population is submitted to an exercise program, psychopathological adaptations of the organism are observed[14], and specific methods of exercise prescription are necessary to fulfill the needs of these patients[15], taking into account each personal and functional adaptation[16].

CLINICAL EXERCISE PHYSIOLOGY IN HOSPITAL PHASE

Clinical exercise physiology is still an incipient science, as evidenced by the weakness of the exercise prescription models for the hospital phase. At this early phase, the focus of physical therapy is prescription to avoid inactivity, and to maintain or improve pulmonary capacities and muscular strength[1,17,18], especially in patients after cardiac surgery. Although it might seem simple, many authors question the efficacy of these physical therapy programs. Sivarajan *et al*[19] evaluated a type of in-hospital exercise prescription in patients who suffered a myocardial infarction and found no improvement in the treadmill performance. There is a low level of evidence to assess the efficacy of chest physical therapy in the hospital phase.

EFFICACY OF CHEST PHYSICAL THERAPY APPLIED IN POST CARDIAC SURGERY

A systematic review was carried out to determine the efficacy of the use of physiotherapy in the prevention of pulmonary complications in post-operative heart surgery patients and to assess the efficacy of chest physical therapy in the hospital phase[20]. Eighteen trials, involving 1457 patients were evaluated: 13 evaluated the use of respiratory physiotherapy in post-operative heart surgery patients; 8 evaluated respiratory boosters; 5 tested the efficacy of applying a continuous positive airway pressure system; and 3 tested the efficacy of applying intermittent positive pressure. Changes in the following variables were assessed: incidence of atelectasis and pneumonia; partial oxygen pressure in the arterial blood; forced vital capacity; and forced expiratory volume in the first second. No intervention showed superiority for any end point confirming findings from previous studies[21,22]. However, it is well accepted that patients submitted to cardiac or thoracic surgery need ventilatory special attention.

As a result of sternotomy and the insertion of thoracic and mediastinum drainage tubes, the majority of these patients tend to present a restrictive disturbance with reductions in the pulmonary volumes and capacities[23]. Thus ventilation tends to be compromised and the diffusion of systemic oxygen also tends to be reduced[24], as shown by the low oxygen levels found in the arterial blood in exams such as gasometry, up to 72 h after the surgical procedure. The exercise tolerance of these patients tends to be lower, demanding an exercise prescription that respects the balance between oxygen offer and consumption, avoiding an overload which, in this specific case, can lead to hemodynamic instability[25-27]. So there is a clear paradox: although it seems clearly reasonable to accept that respiratory interventions are needed in this population during phase I of cardiac rehabilitation, this is still not supported by strong evidence (Table 1).

THE SUBJECTIVITY OF PHASE I OF CARDIAC REHABILITATION

When evaluating current protocols for phase I of cardiac rehabilitation, subjectivity regarding exercise prescriptions can be noted. The intensity is still determined in a subjective way[34], both for patients after cardiac surgery and for patients after acute myocardial infarction (AMI), using a quantitative index, which is the perceived effort index scale, or even the rating of fixed increments in the values for increase in heart rate, such as +30 bpm for post-acute myocardium infarction patients, or even +20 bpm for post-heart surgery patients[35,36]. In addition there are no specific descriptions of models for respiratory exercise prescriptions (essential for patients after surgery), where the series and repetitions are defined in a random way according to the patient's tolerance. In general the intervals between series are also defined by the patients, which is also subjective in relation to the activity and recovery time or according to the training density[36].

Respiratory exercises still fail to present standardized prescriptions of series repetitions, and a difficulty in adjusting the overload was noted, since the rating of the values for the increment in heart rate could signify different levels of exercise intensity. For example, 130 bpm for a 70-year-old individual with a resting HR of 65 bpm

Table 1 Presentation of end-points of papers disclosed since 1992 about evidence based on cardiopulmonary physiotherapy

Study	Design of study	Study objective	Study conclusions
Dean *et al*[28], 1992	Review study involving 61 articles	Examines advances in cardiopulmonary physiology and clinical medicine since the development of classic chest physical therapy practice, and the discordance of current physical therapy practices with the physiologic advances	(1) Cardiopulmonary physiology, pathophysiology and clinical medicine have advanced exponentially compared with physical therapy; (2) Establishing the efficacy of conventional chest physical therapy has been confounded by the lack of specificity of the underlying pathophysiology; (3) Needed to define the parameters for prescribing, position and mobilization so that the efficacy of these noninvasive interventions can be maximally explored in patient care
Stiller *et al*[29], 1994	Randomized controlled trial, involving 127 patients	Investigate whether prophylactic chest physical therapy affected the incidence of postoperative pulmonary complications	The results suggest that the necessity for prophylactic chest physiotherapy after routine coronary artery surgery should be reviewed
Johnson *et al*[30], 1996	Randomized controlled trial involving 78 patients	To determinate whether higher personnel intensive chest physical therapy can prevent the atelectasis that routinely follows cardiac valve surgery	The routine prescription of high intensity physical therapy does not improve patient outcomes but does add significantly to patient costs
Stiller[31], 2000	Review study involving 82 articles	To evaluate actuation of physiotherapy in intensive care	Although recommendations can be made concerning evidence based practice for physiotherapy, in the intensive care unit (ICU) these are limited because of the lack of data evaluating the effectiveness of physiotherapy in these settings. There is an urgent need for further research to be conducted to justify the role of physiotherapy in ICU
Wynne *et al*[32], 2004	Metanalyses involving 159 articles	To evaluate postoperative pulmonary dysfunction in adults after cardiac surgery	No single method of pulmonary physiotherapy is superior to others in preventing pulmonary complications
van der Peijl *et al*[33], 2004	Randomized controlled trial involving 246 patients	Compare the effectiveness of a low frequency program with high frequency and to assess whether the latter would yield sufficient benefit for the patient to justify higher costs in material end personnel	High frequency exercise program leads to earlier performance of functional tasks but would allow a sensible redistribution of the physiotherapists activity towards complicated and, therefore, more demanding patients
Pasquina *et al*[20], 2003	Review study involving 18 trials (1457 patients)	To assess whether respiratory physiotherapy prevents pulmonary complications after cardiac surgery	The usefulness of respiratory physiotherapy for the prevention of pulmonary complications after cardiac surgery remains unproved

represents an effort of 83.5% of the reserve heart rate (RHR) according to Karnoven's formula, whereas for a 55-year-old individual with the same resting HR of 65 bpm, it represents 75% of the RHR, according to the same formula. Similarly, an increment of 20 bpm during an exercise for an individual with a resting heart rate of 100 bpm can represent a different effort than the same increment for an individual with a resting HR of 80 bpm. This subjectivity in relation to the principles of overload, reversibility and specificity in exercise prescription, explicit in the protocols for phase I of cardiac rehabilitation, warrants a prospective study that would assess current models of exercise prescription. The scientific community should be aware of the lower level of evidence to assess the efficacy of physical therapy. Moreover, exercise prescription during the hospital phase has to be redefined.

The subjectivity in relation to the basics principles of exercise prescription in phase I of cardiac rehabilitation.

In 1768, Herbeden observed that a patient with chest angina significantly improved after wood chopping for half an hour every day. This finding, described by White[37], was one of the first publications referring to the benefits of physical activity on cardiopathies. Nevertheless physical activity as a form of treatment was put aside until the beginning of the twentieth century mainly because of the seriousness that cardiopathy represented to the patient's health. During the sixties, as bed rest was mandatory as part of the treatment in any cardiopathy[38,39] a few studies started demonstrating the deleterious effects of bed restriction not only physically, but also psychologically[40-42].

A trend for early mobilization took a while to become routine in the larger centers, and in 1969 a 3-wk bed rest period was still common after AMI. For years authors like Miller[43] argued that the myocardium continued to take risk when the muscle was precociously mobilized, since the removal of necrotic areas of the myocardium was not complete before the end of the fourth week and collateral circulation could take longer to be recruited. Such publications led many specialists to discuss the subject as the I International Congress on Cardiac Rehabilitation in Hamburg, in 1977, when the need for early mobilization was affirmed[44]. In 1993 the World Health Organization defined cardiac rehabilitation as the sum of the activities required to favorably influence both the subjacent cause of the disease and the physical, mental and social conditions of the patient, allowing patients to preserve or reassume their role in the community as soon as possible. As the years went by, cardiac rehabilitation programs grew in importance as a result of their[45-47], great social relevance[48,49]. According to Charlson *et al*[50], the increase of risk factors towards cardiovascular diseases among the elderly population increase the number of CABG procedures, which is associated with a significant reduction in

Table 2 Presentation of the ACSM recommendations for the prescription of exercises in phase I of cardiac rehabilitation

Intensity
TPE below 13 (scale 6-20)
Post AMI: HR below 120 bpm or resting HR + 20 bpm (Arbitrary lower limit)
Post-surgery: resting HR + 30 bpm (Arbitrary upper limit)
Up to tolerance if non-symptomatic
Duration
Intermittent sessions lasting from 3 to 5 min
Resting periods
As the patient wishes
Lasting from 1 to 2 min
Shorter than the time of the exercise sessions
Total duration of 20 min
Frequency
Early mobilization: 3 to 4 times per day (1st to 3rd days)
Subsequent mobilization: twice per day (As from the 4th day)
Progression
Initially increase the duration by up to 10 to 15 min of exercise time and then increase the intensity

AMI: Acute myocardial infarction; TPE: Table of perceived effort; HR: Heart rate; ACSM: American college of sports medicine.

physical capacity[48,49]. Seventy to 80% of patients submitted to heart surgery tend to recover their complete work capacity 1 year after procedure. This delay could be attributed to post-operative complications such as atelectasis, and pneumonia[51-53], which, amongst others, contributed to a reduction of physical aptitude of the patients during their hospital stay, resulting in a slower recovery[54-57]. According to American college of sports medicine (ACSM), cardiac rehabilitation can be divided into 4 phases[30].

Phase I, known as the hospital phase, aims to minimize the effects of restriction to bed and ends with hospital discharge. Phase II (up to 12 wk) starts immediately after discharge and is known as the early out-patient phase[47,48]. The aim is to develop activities that simulate the metabolic expense of everyday activities. Phase III, known as the late out-patient phase (variable duration) aims to develop exercises with more intensity[47,48]. The fourth and final phase is known as the preventive phase and should have a starting date but not a finishing one, where the patient will choose a cyclical activity of greater affinity, carrying out the program at least 3 times a week throughout one's lifetime[18].

Despite the fact that phase I is considered to be most important in the rehabilitation program, it presents a subjective prescription of exercises. Nevertheless it is one of the most used protocols throughout the world and is used as a study tool by many professionals. ACSM recommendations for the prescription of exercises in phase I of cardiac rehabilitation (both for patients after AMI and for patients after surgery) are shown in Table 2. The subjectivity of the phase I protocol can be perceived from the definition of the intensity of the exercises, where this should be controlled from the table of perceived effort (TPE). This table was developed by Borg (1979) with the objective of allowing the individual who exercises to subjectively classify the sensations during exercise, taking into account the level of personal aptitude, the environmental conditions and the level of fatigue[58,59]. There are currently two TPE scales in use, one classifying the exercise intensity from 6 to 20, and the revised one classifying it from 0 to 10. In addition to control by TPE, exercise intensity can be defined from the variation in heart rate, where post-AMI patients should increase their HR by a maximum of 20 and 30 bpm from resting during the exercise[60]. The control of the exercise intensity by the HR with a pre-determined target does not individualize the prescription of the exercise. Thus individualization, one of the principle fundamentals for the success of the exercise prescription[61], is not respected. In addition, the control of the perceived effort defined by the patient himself, may not picture the true energy consumption with respect to the activity. The value representing the effort can be super-estimated by the more apprehensive patients, or even sub-estimated by more motivated patients.

The intra-hospital protocol, in agreement with ACSM, suggests that an exercise session should last approximately 20 min. The session should be composed of intermittent series of exercises, each lasting between 3 and 5 min, with intervals between the series defined according to the wishes of the patient, or lasting between 1 and 2 min or even shorter than the duration of the exercise sessions. The interval between series appears as the main tool for the principle of reversibility or recovery, being as important as the definition of the series of repetitions. The interval should be defined from the volume and intensity of the exercise carried out, based on metabolic recovery of the energy sources and in the composition of the muscle fibers involved in movement[61]. Thus leaving the definition of the interval time to the discretion of the patient could, for example, generate unnecessary overload, resulting in prejudice to the patient. Thus, it's clear that the criteria for the definition of progression of the series and control of the intensity are still subjective[62]. The individualization of exercise prescription is essential, especially for patients after cardiac surgery. At this moment (phase I), patients have reduced cardiopulmonary reserve in regard to their exercise tolerance[63], meaning it is necessary to provide a judicious prescription controlling its specificity, overload and reversibility. These three basic principles of exercise prescriptions, as described by Bompa[64], must be respected so that the prescription can provide some benefit to the individual independent of his level of physical aptitude, be the patient a recently operated cardiac patient or an athlete.

The principle of specificity defines the effects of training. Improvement and potentiation of the predominant energy substrate system relies on its proper identification. Then an individualized exercise plan that meets the specific needs of the patient can be carried out. Thus the non-inclusion of a well-defined program of respiratory exercises for post-operative heart surgery patients represents the lack of specificity of the present method of phase I cardiac rehabilitation. As a result of median sternotomy and the insertion of thoracic drainage tubes, these patients tend to present with a reduction of up to 30% in their pulmonary volumes and capacities. According to Guizilini *et al*[27], a decrease in forced ventilatory capacity can determine a fall in the expiratory flow peak, which also decreases immediately after surgery. This fall is clinically important since it will compromise the ability to cough and remove respiratory secretions[5]. The precocious closing and obstruction of the small airways predisposes the individual to microatelectasis and consequently to a reduction in the partial oxygen pressure in the arterial blood (PaO_2)[64,65]. Thus if pulmonary re-expansion is not rapidly reestablished, exercise tolerance will be promptly reduced[66-68]. The overload principle establishes that a tissue or organ has to be exposed to a load to which it is not used in order to improve its function (McKirnan *et al*[66]). Repeated exposition is associated with an adaptation on the part of the tissue or organ, which results in an improvement in the functional capacity. An exercise prescription should determine the intensity, duration and frequency of the training session meaning the interaction of these three variables determines the cumulative overload to which the tissue or organ should adapt[64].

INDIVIDUALIZATION OF EXERCISE PRESCRIPTION DURING HOSPITAL PHASE: A NEED TO BE ACHIEVED

The exercises should follow an adequate progression for organ or tissue adaptation. The activity can progress by progressive load model, where it is necessary to plan exercise sessions with the same characteristics in a determined time period or microcycle[64]. An increase in the load of exercises causes a slight physiological imbalance, followed by an adaptation phase, resulting in an improvement in performance[65]. The specificity of the prescribed exercises can directly influence the total session time, depending, obviously, on the clinical situation of the patient and on one´s level of physical aptitude[63]. One example is the prescription of respiratory exercises for post-operative heart surgery patients. In order to tolerate peripheral active exercises, many patients require specific respiratory work in order to potentially increase pulmonary volumes and capacities and gaseous exchange, consequently improving the distribution and capture of systemic oxygen and improving exercise tolerance[66].

Thus it is very difficult to standardize the session time without defining the specificity of the exercises or the work to be carried out with each patient[61]. The third basic principle of exercise prescription is that of reversibility[64]. This can be passive or active, where continuous low intensity exercises can help the metabolic recovery of the individual. In addition, the anatomical-physiological modifications that allow the individual to gradually increase his/her load intensity depend on the overload principle and on the pauses for recovery. The training programs should show intensity, duration and recovery periods that allow the organism to adapt so as to try and recover functional homeostasis (Barbanti[5]). Quite apart from the general principles for the adjustment of exercise prescriptions, the components of a session should also be respected. An exercise session should include a warming-up period, a specific work period referring to the initial objective of the work, a period of recreational activity and a winding-down period[65].

These components arise within an exercise session according to the objective of the prescribed series and the level of physical aptitude of the individual. The need to supervise the longitudinal evolution of an exercise prescription, respecting the general principles and aiming at constantly improving performance, motivated competitive sports trainers to develop a structure that helped in the organization and planning of the activities. Thus models for sports training periods were developed (Gomes[65]). The overload principle, directly responsible for the improvement in physical aptitude, can be represented by the increment in volume or in the intensity of the activity. A random increase in the exercise time, associated with a random definition of the interval between exercises, makes it difficult to prescribe the progression of the series. Thus the problem defining the overload activities for hospitalized individuals makes it difficult to program the series or divide it into periods, including the program of activities to be performed after discharge.

The methods for exercise prescription are represented by the strategies used to obtain a better yield or adaptation to the exercise. There are two main patterns: continuous and intermittent. Continuous exercise is of a submaximal nature and medium to long term, with intervals not permitted. The moderate intensity makes it possible to maintain the effort for a longer period of time. Intermittent exercise is characterized by a series of repeated periods of exercise alternated with periods of active rest or recovery intervals. The repeated series of exercises can have previously defined numbers, duration, intensity and intervals (McArdle *et al*[8]). It is important to point out that Kirkeby-Garstad *et al*[61] questioned the efficacy of low intensity activities in this phase of cardiac rehabilitation. The correct combination of stimulus intensity and duration with adequate recovery intervals allows the individual to support more intense activities.

PERIODIZATION IN HOSPITAL PHASE OF CARDIAC REHABILITATION: A NEW IDEA FOR PHYSICAL THERAPY BASED ON EVIDENCE

The difficulty found in demonstrating the results of a subjective program of prescribed exercises in the hospital phase (phase I), has contributed to the lack of adhesion to rehabilitation programs. Currently, less than 25% of the patients eligible for rehabilitation are enrolled in training programs in specialized centers in developed countries (Carlson *et al*[69]). After CABG these values reach 25%-50% of the cases. When the number of patients taking part in supervised rehabilitation programs in developed countries is considered, 25%-50% give up after 6 mo and more than 90% after 1 year. The pertinent protocols have been shown to be non-executable in daily practice. Thus the need has arisen to redefine the methodology for prescribing exercises for phase I so as to motivate participants to continue in the rehabilitation program, and primarily to demonstrate objectivity in their prescription, respecting the basic exercise prescription principles.

Over the years, medicine has based itself on personal experiences, on the authority of more titled academics and on the descriptions of physiopathological theories. According to Atallah *et al*[70], evidence based medicine has arisen to guide decisions about health care. In a way, this conception of medicine removes the emphasis on practice based on intuition and on non-systematized clinical experience. Thus, according to Sackett *et al*[71], clinical reasoning in the form of research gains special distinction. In addition to new followers, evidence based physiotherapy is currently gaining importance since the activities of the professionals do not simply limit themselves to the clinical or medical diagnosis, but also include an evaluation of the repercussions or impact the disease brings to the life of the individual. Thus descriptive epidemiology becomes fundamental for the knowledge of a certain disease and its repercussions, where the physiotherapist should establish his/her diagnosis, prognosis, activity or treatment program, also carrying out interventions or reevaluations. The professional should fall back on books and periodicals to find the theoretical foundation to define the treatment program and apply a certain technique or exercise prescription methodology. The evidence levels produced in scientific studies are used as classification criteria according to the quality of studies in the health area[70].

Thus Wright *et al*[34] questioned the benefit of low intensity exercise for heart surgery patients. For his part, Hulzebos *et al*[72] stated that the physiotherapeutic techniques applied to post-heart surgery patients in the hospital phase, presented controversy regarding their efficacy in reducing the incidence of pulmonary complications. Britto *et al*[73] showed a significant lack of evidence regarding the effectiveness of physiotherapeutic techniques applied in the treatment of pulmonary empyema in the hospital phase, and, according to the author, the clinical decision taken by the physiotherapist was based on studies, the majority of which presented rudimentary methods, on personal experiences and on information obtained from books and from the opinions of professors and experts. Crowe *et al*[22] questioned the effectiveness of using inspiratory boosters associated with respiratory physiotherapy in the pulmonary re-expansion of patients with a high risk for respiratory complications, already in the hospital phase of patients who suffered an AMI and submitted to CABG[74], Overend *et al*[75] evaluated the effect of incentive spirometry (IS) on postoperative pulmonary complications (PPC), and it follows that the evidence does not support the use of IS for decreasing the incidence of PPC following cardiac or upper abdominal surgery. Thus it is apparent that some of the results referring to the prescription of exercises in cardio-respiratory physiotherapy are being questioned.

PHYSIOTHERAPIC APPROACH AND NEEDS

The physiotherapic approach and needs are different. The methods of prescribing exercises during in hospital phases need an urgent review, especially the methods related to cardiac surgery. Currently different needs such as individualization and periodization of exercise prescription during the hospital phase of cardiac rehabilitation should be studied, aiming to improve outcomes and levels of evidence regarding the application of techniques of cardiopulmonary physiotherapy. From the subjective way that is done today, exercise prescription at this stage has little effectiveness. It´s not possible to argue in the 21st century the efficacy of physical therapy in this field. Maybe the starting point for reviewing methods of prescription in phase I is to take a look at subjective quality related to the basic principle of exercise prescription: specificity, overload and reversibility. Importing the periodization applied on sports training programs and respecting the different levels of physical aptitude during the hospital phase may help improve the quality of prescription.

CONCLUSION

Thus phase I of cardiac rehabilitation has become a challenge for evidence based physiotherapy, having the means for success with the adjustment of a new exercise prescription model as long as this model is based on the principles of the clinical physiology of exercise, in the individualizing of the prescription. There is a real necessity for prospective randomized clinical trials in the physical therapy field. Maybe the way of programming the activities, creating a pattern including periods with well defined micro-cycles and series based on the application of functional tests, could guarantee greater objectivity, greater adherence to the programs and, as a consequence, better results.

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