Universitat de Girona
Facultat de Medicina

FINAL DEGREE PROJECT

THE IMPLEMENTATION OF A CARDIAC REHABILITATION PROGRAM ADAPTED TO CHILD'S REQUIREMENTS IN PAEDIATRIC POPULATION WITH CONGENITAL HEART DISEASE

A RANDOMIZED, CONTROLLED, AND OPEN-LABEL CLINICAL TRIAL

AUTHOR: Mireia Boadas i Gironès

CLINICAL TUTOR: Dr. Eloi Arias Labrador

METHODOLOGICAL TUTOR: Dr. Rafel Ramos Blanes

Girona, November 2021

M'agradaria agrair a totes les persones que han fet possible aquest treball:

En especial, gràcies a l'Eloi, per la seva dedicació i motivació en tot allò que fa. Gràcies per ensenyar-me que hi ha molt més darrere la Medicina que estudiem.

Gràcies també a tota la Unitat de Rehabilitació Cardíaca i als seus pacients, especialment a en Pol i en Dani, que durant aquest temps m'han fet sentir una més de l'equip.

Gràcies també a en Rafel, per resoldre i ajudar-me en totes les adversitats sorgides.

I finalment, gràcies a la meva família i amics, ja que sense el seu suport i ajuda durant tots aquests anys, el camí s'hagués fet molt més dur.

Gràcies!

INDEX

INDEX OF FIGURES AND TABLES

1. ABBREVIATIONS

ACHD AP	Adult congenital heart disease anatomic and physiological
ACSM	American College of Sports Medicine
AHA/ACC	American Heart Association / American College of Cardiology
ALCAPA	Anomalous left coronary artery from the pulmonary artery
ANOVA	Analysis of variance
ASD	Atrial septal Defect
AT1	Aerobic threshold
AVSD	Atrioventricular septal defect
BMI	Body mass index
CEIC	Comitè d'Ètica d'Investigació Clínica
CHD	Congenital heart defect (or disease)
CPET	Cardiopulmonary exercise test
CRP	Cardiac rehabilitation program
DORV	Double outlet right ventricle
ECG	Electrocardiography
ESC	European Society of Cardiology
GREC	Grupo Español de Cineantropomería
HCM	Hypertrophic cardiomyopathy
HF	Heart failure
HR	Heart rate
HRQoL	Health-related quality of life
IMT	Inspiratory muscle training
LVEF	Left ventricular ejection fraction
MET	Metabolic equivalent of task
MIP	Maximal inspiratory pressure
NYHA FC	New York Heart Association Functional Classification
PA	Physical activity
PAH	Pulmonary arterial hypertension
PCQLI	Paediatric Cardiac Quality of Life Inventory

PS	Pulmonary stenosis
SD	Standard deviation
SEC	Socieddad Española de Cardiología
SEPAR	Sociedad Española de Neumologia y Cirugía Torácica
SPSS	Statistical Package for Social Sciences
SSC	Stretch-shortening cycle
STAI-C	State-Trait Anxiety Inventory for Children
TAPVC	Total anomalous pulmonary venous connection
TGA	Transposition of the great arteries
VO_2 peak	Peak oxygen uptake
VSD	Ventricular septal defect
WHO	World Health Organization
6MWT	6 minutes walking test

2. ABSTRACT

BACKGROUND. Congenital heart diseases are the most frequent malformation that occur during birth. Due to the extraordinary advances in diagnosis and treatment, nowadays, a huge number of children reach adulthood, however, evidence demonstrates that these children are involved in some functional and cognitive limitations, outlining lower physical condition and quality of life. Implementing a cardiac rehabilitation program for those patients has shown an improvement of quality of life and cardiopulmonary endurance, even though, an insignificant percentage of children around the world take part in what of them. This may be explained by a lack of adaptation to the interest of the child, thus decreasing his motivation.

OBJECTIVE. This clinical trial aims to assess whether a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics improves the health-related quality of life in congenital heart disease paediatrics population, in comparison to those who participate in a conventional cardiac rehabilitation program.

DESIGN. A prospective, randomized, controlled and open-label intervention clinical trial, carried out in Cardiac Rehabilitation Unit in Parc Hospitalari Martí i Julià.

PARTICIPANTS. Participants included in this study are children from 8 to 12 years old with a diagnosis of congenital heart disease in the Region of Girona. The sample size will be 106 patients, with 53 in each group.

METHODS. 106 patients will be recruited in a random simple sampling from the Hospital database, and contacted with their legal guardians by phone. Patients will be randomized into two groups, an experimental group that will be undergoing a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics; and a control group that will take part in a conventional cardiac rehabilitation program. Apart from the training exercise, both programs will be equally. Patients will be assessed for measure endpoints of the study before starting the program, in 6-week, finishing the program (12-week), in 6-month and 12-month follow-ups. Results will be analysed and compared in both groups.

KEYWORDS. Congenital heart disease, cardiac rehabilitation, paediatrics, plyometrics, Nordic walking, outdoor, game-based, quality of life.

3. INTRODUCTION

3.1. COGENITAL HEART DISEASE

3.1.1. DEFINITION

A congenital heart defect (CHD) is defined as any anatomical o functional abnormality that affects any structure of the heart including its cavities, valves, septum, or blood vessels, and is present at birth (1,2).

3.1.2. EPIDEMIOLOGY

Congenital heart defects are not rare, not abstractly, they are the most frequent malformation that occurs during birth. As well, CHD are considered the leading cause of perinatal and infant death from a congenital birth defect (3).

Its incidence in Catalunya is around 0,8% of the alive newborns (4). If we use the data given by Idescat (5) of the number of alive births in 2020 we can reach the conclusion that there are around 500 new cases each year in Catalunya, more concretely, 50 in the Province of Girona.

Critical CHD represents around 25 % of all CHD patients (6). Thanks to the great advances in diagnosis and consequently an earlier and more accurate treatment, nowadays, 85 - 90% of the patients with CHD survive into adulthood (7). Nonetheless, even the survival tax has improved, children with CHD seem to be involved in some functional limitations and cognitive deficits, emphasising the lower physical condition and psychosocial quality of life (7).

The most common CHD defect is the ventricular septal defect, followed by the atrial septal defect and pulmonary stenosis (8).

3.1.3. EMBRYOLOGY

Embryogenesis is such a meticulous and complex process that any tiny modification during these stages can produce serious consequences in the newborn.

The cardiovascular system is one of the first ones to be developed, starting beating and pumping blood around day 21st or 22nd (9). In the seventh week, the heart of the fetus doesn't differ too much from an adult one. For this reason, that weeks are crucial for proper heart formation.

A timeline of that process is shown in **Figure 1**.

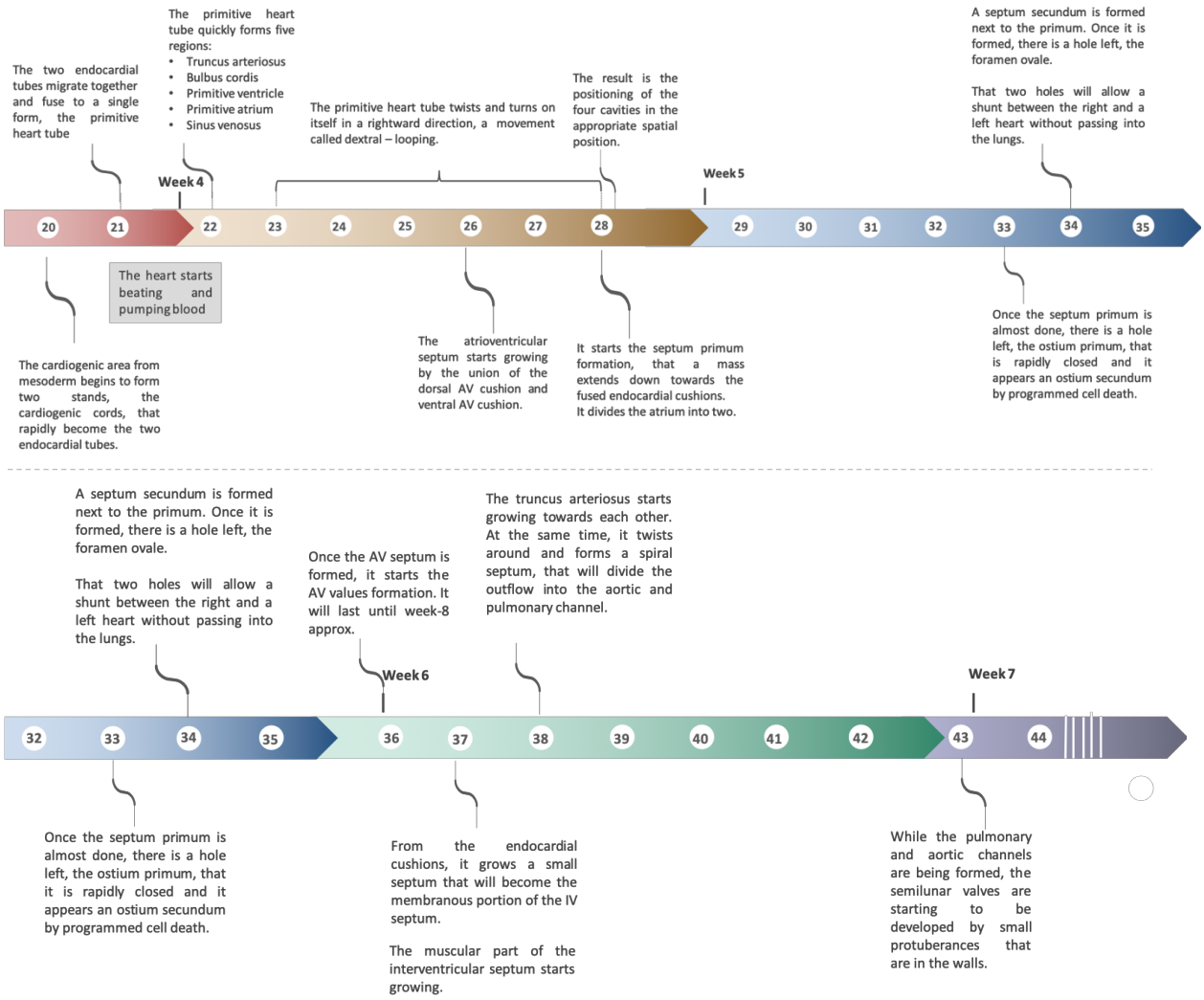


Figure 1. Timeline of heart development. Own elaboration. Source (10).

Congenital heart defects are a result of any change produced during the complex embryological heart development. In ***Table 1*** is summarized the target tissues and the birth defects that can be caused when a stage of the process is affected. It is relevant to highlight that not always a birth defect is caused by only one specific alteration, otherwise, the same cardiac malformation can be resulted from different variations in time stages.

Table 1. Heart development stages that are susceptible for a birth defect. Source (10)

Target tissue	Cell process	Normal effect	Birth Defects
Primary heart field	Establishment of laterally and patterning	Formation of the four chambered heart	Double outflet right ventricle; transposition of the great arteries (TGA); left-trans-position of the great arteries; ventricular septal defect (VSD)
Heart tube	Genetic signalling cascade for normal looping	Looping	Dextrocardia
AVC endocardial cushions	Cushion formation: cell proliferation and migration	Division of the atrioventricular canal into left and right channels; formation of the mitral and tricuspid valves and the interventricular septum	VSD, mitral and tricuspid valve defects; position and leaflet defects
Secondary heart field	Splanchinc mesoderm ventral to the pharynx and signalling from neural crest cells	Lengthening and partitioning the outflow tract into aortic and pulmonary channels	Tetralogy of Fallot, TGA, pulmonary atresia and stenosis
Outflow tract (conotruncus)	Neural crest cell migration, proliferation and viability	Formation of the conotruncal cushions for division of the outflow tract	Common truncus arteriosus and other outflow tract defects
Aortic arches	Neural crest cell migration, proliferation and viability	Pattering the arches into the great arteries	Anomalous right pulmonary artery; Interrupted aortic arch type B

3.1.4. ETIOLOGY AND RISK FACTORS

Nowadays, we unknow the real cause of that origins malformations or alterations in cardiac development. It is highly likely that there are genetic alterations that are involved in that scenario. Becoming a multifactorial origin, involving genetic factors and environmental ones. In other words, the malformation could be expressed when there are addictive underlying effects that get over a threshold. Nevertheless, a large part of that elements hasn't been identified (11).

Actually, almost 10 % of the cases are associated with known chromosomal variations seen in conventional techniques. Hopefully, in the next years, that percentage will increase thanks to the innovation in molecular and genetics techniques (12) .

On the other hand, almost 3 % of the cases are related to environmental factors (8). Even though, it is hard to determine a directly cause-effect connection between environmental

factors (cause) and the congenital defect (effect), due to the variability of the risk and the etiological heterogeneity of abnormalities that are phenotypically similar. The most relevant environmental factors are shown in **Figure 2** below.

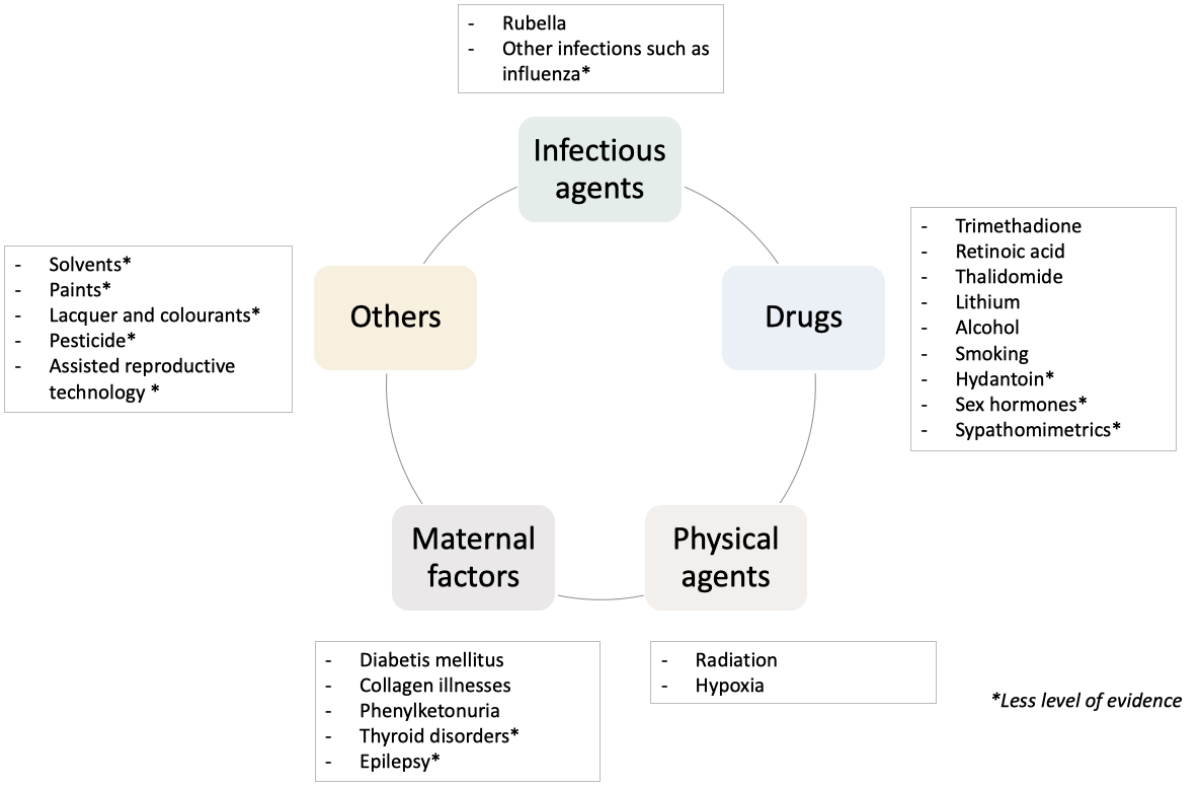


Figure 2. Environmental factors that are related to CHD. Adapted from (8,13) .

3.1.5. CLASSIFICATION

There are large types of congenital heart defects that can be classified in different ways, such as their physiology, anatomy, or clinical presentation. Notwithstanding, one of the most useful and commonly used is the physiopathology classification.

This classification is based on the way in how the defect works (physiological) and its clinical effects (pathological). It divides cardiopathies, according to a syndromic view, in cyanotic and acyanotic, and with shunt or without it (14).

3.1.5.1. ACYANOTIC CARDIOPATHIES

Acyanotic CHD are defined as anatomical connections between pulmonary and systemic circulations, in which the blood contains enough oxygen, but it's pumped throughout the body in an abnormal way (15). For this reason, these malformations do not involve alterations in the amount of oxygen in the blood.

These can be divided into (14):

- **Left to right shunts**, where, oxygenated systemic blood flow on the left side of the heart shunts on the partially deoxygenated pulmonary blood flow on the right sight of the heart. These do not cause cyanosis at birth but can result in heart failure due to the overload volume and hyper pulmonary flow (15,16).
  In these groups are included almost 50 % of the CHD, becoming the most numerous type.

- **Obstructive left lesions.** Are all defects that can affect since pulmonary venous until thoracic aorta, blocking or difficult the blood flow through the left side of the heart.

- **Acyanotic obstructive right lesions,** concretely are lesions that reduce the blood flow through the pulmonary artery, without involving hypoxemia.

- **Miscellaneous lesions.** in this group are included all acyanotic CHD that do not have even a left-right shunt nor an obstructive lesion.

3.1.5.2. CYANOTIC CARDIOPATHIES

Cyanotic heart defects are a heterogenic group that all of them have in common the presence of a right-left shunt at a cardiac level. This shunt produces a reduction in the amount of oxygen that is delivered to the body, in other words, hypoxemia. Consequently, the skin and mucosa may express a bluish colour, that receives the name of cyanosis (14). But, not always, all the hypoxemic patients will be visibly cyanotic at all times (17).

From a physiopathological view, these defects can be divided into (14):

- **Cyanotic congenital heart defects with increased pulmonary blood flow.** Characteristically, this group can develop heart failure and pulmonary hypertension (PAH).

- **Cyanotic congenital heart defects with decreased pulmonary blood flow.** This group may also be ductus-dependent, but they do not develop PAH.

Cyanotic lesions may be **ductus dependent**, which means that they need the permeability of the ductus in order to maintain systemic or pulmonary circulation. With these patients, there must be a rapid initiation of prostaglandin E1 in order to reopen the ductus and maintain circulation (18). Almost all cyanotic lesions are ductus-dependent.

Non-ductus-dependent congenital heart defects that cause cyanotic include (18):

- Total anomalous pulmonary venous connection (TAPVC).
- Truncus arteriosus
- Tetralogy of Fallot and tricuspid atresia, may or not be ductus-dependent. It is defined by the degree of right ventricular outflow tract obstruction and the ventricular septal defect in tricuspid atresia.

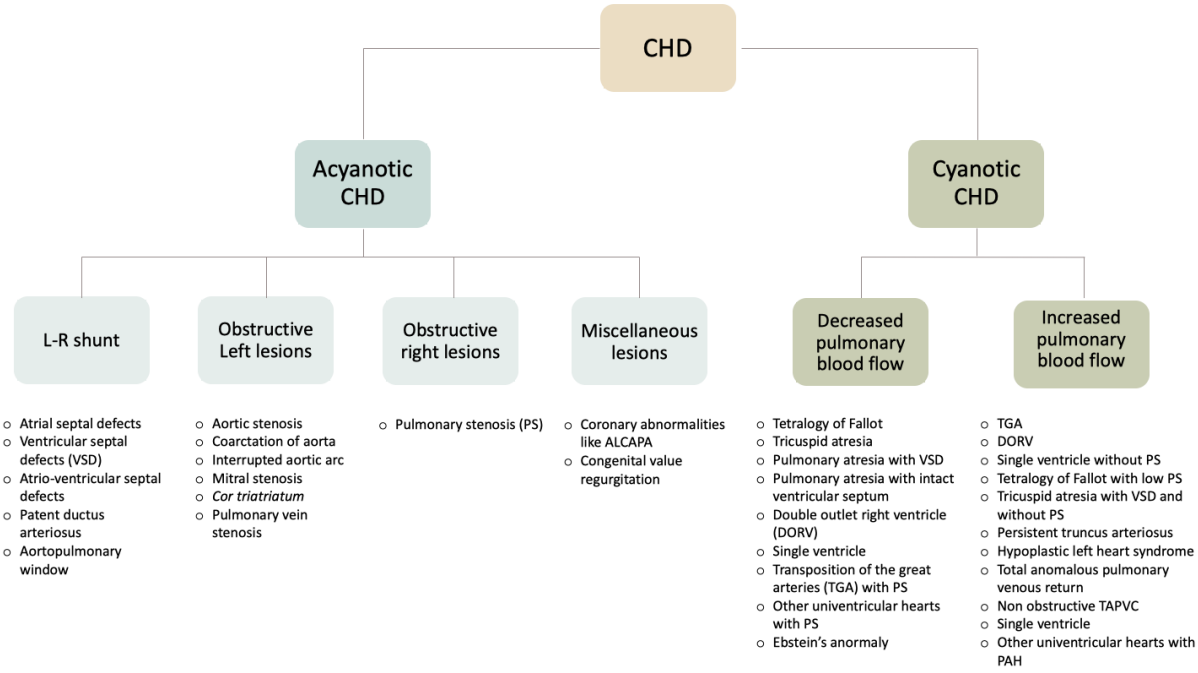


Figure 3. Classification and types of CHD. Modified from (19)

3.1.6. THE ACHD AP CLASSIFICATION

In a patient with CHD, the severity of the disease is not only defined by its anatomy or surgical treatment that may need, but it is also essential the physiological consequences that it causes. Prior and classical classifications normally join together all patients that have the same defect. As a consequence, they generally have the same physical restrictions, especially when we talk about physical activity. However, not always have the same physiological stage, which means that some patients are not receiving their fittest recommendations and follow-up.

In 2018 AHA/ACC publish an updated *Guideline for Management of Adults with Congenital Heart Disease* (17). In this guideline, there is a new and useful classification, ACHD AP Classification, that intends to capture the complexity of the CHD anatomy and physiology, that as I said before, is not always correlated. It is found in ANNEX 1.

It is indeed an adult-based classification but analysing it, it could be highly helpful in children, considering that the variables included in the classification have an important role in prognosis, management, and quality of life (17).

3.1.7. CLINICAL MANIFESTATIONS

Congenital heart defects have a range of signs and symptoms, depending on their structure and shunt. In general words, that signs are referred to as hypoxemia or, in severe stages, congestive heart failure that CHD can involve.

The most common signs are excessive sweating, fatigue, tachycardia, tachypnoea, excessive irritability, alterations in sleeping, swelling of the legs or around the eyes, poor feeding, central cyanosis, chest paint, and clubbed fingers (11,18,20).

In the case of cyanosis, this one will get worse when the baby is crying (21).

Even the heart defects are developed before birth, not always the signs and symptoms are noticeable during the early times. The mild symptoms do not develop until early childhood or even teenage years. And just the severe ones are noticeable soon after birth, normally at two weeks of age when the ductus arteriosus closes (ductus-dependent ones).

3.1.8. DIAGNOSIS

Congenital heart disease may be diagnosed during pregnancy, after birth, or even during the child or adulthood.

In 2013, the International Society for Ultrasound in Obstetrics and Gynaecology, recommended that antenatal ultrasounds should include an assessment of the four chambers and the outflow track, in order to recognize a CHD (22). If something is abnormally seen, or there are risk factors, the next stage is a specialist ultrasound, called foetal echocardiography. This one can be carried out around 18 to 24 weeks, and it will let analyse more accurately the structures and the blood flow of the fetus' heart (23).

During the birth hospitalization, CHD can be diagnosed thanks to routine examination. For this reason, the diagnosis is based on the clinical presentation, anamnesis, and physical examination, which includes observation, pulse oximetry, and hearing with a stethoscope. Heart murmurs can be decisive for diagnosis (23).

The timing depends on its ductus dependence and the severity of the lesions (18).

During the second week approximately, if we are in front of a severe and ductus-dependent undiagnosed CHD, the newborn will have a rapid clinical deterioration, due to the closure of the ductus. It will come to the emergency department with shock caused by inadequate systemic perfusion, central cyanosis, cardiac arrest, severe metabolic acidosis, or another end-organ.

However, some defects do not cause any noticeable symptoms for months or even years. In these cases, apart from the physical examination, another testing should help to confirm the diagnosis, such as echocardiography, electrocardiogram, chest X-ray, pulse oximetry, cardiovascular MRI scanner, or even biomarkers and cardiac catheterization (24).

3.1.9. TREATMENT

Not everyone with a congenital heart defect requires treatment. It strictly dependents on the type of defect that the patient has, and the clinical manifestations that are involved.

In some cases, one or more surgeries or cardiac catheterization may be needed in order to repair the structural defect or to reduce the systemic effects that are involved (25). Other

cases, may only need a periodical visit by a cardiologist and stay under observation for any changes.

On the other hand, children and adults with CHD may also need medical treatment to treat the congestive heart failure, arrhythmias, or pulmonary hypertension that CHD can cause.

3.1.10. LATE COMPLICATIONS

In the last decades, new surgical technics in paediatric heart surgery have significantly reduced mortality rates for children with CHD (26). Although this, it is strongly essential to comprehend that surgical treatment in CHD is seldom curative, so many adolescents and adults that had been treated during their infancy will lately have some significant drawbacks, such as neurodevelopment, psychosocial or physical morbidities that may affect their quality of life. For this reason, it is important to highlight that a regular follow-up of these patients should focus on early signs of these complications.

Some of these complications are:

- **Heart failure (HF),** is a complex clinical syndrome that involves impairment in the ventricle function, disrupting the ability of the ventricle to fill or eject the blood. It results from a structural or functional cardiac disorder, in this case, due to de CHD (27). The prevalence of HF in patients with CHD is almost 40 % during their adulthood (27).

- **Arrhythmias**, are the most frequent long-term complications in CHD patients and are the main cause of mortality and morbidity in adulthood. CHD involve several types of arrhythmias, being the intraatrial reentrant tachycardia (IART) the most common one (28). The incidence of these arrhythmias often increases among the ages. More serious ventricular arrhythmias are often rare in CHD, but once they reach adulthood ventricular tachycardia and **sudden death**, is a serious risk that it should be considered in some patients (28).

- **Pulmonary arterial hypertension (PAH),** is defined as high blood pressure in pulmonary arteries, that can damage the right side of the heart (29). Is mainly caused by a left-right shunt that produces an overload pulmonary flow. Almost all CHD patients with PAH are

symptomatic, and a half of them are classified in the last stages (III or IV) on the WHO functional classification (28,30).

- **Endocarditis.** Defined as an inflammatory process that affects all the endocardia, affecting or not cardiac valves. Normally has an infectious origin, being the streptococcus the most common microorganisms, followed by staphylococcus (28). Once the infection has been overcome, there can be some complications such as valvular regurgitation, a deterioration of the cardiac failure, or a systemic embolus (28). It is highly important to remark to the patient the requirement to maintain a good oral hygienic and to visit periodically the dentist, as it has been demonstrated to be more effective than antibiotic prophylaxis (31).

- **Cardiovascular comorbidity**. Almost 80% of adults with CHD have at least one cardiovascular risk factor (28). This have a negative impact on the basis heart condition that the patient already has. Not only is it an adult care complication, but also is a warring matter in children. Around 15% of the children with CHD are diagnosed with obesity, and it reaches 30% if overweight patients are included (32). The reason for that may lay in the historical recommendations which encouraged children with CHD to gain weight (32). Moreover, children with heart conditions have commonly been restricted to physical activity. This fact may be a predictor of obesity development (33). In addition, there is much emphasis on primary and secondary prevention in adult cardiology, but there isn't the same interest in paediatric cardiology, even recent guidelines highly recommended it (34).

- **Psychosocial function**, signs of depression and anxiety, are commonly found in teenagers and young adults with heart disease (35). Furthermore, behaviour and social cognition are commonly affected in some types of CHD (36).

- **Neurodevelopmental impairment,** especially in fine and gross motor skills. Children have a basic need for motor activity, that will influence their emotional, psychosocial, and cognitive development (37). However, cardiac disease is often mistaken as related to a

physical activity restriction, which adds up to parents' overprotective behaviour, it is translated to moderate and severe deficits in gross motor skills, in comparison to their age-matched healthy peers. Concretely, almost 60% of children with CHD reported moderate or severe impairment in motor development (38). This deficit increases as the severity of the illness augment.

3.2. PHYSICAL ACTIVITY

According to WHO, physical activity is one of the most basic functions that human has. And undoubtedly, it has an essential role in the development of health (39).

It is well-known the benefits that it has to our body. The more distinguished ones are related to physical fitness and cardiovascular health, cognitive outcomes (academic performance and executive function), immune system, mental health (reducing stress reactions, anxiety, and depression), and achieving energy balance and adiposity reduction(40). As well as, a reduction in body mass index (BMI), and improvement in quality of life (41).

Furthermore, during childhood and adolescence, physical activity is necessary for the proper development of basic motor skills and musculoskeletal development (39).

Many different types of physical activity and exercise can be performed in many different settings with different aims. It is fundamental to different types of exercise:

– **Physical activity** is defined as any bodily movement that is produced by the contraction of skeletal muscles and increases energy expenditure above the basal level (38,42).
  The energy cost of physical activities may be expressed in a measurable unit called METS (metabolic equivalent of task). One MET equals the amount of oxygen consumed while a person is sitting at rest (3,5 mL O_2/kg/min). Moderate activity equals 3.0 – 6.0 METS, while vigorous one represents more than 6.0 METS (43).

– **Exercise**, is a subset of physical activity that is planned, structured, repetitive, specialized, and purposeful, with the main aim to improve or maintain one or more components of physical fitness (38,42).

- **Physical fitness** is a set of attributes that people have or archive, in order to perform daily physical activities (38,42). Endurance exercise is the most common way to improve cardiovascular fitness (38).

- **Sport**, that is defined as organized, competitive, and skilful physical activities inside fixed rules of commitments and fair play. It is undertaken as part of leisure or competition. In the competition ones, it involves the pressure to train or play in high intensity, and not to stop (38,42).

3.2.1. PHYSICAL ACTIVITY RECOMMENDATIONS FOR CHILDREN

The latest WHO *Guidelines on physical activity and sedentary behavior* (2020), strongly recommends children and adolescents do at least an average of 60 minutes per day of moderate to vigorous physical activity, preferably, aerobic activity (40). Furthermore, it adds at least 3 days a week of vigorous-intensity aerobic activity, as well as, those that strengthen muscles and bones (40).

On the other hand, WHO supports the fact that children and teenagers should limit the amount of sedentary time, in particular, the amount of time spent with recreational screen time (40).

In Spain, the latest general recommendations are from 2015, and are based on WHO 2010 ones. These are *"Recomendaciones sobre Actividad Física, Sedentarismo y Tiempo de pantalla. Estrategia de Promoción de la Salud y Prevención en el Sistema Nacional de Sal*

" (44).

These recommendations are similar to WHO 2020 ones. It suggests at least 60 minutes of moderate physical activity per day. Also, there should be at least 3 days per week of vigorous physical activity with strengthening exercises. Additionally, it also adds a maximum of two hours per day of recreational screen time. As well as, it encourages outdoor activities and active transport, such as walking or cycling (44).

3.3. PHYSICAL ACTIVITY IN CHILDREN WITH CHD

In general words, children with CHD have a reduced exercise capacity and a low level of physical activity in comparison to healthy children (38). In fact, patients with congenital cardiopathies have a basis of physical activity 25 to 50% lower than the general population (45). This may lay in the fact that parents, educators, and healthcare professionals are overprotective and over-restrictive (46).

This situation is contrary to what statements mention in their recommendations. Exercise is safe and beneficial (47). It is essential for children with CHD to be physically active in their daily life for well-being and healthcare. There are numerous benefits for those children to participate in regular exercise and recreational activities, therefore physicians should emphasize that need during the follow-up visits.

European Society of Cardiology (ESC) suggests that children and adolescents should do the same amount of moderate physical activity as healthy children, achieving at least 60 minutes per day (38). Furthermore, AHA manifests that there is no evidence of the need for restricting leisure PA in patients with CHD (48). Not only have not restrictions in PA been demonstrated to reduce mortality but also, has damaging adverse effects on patient well-being such as obesity, hypertension, insulin resistance, or dyslipidemia (47). In other words, cardiovascular comorbidities associated with a deficient physical activity level, are present in both, non-CHD and CHD population.

However, there are some specific restrictions that should be considered when exercise is being planned, that are summarized in ANNEX 2**.** Most guidelines focus restrictions on competitive and contact sports, and this may be traduced in a misunderstanding when pediatrics cardiologists promote PA and exercise prescription. The prevalence of exercise restriction recommendations by caregivers and physicians varies to 40-70% (47), which represents a high number if we consider the latest recommendations (38).

By the same token, many children with CHD are excluded from participating in their physical education classes, due to a sense of discomfort by their educators, as they aren't aware of which kind of exercise the child may be able to do (47).

Even though there is strong evidence on the benefits of physical activity in CHD patients, there is not enough consensus among professionals in the promotion of a physically active lifestyle (47). Besides, this promotion should start early on paediatric population, so they will track their lifestyle from childhood to adulthood (49).

Clear communication around exercise restriction by a pediatric cardiologist to the patient and his caregivers is essential (47) is highly important for patients and their families, not only to hear what cannot do but also, highlight all that are able and deeply recommended to do.

Considering all mentioned above, the creation of a multidisciplinary and specialised unit, providing physical activity education, nutritional education, exercise prescription based on a medical evaluation could help to reduce and even overcome the barriers and limits that are found in physical activity promotion in paediatric CHD (47).

3.4. EXERCISE TRAINING IN CONGENITAL HEART DISEASE

As it was mentioned above, it is known that children with CHD have a lower physical activity level and exercise capacity than their age-matched healthy peers, what is attributed to a combination of cardiopulmonary, muscular, and psychosocial restrictions (50).

In the light of some studies, it has been demonstrated that exercise training in patients with CHD have a positive impact on VO_2 peak and an improvement on the quality of life (50). Not only improves some physiopathological aspects of the basis congenital cardiopathy but also, it decreases the risk of acquired cardiopathies.

An alteration of aerobic capacity is defined as 80% of the theoretical VO_2 peak (45). This fact is common in the majority of children with CHD, and it has a multifactor origin.

This alteration can be explained by hemodynamic changes, electrical abnormalities, an increase in volumes and/or pressures of the ventricle, a decreased respiratory capacity, and changes in muscle metabolism including respiratory muscles (45). Chest hypoxia may also have a role in low exercise tolerance as it reduces oxygen supply to peripheral muscles (51).

Last but not least, another major explanation for this low aerobic fitness, even in non-severe CHD, is more in the psychosocial field. CHD patients usually are involved in a sedentary lifestyle from an early age leads to muscular deconditioning. Those origins a vicious circle

leading to a reduction in activities and excess handicap (45). It seems logical to try to reverse that circle as soon as possible.

For all above, planned exercise training should be considered as a non-pharmacological treatment for children with CHD (50).

3.5. CARDIAC REHABILITATION

WHO has defined cardiac rehabilitation as the sum of activities that are required to influence in a positive way the underlying cause of the disease, as well as, to provide the best physical, mental, and social conditions for the patient with the aim of improving prognosis and consequently the quality of life (52).

Cardiac rehabilitation programs (CRP) are the standard of care of adult patients with coronary in all the medical reference guidelines around the world, with the highest class of recommendation and level of evidence (53). Even though data from 2020 in Spain the incidence of application is less than 7% (54).

Cardiac rehabilitation is growing in importance in the context of CHD, as it is feasible, safe, and effective, with the promise of better outcomes in the patient's future. Furthermore, cardiovascular effects can be sustained. However, there are very few pediatric CRP around the world and there isn't too much consensus, as there is not an optimal program defined (55).

The principles of any cardiovascular rehabilitation are based on physical rehabilitation and the learning of those activities so the patient is able to maintain the physical condition on his own. Optimization of therapy is also highly important, such as the patient's condition and lifestyle for individualizing the training (45). Likewise, CRP is characterized to be a multidisciplinary therapeutic education program, whose core components are well recognized, including patient assessment, management and control of cardiovascular risk factors, physical activity counselling, prescription of exercise training, nutritional advice, and psychosocial management (53).

Nowadays cardiac rehabilitation contemplates three phases of intervention once the disease has been developed:

- **Phase I,** is in the period in hospital following the acute event. The physical therapist may start working with the patient in the intensive care unit. It consists of physiotherapeutic in-hospital phase and the knowledge of the illness.

- **Phase II**, which is commonly known as cardiac rehabilitation program, as it is the core of cardiac rehabilitation. In this case, the aim is to return or to acquire a full functioning as quickly as is safe for the patient.

  Organized and supervised exercise training is the heart of the phase. It is highly important the preliminary assessment and monitoring during the exercise. As well as tailored exercise training according to the patient's functional capacity.

  Not only is exercise essential but also, different aspects are included in this phase. In fact, it is the most well-organized one.

- **Phase III,** defined as an out-of-hospital maintenance phase. It corresponds to the long-term future's patient. It involves the maintenance of healthy lifestyle habits that the patient has acquired during the other phases.

  There are a few models of organized training planned in phase III, in order to increase adherence, although it has no same evidence as phase II.

Adapting these phases into congenital heart diseases is challenging as are not acquired illnesses. Even though, the basis may be useful, especially phases II and III.

As it was mentioned before, phase II is the most well-organized one, and at the same time, the one with the highest class of recommendation at the level of evidence in chronic heart failure, acute coronary syndrome, and chronic coronary syndromes (53). That does not mean the other stages are not beneficial for patients, but it may be explained due to a lack of randomized clinical trials published.

ESC has published a scheme of core components and objectives that should be common to all phase II of a CRP (53):

- **Patient primary assessment** that should include:
  - Clinical history emphasizing a screening of risk factors, symptoms, comorbidities, disabilities, adherence to the medical treatment, adequate lifestyle… Questions of his physical activity level in domestic, occupational, and recreational habits are needed.
  - Physical examination, where general health status and heart failure signs must be fully examined. As well as cardiac and carotid murmurs and arterial pulse.
  - Blood testing as a screening of cardiovascular risk factors.
  - Electrocardiography, including heart rate, rhythm, repolarization change, or signs of dysfunction.
  - Two-dimensional and Doppler echocardiography, in particular, left ventricular systolic and diastolic function, right ventricular systolic function, and heart valve evaluation.
  - Cardiopulmonary test as it is the gold standard for evaluation peak exercise capacity. Furthermore, it provides the required information for exercise training and monotonizing, as it is an objective test of exercise responses. 6 minutes walking test may be useful if it is supplementary.

- **Physical activity counselling**, should be tailored and patient-specific according to the characteristics of the disease. It should be emphasized to recommend to the patient to look for an activity that encourages and motivate herself, and to explain the effects of inactivity. Also, adverse effects should be mentioned, as red flags.

- **Exercise training** must be prescribed on an individualized approach after the clinical evaluation and the cardiopulmonary test. Risk stratification must be included.

  As general advice is recommended:
  - Frequency: At least 3 days per week for aerobic training, and at least 2 times per week for strength one.
  - Intensity: moderate or moderate-to-high intensity for endurance training. Different exercise models are available, such as endurance in constant intensity, intermediate intensity, or interval training with active or passive resting.

  - Time: at least 20 – 30 minutes are needed, even though is preferably recommended 40 to 60 minutes per session.
  - Type: aerobic training, strength training, flexibility training, balance training, and inspiratory muscles training should be included.

- **Nutritional counselling** not only for the patient but also, for family members should be available. Eating habits must be assessed. Education here is highly important. Diet recommended should be balanced, reducing saturated fatty acids, salt, and processed food. The Mediterranean diet would be suitable for patients with cardiovascular disease.
- **Psychosocial management.** An assessment of psychosocial risk factors is crucial, analyzing stress during her daily life, economic status, family network support. Signs of depression, anxiety, or other mental disorders should be identified. Moreover, some standardized questionnaires can be used.

Apart from cardiac rehabilitation, some of the programs also include inspiratory muscular training (IMT). Defined as a non-pharmacological treatment that aims to improve the inspiratory muscle force, the inspiratory muscular endurance, and quality of life, as well as a feeling of well-being and better physical condition (56). In CHD paediatrics population, diaphragm potentiation improves functional capacity as CHD patients normally hyperventilate in excess during exercise (57).

3.6. NORDIC WALKING

Nordic walking is defined as a form of physical activity, that enhanced and regular walking technique that actively uses a pair of special-designed poles to work the lower limb as well as upper body. The characteristics of natural, biomechanically-correct walking and appropriate posture are maintained. It can be done by nearly everybody, everywhere, and at almost any time (58).

The origin of Nordic walking is situated in Scandinavia and it was introduced in central Europe nearly 20 years ago. Since then, its popularity has been an increase (58).

Not only, Nordic walking can potentially be incorporated into a patient's daily physical activity, but also it is well suited for primary and secondary cardiovascular prevention. This

lay in the fact that Nordic walking exerts beneficial effects on relevant parameters such as peak heart rate, maximal oxygen consumption, exercise capacity, or quality of life, in a wide range of diseases, including cardiovascular ones. Moreover, it reduces dyspnea induced by exercise, besides anxiety and depression (58).

3.7. PLYOMETRIC EXERCISE

Plyometrics is defined as a type of exercise training that uses speed and force of different group muscles, especially lower limb but it can also be used to strengthen the upper limb and trunk. It is also known as jump training as it involves the usage of jumps, hops, bounds, or skips. It involves a stretch of the muscle-tendon unit immediately followed by a shortening of the muscle unit. This is called the stretch-shortening cycle (SSC) the core of plyometrics.

During plyometric exercise, it can be defined three distinct phases, indifferently of the muscles that are working. It is a triphasic description of the movement (59):

- The **eccentric phase,** also called the loading phase. This phase increases muscle spindle activity by pre-stretching the muscle prior to activation. Potential energy is stored in the elastic components of the muscle during this loading phase.

- The **amortization phase**, that involves dynamic stabilization and is the time between the eccentric contraction and the initiation of the concentric contraction. During this phase, there is an electromechanical delay when the muscle must switch from overcoming force to imparting force in the intended direction.

- The **concentric phase** or unloading phase, occurs immediately after the amortization phase and involves a concentric contraction. It results in enhanced muscular performance following the eccentric phase of the muscle contraction. This occurs due to a summation and reuse of the elastic potential energy, muscular potentiation, and contribution of the myotatic stretch reflex.

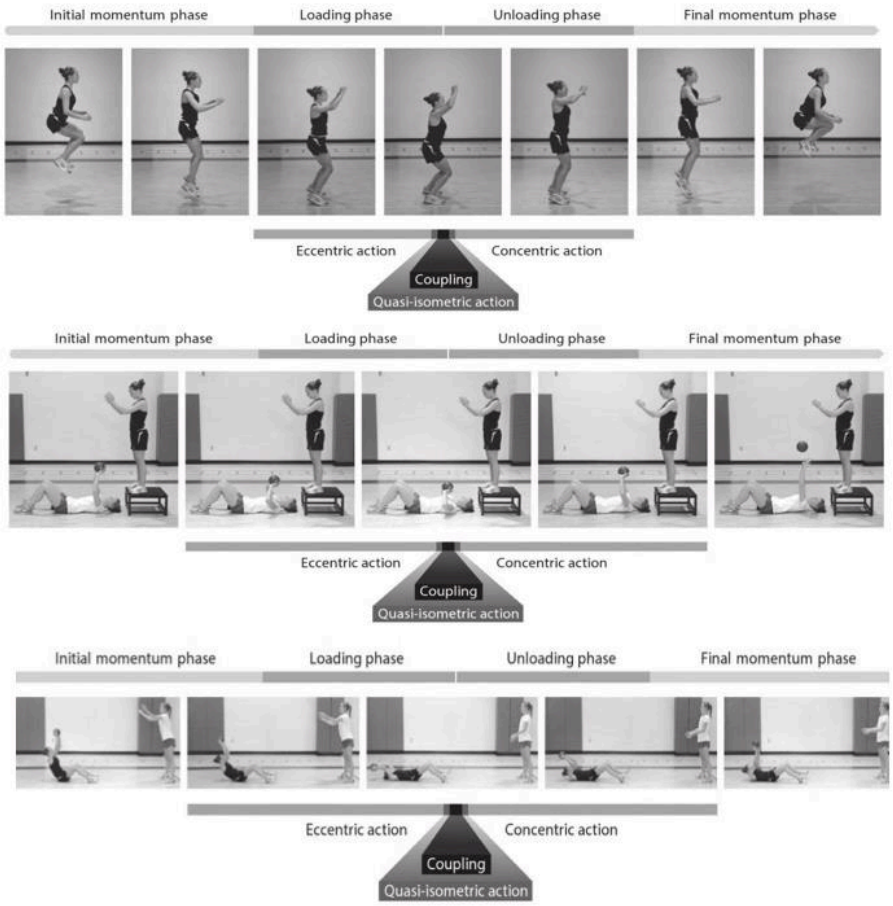


Figure 4. Different phases of plyometric exercise in lower-extremity, upper-extremity, and trunk. Source (59)

This type of exercise can enhance child's speed of movement, increase power production, strengthen the bone and neuromuscular efficiency. Likewise, it prevents injuries.

Furthermore, it has been demonstrated to improve running speed and jumping ability as well as strength, balance, and agility (60).

In low motor competence children, improvement in running and jumping may be an appropriate intervention for increasing physical fitness, and physical activity levels. What may involve an improvement of participation in recreational and play activities, in other words, a better quality of life (60).

American College of Sports Medicine (ACSM) has reported that plyometric training can be a safe, effective and fun activity for children and adolescents provided that the program is properly designed, sensibly progressed, and supervised by qualified professionals.

Furthermore, well-organized fitness programs that include plyometric training have been found to decrease the risk of sports-related injuries (61).

It is significant to underline that plyometric training should begin with lower intensity drills and gradually progress to higher intensity drills over time. Although there is not one plyometric training program that is optimal for all youth, beginning with one to three sets of 6-10 repetitions twice per week is reasonable. Depending on individual characteristics, the plyometric training program can progress to include multiple jumps, single-leg hops, and throws using lightweight medicine balls. Modifying the program over time will help to maximize enjoyment, optimize gains and prevent overtraining (61).

3.8. GAMIFICATION

Gamification is defined as the use of game mechanics, game design techniques, and/or game style in a non-game context. This nongame context is everywhere imagined such as education, sports, or business. Gamification started to become a worldwide trend around 2010 and its expansion has led to further research into engagement and motivation (62,63).

Nowadays, gamification is starting to make a space in the medical field. Few studies use that concept for medication adherence, stroke rehabilitation, or physical fitness in some children's diseases. Nonetheless, a field that is still in discovery and could be very advantageous is peadiatric cardiac rehabilitation.

A game-way seen of therapy design can support the creation of a more playful and context-specific setting. Children are more likely to be motivated during therapy, which can be turned into greater therapy involvement and higher intensity. This fact lays in a neurological molecular cascade, as reward facilitates dopamine, which in turn can facilitate neural plasticity and learn through long-term potentiation of synaptic connections (62).

A relevant concept to underline is that in game design the primary goal is to create and manipulate behavior. With this in main, it is vital to explore a child's interests and hobbies, identify triggers, and take all of that into account when the game is being designed. Therefore, the child will be fully motivated (62).

4. JUSTIFICATION

Congenital heart defects are the most frequent malformations that occur during birth, with an incidence that around 0,8% in alive newborns. On the strength of greater advances in early prenatal diagnosis and improvements in treatments, mortality has drastically decreased in the last years. Although survival tax has improved, children with CHD are involved in some functional limitations and cognitive deficits, such as a lower physical condition, a reduced exercise capacity, and a decreased psychosocial quality of life in comparison to healthy children.

This reality may lay on the fact that there is a misleading concept of restriction in physical activity for those children, as well as, overprotective behaviour by parents, educators, and healthcare professionals. Children spend the majority of their time at school and in extracurricular activities. Thus, it is where social interaction is maximum, for this reason, any change in that scenarios may entrails a significant consequence in their quality of life. This can be traduced in a concept called "growing into lesion", which strongly defines the life of a child that has a diagnosis of congenital heart disease.

The beneficial effects of exercise on cardiovascular health and psychosocial functioning are undisputed. On account of this, all International Societies strongly recommend an average of 60 minutes per day of moderate and vigorous physical activity. The same concept is applied to children with congenital heart disease, as there is no evidence of the need for restricting leisure physical activity in those patients.

Under those circumstances, the implementation of a multidisciplinary and specialised unit that provides physical activity education, nutritional education, and exercise prescription can help to reduce and overcome barriers and limits that children with congenital cardiopathies have.

Cardiac rehabilitation programs for children have been shown to be safe, effective and cardiovascular effects can be sustained. However, currently, there remain a few programs around the world and a minimum representation in our country.

There is not any publication that reaches a conclusion why paediatric cardiac rehabilitation programs are anectodical. Even though, the few clinical trials published follow a conventional

exercise training based on indoor cycling and isotonic strengthen exercises what may be unmotivating for children and not in line with what children encounter outside the hospital.

By all means, it is important to determine the most appropriate methods to achieve the best results regarding peak VO_2 and quality of life in pediatric rehabilitation, taking into account that motivation and engagement are crucial aspects of rehabilitation.

With this in mind and considering the great benefits of Nordic walking and plyometric training, they could be a good alternative for those conventional exercises, as they are outdoor and non-routine exercises.

Furthermore, the use of gamification on physical training may also improve paediatric cardiac rehabilitation programs as it has been demonstrated that including a game concept in therapy design increases motivation, which has the potential for greater therapy involvement and higher intensity. As well as, it is more exciting and attractive for children.

Therefore, considering the current limitations of pediatric cardiac rehabilitation studies, the aim of this clinical trial is to find evidence that the implementation of an outdoor cardiac rehabilitation program based on Nordic walking and plyometrics and with a game as a unifying thread improves the health-related quality of life in congenital heart disease pediatrics population improving also exercise capacity parameters, in comparison to the ones who take part in a conventional rehabilitation program.

In this way, hopefully, in the next years, the implementation of that program could be a reality around rehabilitation centers helping pediatric patients to overcome barriers by letting them lead a life just like other children bringing out the needs they have as a child.

5. HYPOTHESES

5.1. MAIN HYPOTHESIS

Our main hypothesis is that the implementation of a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics, in paediatrics congenital heart disease population, improves the health-related quality of life of participants, against a conventional cardiac rehabilitation program.

5.2. SECONDARY HYPOTHESES

Our secondary hypotheses are:

- Maximal oxygen consumption (VO_2 peak) will make at least the same progress in children with cardiac heart disease that are involved in a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics than the ones who take part in a conventional cardiac rehabilitation program.
- Left ventricular ejection fraction (LVEF) will improve at least the same in children with cardiac heart disease that are involved in a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics than the ones who take part in a conventional cardiac rehabilitation program.
- Dyspnea perceived post effort and walking distance in 6 minutes walking test will meliorate at least the same in children with cardiac heart disease that are involved in a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics than the ones who take part in a conventional cardiac rehabilitation program.
- Proportion of lean body mass will show at least the same improvement in children with cardiac heart disease that are involved in a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics than the ones who take part in a conventional cardiac rehabilitation program.

6. OBJECTIVES

6.1. MAIN OBJECTIVE

The main objective of this study is to assess whether a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics improves the health-related quality of life in congenital heart disease paediatrics population, in comparison to those who participate in a conventional cardiac rehabilitation program.

6.2. SECONDARY OBJECTIVES

The secondary aims of this study are:

- To compare the difference between the maximal oxygen consumption (VO_2 peak) in ergospirometry in paediatric patients with cardiac heart disease in both cardiac rehabilitation programs.
- To examine the difference between left ventricular ejection fraction (LVEF) in echocardiography in paediatric patients with cardiac heart disease in both cardiac rehabilitation programs.
- To evaluate differences between dyspnea perceived post effort and walking distance in 6 minutes walking test in paediatric patients with cardiac heart disease in both cardiac rehabilitation programs.
- To analyse differences in the proportion of lean body mass in paediatric patients with cardiac heart disease in both cardiac rehabilitation programs.

7. METHODOLOGY

7.1. STUDY DESIGN

This study will be carried out through a prospective, randomized, controlled, and open-label intervention clinical trial.

Patients will be randomly assigned into 2 groups with a ratio of 1:1:

- The control group will take part in a conventional cardiac rehabilitation program.
- The experimental group will be undergoing a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics.

The study will be performed in Cardiac Rehabilitation Unit in Parc Hospitalari Martí Julià. Cardiac Rehabilitation Unit is formed by a multidisciplinary team constituted by cardiologists, cardiac rehabitation physicians, physiotherapists, phycologists, nutritionists, and nursing. In this case, a paediatric cardiologist will be incorporated into the unit.

7.2. STUDY POPULATION

The study population of this clinical trial will be 8 to 12 years children that have a diagnosis of congenital heart disease and are residents in Girona Health Region, therefore, have as a reference Hospital Universitari Dr. Josep Trueta, as it is the only hospital in the province where there is a paediatric cardiologist.

All patients must meet the inclusion and reject exclusion criteria.

7.2.1. INCLUSION CRITERIA

- Patients aged 8 to 12 years old, both included.
- Patients diagnosed with congenital heart disease.
- Patients whose parents or legal guardian have signed the written informed consent.

7.2.2. EXCLUSION CRITERIA

- Patients that have received a previous cardiac rehabilitation treatment.
- Patients that her health-related quality of life is over 90 out of 100 in the questionnaire PCQLI.

- Patients that apart from the congenital heart defect have another significant disease or defect that causes a decompensated disease such as an acute renal disease, hepatitis, or infection.
- Patients with severe mental impairment leading to inability to follow the instructions.
- Patients with a documented life-threatening arrhythmia that is not palliated by an automatic internal cardiac defibrillator.
- Patients who have been involved in cardiac surgery in the last eight weeks or a cardiac catheterization in the last 15 days if it was with radial access or 21 days if it has a femoral access.
- Patients who have absolute contraindications for ergospirometry: fever, uncontrolled asthma, respiratory failure, acute myocarditis or pericarditis, uncontrolled heart failure, acute pulmonary embolus or pulmonary infarction.

7.2.3. WITHDRAWN CRITERIA

Our withdrawal criteria are the ones that may follow next scenarios:

- Parents or legal guardian revoke the informed consent.
- The patient meets exclusion criteria either newly developed or previously unrecognised at some point of the clinical trial.
- The patient does not follow the clinical trial protocol, not attending in more than 20% of the appointments.

7.3. SAMPLING

7.3.1. SAMPLE SELECTION

Our sample will be obtained through a random simple sampling since patients who meet the previous criteria will be included in the study.

Their paediatric cardiologist or general practitioner will be the people in charge of contacting the patients who meet the inclusion criteria and will informed to the patient and family about the clinical trial and will purpose the chance to take part in it. Data of patients with congenital heart disease will be obtained from the hospital database, so all types of congenital heart disease may be included, and not only the ones that need medical consultation as there should be a selection bias.

7.3.2. SAMPLE SIZE

We used the program GRANMO free calculator available online to calculate the sample size for the clinical trial.

Accepting an alpha risk of 0.05 and beta risk of 0.2 in a two-sided test, a total of 106 subjects is necessary to detect as statistically significant a minimum difference of 9 units in PCQLI questionnaire test. All subjects will be distributed into these two groups in a ratio of 1:1. Therefore, 53 subjects will take part in the first group and 53 subjects in the second group.

The common deviation is assumed to be 16 based on the data facilitated in similar studies, and adapting these findings in our trial (64,65). A 5% drop-out rate has been estimated.

7.3.3. RANDOMIZATION AND BLINDING METHODS

Patients will be randomly allocated to one of the groups: the experimental group that will take part in a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics and the control group receiving a conventional cardiac rehabilitation program.

Randomization will be performed by an independent statistician after the enrolment of participants. All patient data will be confidentially maintained and an identification number will be assigned to each patient, this will be generated automatically by the software of the company.

In the best-case scenario, in a clinical trial, patients do not know which procedure are receiving, neither does the professional know. Unfortunately, in this case, is not possible, as the patient, rehabilitation physician and physiotherapeutic know which kind of cardiac rehabilitation program the patient is receiving.

Otherwise, in order to reduce the possible bias, the paediatric cardiologist, the cardiologist, the nutritionist, and the psychologist will be blinded as are the ones that will collect the data for the study. Moreover, the statistician that will be in charge of evaluating the procedure results will be also masked. In other words, they will not know which rehabilitation program each patient has undergone.

7.3.4. ESTIMATED TIME OF RECRUITMENT

According to the bibliography, the incidence of alive newborns with congenital heart disease is around 0,8% (4). If we recollect the data information of newborns in 2009 – 2014 in the Province of Girona (5), as are children who in 2022 will be 8 to 12 years old, we estimate that during that years, there were roughly 326 newborns with congenital heart disease.

Considering an approximate mortality rate of 5% of children with CHD in the first years of life (4), currently, there is about 310 patients that in 2022 will be 8 to 12 years old that are diagnosed with congenital heart disease.

The procedure followed to obtain the information is summarized in **Table 2.**

Considering the estimated population, we expected that it will take six months to recruit the 106 patients necessary to complete the trial.

Table 2. Data used for estimating population in Girona with CHD. Data source from (5)

Age in 2022	Year of birth	Newborns	Estimated newborns with CHD (0,8% of the newborns)
7 -8	2014	7404	59
8	2015	7509	60
9	2016	8037	64
10	2017	8431	67
11	2018	8873	70
12 - 13	2019	8919	71
Estimated number of newborns with CHD during 5 years			326
Estimated number of children with 8 to 12 years in 2022 with CHD (95% of the newborns)			310

7.4. STUDY VARIABLES

7.4.1. INDEPENDENT VARIABLE

The independent variable of the study will be the type of exercise training that will receive in the cardiac rehabilitation program.

The clinical trial will have an experimental group that will perform a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics, and a control group that will perform a conventional cardiac rehabilitation program based on cyclometer and isotonic using one's body weight or overload strength exercises.

This is a dichotomic qualitative variable.

7.4.2. DEPENDENT VARIABLES

7.4.2.1. MAIN OUTCOME: HEALTH-RELATED QUALITY OF LIFE

Health-related quality of life (HRQoL) refers to the perception of the impact of a specific illness or medical therapy on a person's satisfaction in life's physical, psychological and social experiences.

The measuring method that will be used is **PCQLI test** (Paediatric Cardiac Quality of Life Inventory), a disease-specific HRQOL instrument form for children from 8 to 12 years old with congenital or acquired heart disease. It incorporates both child self-respondent and parent-proxy reporting. They are attached to ANNEX 4.

Child From is a self-respondent form that is composed of 28 items. Of those 14 belong to Disease Impact subscale, 9 belong to Psychosocial Impact subscale and 5 belong to Emotional Environment subscale. All items start with "Because of my heart problem…" and use the first person.

The Parent of Child From is a parent proxy form for parents or legal guardians. It is also composed of the same items that are classified in the same subscales. The items are identical to those of the Child Form but in this case, items start with "Because of my child's heart problem…" and use the third person.

All items' responses options range from 1 (strongly agree) to 5 (strongly disagree) on a five-point Likert scale.

Both forms start with a General Health Perception Question that ranges from 1 (Excellent) to 5 (Poor) on a five-point Likert scale. Even though, this is not included in the scoring.

SCORING

Both Child and Parents form of PCQLI generate three scores: Disease Impact subscale score, Psychosocial Impact subscale score, and Total score.

The Disease Impact and Psychosocial Impact subscale score are calculated individually adjusting the values from Likert scale of 1 – 5 to an absolute scale of 0 – 4, calculating a ratio and multiplying it by the maximum subscale score of 50, to yield the subscale score. A more detailed explanation for scoring is in ANNEX 4.

The Total score is calculated from the Disease Impact subscale to add to Psychosocial Impact subscale. Emotional Environment and General Health Perception are not included in the Total score. The Total score has a maximum of 100 points possible, being the one that we will use as the main outcome.

It is a discrete quantitative variable.

7.4.2.2. SECONDARY OUTCOMES

MAXIMAL OXYGEN CONSUMPTION (VO2 PEAK)

Maximal oxygen consumption or VO_2 peak refers to the maximum amount of oxygen that an individual can utilize during maximal exercise. It is considered the best indicator of cardiovascular endurance. It will be measured by an ergospirometry or cardiopulmonary exercise test.

It is a discrete quantitative variable. It will be expressed in %.

LEFT VENTRICULAR EJECTION FRACTION (LVEF)

Left ventricular ejection fraction (LVEF) is the fraction of chamber volume ejected in systolic in relation to the volume of the blood in the ventricle at the end of the diastole. It will be measured with echocardiography.

It is a discrete quantitative variable. It will be expressed in %.

DYSPNEA PERCEIVED POST-EFFORT IN 6 MINUTE WALKING TEST (6MWT)

Dyspnea perceived post 6MWT will be measured with Modified Borg Scale, a 0 to 10 scale.

It is a discrete quantitative variable. It will be expressed in an ordinal number.

WALKING DISTANCE IN 6 MINUTES WALKING TEST

Walking distance in 6MWT is related to the total distance that the patient will march during 6 minutes following the protocol established by Sociedad Española de Neumología y Cirugía Torácica (SEPAR).

It is a continuous quantitative variable, expressed in meters.

LEAN BODY MASS

Lean body mass is a component of body composition that is defined as the difference between total body weight and body fat weight. It will be measured by bioelectrical impedance analysis.

It is a continuous quantitative variable, expressed in %.

7.4.3. COVARIATES

Other variables will be also registered and collected in order to see if they have any effect on the results. As this study is a randomized clinical trial, we assumed that it will not affect our results as they will be comparable on both groups. These variables are:

- **Age**: it is a discrete quantitative variable. It will be expressed in years.
- **Sex**: it is a qualitative nominal dichotomous. It will be recorded as female (F) or male (M).
- **Ethnicity**: it is a qualitative nominal non-dichotomous variable. It will be recorded as African, Asian, Caucasian, Latin-American, or other.
- **Congenital heart disease type**: It will be parents or legal guardian reported and verified with the medical history. it is a qualitative nominal non-dichotomous variable.
- **Body Mass Index (BMI**): it is a categorical quantitative variable.
- **Level of daily physical activity** will be assessed with the PAQ – C (Physical Activity Questionnaire for Children). It is attached in ANNEX 5. It is a self-respondent questionnaire that measures moderate to vigorous physical activity in the last 7 days in a child from 8 to 14 years old. It consists of ten items, nine of them are used to measure physical activity, and the last one evaluates if there is an illness or another event that

prevents the child to do her regular activity in the last week. The global result is a number between 1 and 5, which the highest scores mean a higher level of physical activity.

It is a discrete quantitative variable.

- **Adherence to the Mediterranean diet** will be assessed with the KIDMED test (Mediterranean Diet Quality Index for children and teenagers), which is a tool to evaluate the adherence to the Mediterranean diet for children and youth. It is attached in ANNEX 6. It consists of a battery of 16 questions where each aspect is assigned a value of + 1 or – 1. The sum of the values is later classified into three levels: optimal Mediterranean Diet, improvement needed, or very low diet quality. The sums of the values from the test are classified into three levels: 1) > 8, optimal Mediterranean Diet; 2) 4 – 7, improvement needed to adjust; 3) ≤ 3, very low diet quality.

  It is a qualitative nominal non-dichotomous variable.

- **Level of anxiety** will be assessed with STAI-C (State-Trait Anxiety Inventory for Children), which is an instrument for measuring anxiety in children. It consists of two scales, the State Scale, which aims to measure the current feelings of anxiety; and the Trait Scale, which assesses a more stable and long-lasting tendency to experience anxiety. On each scale, there are 20 questions, and each question has a 1 to 3 grade of scores, that corresponds to "hardly-ever, sometimes or often". Total score ranges of 20 to 60 for each subscale, higher scores indicate higher anxiety.

  It is a discrete quantitative variable.

- **Physiological stage of ACHD AP Classification** is shown in ANNEX 1**.** As it was mentioned above it is an adult classification, but it may be comparable to children once we want to stratify risk before starting and for planning individualized exercise training.

  The physiological stage of ACHD AP Classification classified patients into 4 groups: "A, B, C, D" according to their physiological state. Results from the echocardiogram, ECG, ergospirometry, and medical history will be used.

  It is a qualitative nominal non-dichotomous variable.

- **Total body water**, measured by bioelectrical impedance analysis. It is an estimation of the total amount of fluid that is on the body.

  It is a continuous qualitative variable, expressed in litres.

- **Fat mass**, measured by a bioelectrical impedance analysis. It is an estimation of the representation of fat in the body.

  It is a continuous qualitative variable, expressed in %.

- **Maximal inspiratory pressure (MIP),** defined as a measure of the strength of inspiratory muscles. It is measured by a respiratory pressure meter. It is highly important to the patient's position and the mouthpiece design.

  The participant will be comfortably seated on a chair with the feet touching the ground, without supporting the back. The trunk will be at a 90º angle to the back of the head. The respiratory pressure meter will be used with a conventional filter. Participants will be asked to breathe in through the filter into an airway that will be obstructed by an almost residual volume. The MIP will be measured from the residual volume in the best result of three attempts of maximum inspiration with variability lower than 10%.

  It is a continuous qualitative variable, expressed in cm H_2O.

Table 3. Independent and dependent variables

	Variable	Description	Measurement
INDEPENDENT VARIABLE	Game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics	Dichotomic qualitative	Use of intervention (yes / no)
DEPEDENDENT VARIABLES	Health-related quality of life	Discrete quantitative	PCQLI
	VO2 peak	Discrete quantitative	Ergospirometry or CPET
	LVEF	Discrete quantitative	Echocardiography
	Dyspnea perceived post effort	Discrete quantitative	6MWT
	Walking distance	Continuous quantitative	6MWT
	Lean body mass	Continuous quantitative	Bioimpedance

Table 4. Covariates considered for the study

	Variable	Description	Measurement
COVARIATES	Age	Discrete quantitative	Self-reported
	Sex	Qualitative nominal dichotomous	Self-reported
	Ethnic	Qualitative nominal non-dichotomous	Self-reported
	CHD type	Qualitative nominal non-dichotomous	Self-reported and medical history
	Body mass index (BMI)	Categorical quantitative	Weight and height
	Level of daily physical activity	Discrete quantitative	PAQ – C
	Adherence to the Mediterranean diet	Qualitative nominal non-dichotomous	KIDMED
	Level of anxiety	Discrete quantitative	STAI – C
	Physiological stage of ACHD AP Classification	Qualitative nominal non-dichotomous	Medical history, ergometry, ECG, echocardiography,
	Total body water	Continuous quantitative	Bioimpedance
	Body fat mass	Continuous quantitative	Bioimpedance
	Maximal inspiratory pressure	Continuous quantitative	Respiratory pressure meter

7.5. INTERVENTION

We will divide patients into two groups. Both groups will receive a cardiopulmonary rehabilitation program (CRP). Both of them will have the same structure and the only difference between them will be on the type of exercise training that patients will receive.

The CRP common part and group control training exercise is adapted from an existing protocol of CHD cardiorespiratory rehabilitation (57) and the one that is actually on course in Parc Hospitalari Martí i Julià for ischaemic patients with acute coronary syndrome in phase II (54).

This program is conceived in a multidisciplinary environment of different services and units, including paediatrics cardiology, rehabilitation, physiotherapeutic, nursing, psychology, and nutrition.

Both CRP will have a length of twelve weeks in which there will be three training sessions per week, in total thirty-six sessions. During that sessions, inspiratory muscular training will be also included. As well as, three hours of individual nutritional counselling and four hours of individual physiological therapy. Moreover, CRP will be supplemented with three hours of physiological group therapy and three hours of educational strategies and knowledge of the CHD, also as a group, in this case, aimed at families or legal guardians. All that activities will be performed by specialists in each field.

Additionally, some complementary tests will be carried out before starting the program, in the middle, and once the program finishes. Likewise, follow-up in 6 months and 12 months post-program will be done.

7.5.1. CARDIOLOGIC ASSESSMENT

Firstly, as a part of the medical history and physical exploration, all anthropometric and demographic data will be collected by a paediatric cardiologist and nursing, likewise, all cardiovascular risk factors will be as well collected. Paediatric cardiologist will also give an information sheet about the program and will provide the informed consent form.

All patients will be subjected to a specific assessment, that will be carried out before starting the program, in the middle, and once the intervention will be finished. This assessment will follow the next steps:

- **Twelve lead electrocardiography** (ECG)

- **Echocardiogram**, describing the CHD that the patient has, residual lesions, and physiological parameters of the left ventricle, right ventricle, and valves. Some of them will be used to stratify risk according to ACHD AP classification. LVEF value will also be collected.

- **Ergospirometry**, that will quantify functional capacity. It will be conducted by Bruce, modified Bruce o Naughton protocol, on a treadmill, stopping for fatigue or symptoms following the defined standards by Sociedad Española de Cardiología (SEC) in a publication adapted for children (66).

  VO2 peak will be obtained in this test. ECG alterations and clinical symptoms during the test are also taken into account.

- **Six minutes walking test (6MWT)**, in a twenty meters aisle, following the protocol established by Sociedad Española de Neumología y Cirugía Torácica (SEPAR) (67) as the test is well correlated with children (68). Modified Borg Scale will be used to quantify initial and final dyspnea and leg fatigue. That test will be performed on a different day.

- **Maximal Inspiratory Pressure (MIP),** measured by a respiratory pressure meter, in this case, PowerBreath K1H digital device will be used with a conventional filter.

  The PIM will be measured from the residual volume in the best result of three attempts of maximum inspiration with variability lower than 10%.

- **Level of daily physical activity,** using the Physical Activity Questionnaire for Children (PAQ-C). It consists of a self-respondent questionnaire that measures moderate to vigorous physical activity in the last 7 days from 8 to 14 years old.

7.5.2. NUTRITIONAL ASSESSMENT

As is mentioned above, the CRP will include three hours of nutritional counselling, where a specialised paediatrics nutritionist will assess the patient and his family into a Mediterranean Diet, as it has been demonstrated to reduce the risk of metabolic syndrome and cardiovascular disease, DM type II, neoplastic disease and overall mortality (69). Moreover, will be also used the Kid's Healthy Eating Plate (70) to make easier the explication.

In all three sessions, a nutritionist will do the next assessment, to objectify any change:

- Bodyweight, height, and abdominal circumference will be measured. Body Mass Index (BMI) will be calculated.

- **Body composition test,** that will be studied using bioelectrical impedance analysis (Bodystat 500, England) following the standards defined by Grupo Español de Cineantropomería (GREC). Data from Lean body mass, Body fat mass, and Total body water will be collected.

- **Adherence to the Mediterranean diet,** the KIDMED test will be applied to the child and parents or legal guardian. It is a specific tool to evaluate adherence to the Mediterranean diet for children and youth. It consists of a battery of 16 questions where each aspect is assigned a value of + 1 or – 1. The sum of the values is later classified into three levels: optimal Mediterranean Diet, improvement needed, or very low diet quality.

7.5.3. PSYCHOLOGICAL ASSESSMENT

Psychological therapy will be based on four hours of individual physiological therapy and supplemented with three hours of physiological group therapy.

During these individual sessions, treatment will be individualised depending on the patient's needs. Specialists will decide even if these sessions are alone with the child or accompanied by parents or a legal guardian.

Group therapy sessions will lead to common worries that children with CHD normally have such as medication, daily life, school routine, or physical activity.

Likewise, there will be some assessments to do in the first and the last individual session:

- **PCQLI,** is a disease-specific HRQoL instrument form for children from 8 to 12 years old with congenital or acquired heart disease. It has two different forms, a child self-respondent, and a parent-proxy reporting. The Final score has a maximum of 100 points possible, the higher the better the quality of life is.

- **STAI-CH test**, that it is a potentially helpful tool for children that consist of two twenty-item scales that distinguish between a patient's proneness to anxious behaviour rooted in the personality and anxiety as an emotional state. We will need to buy its license.

7.5.4. EDUCATIONAL TALKS

Educational talks will be carried by different specialists in each field. There will be three different talks about congenital heart disease. The public target will be families or legal guardians, to inform and teach different strategies and knowledge of CHD. The first talk will be carried by a pediatric cardiologist, the second one by the psychologist, and the third by the physiotherapeutic.

7.5.5. PHYSICAL TRAINING

The training exercise program will be carried out with a frequency of three one-hour and half sessions per week on afternoon alternate days, to not disrupt the school routine.

The training program will start after the described preliminary assessment. Before starting, the physiological stage of ACHD AP Classification (ANNEX 1) will be used to stratify the patient's risk. Even this classification is based on adults, we will use it for children as variables have an important role in prognosis, management, and quality of life (17).

All training programs will be personalized according to the patient basal state.

Monitoring will be carried out throughout all sessions by telemetry (Nuubo nECGSuite, Spain) and blood pressure will be measured (Riester Minimus III, Germany) at baseline, maximal effort, and after the return to a calm state.

All sessions will have the same structure. Each session will last 1h30. It will start with 15 minutes of respiratory muscle training exercises. After that, it will continue with 10 minutes of light aerobic resentence exercise warming up which the work intensity will be increased every 2 minutes until reaching 60% of the HR peak. After that, the next 15 minutes will be

devoted to muscular toning. Intensity will increase as the sessions go by. High-intensity interval training (HIIT) will be performed during the next 25 minutes with different intensities depending on the week. Finally, there will be 10 minutes for calming down and 10 minutes for stretching out the large peripheral muscle groups, especially the ones that have been working during the session.

7.5.5.1. INSPIRATORY MUSCULAR TRAINING

During the CRP, both groups will also train respiratory muscles. The training will carry out with a frequency of three times per week, before the exercise training sessions.

The Power Breath Medic digital device will be used for IMT. This device will provide constant pressure to strengthen and increase the resistance of inspiratory muscles. It has a unidirectional valve that is adjusted with a determinate pressure measure in cm H_2O. Once the patient breathes through the mouthpiece, the valve provides the necessary resistance to allow the inspiratory muscles to work. Training intensity will be 60% of the MIP of the patient.

The training resistance will increase once the patient capacity increases, in other words, it will be adjusted to the latest MIP measure.

Each session will be divided into 5 sets of 1 - 2 minutes each, with a rest period of 1 minute between sets.

IMT will follow the schedule in **Table 5**.

Table 5. Inspiratory muscle training schedule.

Week	1	2	3	4	5	6	7	8	9	10	11	12
Intensity (%)	55	60	65	70	75	80	85	90	95	100	105	110
Number of series	3	5	5	5	5	5	5	5	5	5	5	5
Working time (min)	1	1	1,5	1,5	2	2	2	2	2	2	2	2
Rest between series (min)	1	1	1	1	1	1	1	1	1	1	1	1

7.5.5.2. CONTROL GROUP

Sessions will take place inside the gym of the hospital, with at least two specialized physiotherapeutics and a cardiac rehabilitation physician.

WARM-UP

It will start with a warming-up on a cycle ergometer or treadmill on which the work intensity will be increased every 2 minutes until reaching 60% of the HR peak (AT1), obtained in the initial ergospirometry.

FIRST 2 – 4 WEEKS

In the first 2-4 weeks, the main part of the session will be dedicated to light aerobic resistance exercise with four intervals of five minutes work between 65 – 70% of the HR peak combined with 4 intervals of 3 minutes of active recovery between 55 – 60% peak.

Borg scale will be used for defining progression during the exercise.

During these weeks, strength training will be based on anatomical adaptation with the aim of learning technical execution, breathing technique, and carrying out prophylaxis of the soft tissue. In this stage, isotonic using one's bodyweight strength exercises involving large muscle groups of the lower limb (squat and scissors) will be the exercise selected (71).

Upper limb and trunk exercises (floor dips, chest rowing with an elastic band, pullover with a medicine ball or disc and front shoulder raises with a medicine ball or disc) will be introduced always after eight weeks if there is a recent cardiac surgery involved (71).

Each exercise will be started at an intensity of 3 series of 60 seconds with 60 seconds of resting (3x60'' resting 60'') with self-loading until the patient's subjective feeling of fatigue value under 12 in the Borg scale. At that point, the intensity will increase with 5 series of 60 seconds with 30 seconds of resting (5x60'' resting 30'').

The anatomical adaptation period will end up when the patient masters the execution and breathing technique of each exercise, and once the patient's subjective feeling of fatigue value is under 12 in the Borg scale for each exercise in the absence of clinical symptoms.

FROM 3 – 5 WEEKS TO THE END

In the main part of the session from week 3 – 5, the intensity of the aerobic resistance exercise will progressively increase with four work intervals of three minutes over the aerobic

threshold (AT1), 75 – 90% peak, and four active recovery intervals of 5 minutes between 65 – 70% HR peak.

Passive rest will be avoided at all times unless there is electricity that justifies it. Likewise, continuous harmonic method of constant intensity will also be avoided.

From week 3-5 the intensity of the muscle toning training with overload will also be increased. The global dynamic isotonic strength exercises already learned will weigh with a medicine ball or disc. Intensity will follow 5 series of 60 seconds with 60 seconds of resting (5x60'' resting 60'').

During the muscular toning stage, Borg scale should be between 13 and 15.

The progression will follow the nature of the proper load according to the training theory (72). It will be established based on the subjective sensation of fatigue, without reaching values higher than 15, telemetry is normal, and no clinical symptoms or hypotensive or hypertensive responses to the effort are present.

CALM-DOWN

All sessions will have a progressive return to calm with 3 intervals of 2 minutes until reaching 60% HR peak and or values below 10 in the sensation of dyspnoea.

Finally, all sessions will end with 10 minutes of passive stretching involving the large peripheral muscles groups.

7.5.5.3. EXPERIMENTAL GROUP

Sessions will take place outdoors, specifically, in the gardens inside the hospital grounds. They will be conducted by at least two specialized physiotherapeutics.

If the meteorological situation is not favourable, it has been asked to L'Associació de Cardiopaties Congènities (AACIC) they have agreed to have contact with the municipality of Fornells to ask for the facilities of the old pavilion of the village.

WARM-UP

Aerobic exercise will be performed with Nordic walking.

In concordance to aerobic exercise that will be used, warming-up will be organized with Nordic walking in the gardens that are inside the hospital ground. Work intensity will be

increased every 2 minutes until reaching 60% of the HR peak (AT1), which will be obtained in the initial ergospirometry.

FIRST 2 – 4 WEEKS

In the first 2-4 weeks, the main part of the session will be dedicated to light aerobic resistance exercise with four intervals of five minutes work between 65 – 70% of the HR peak combined with 4 intervals of 3 minutes of active recovery between 55 – 60% peak. Aerobic exercise will be trained with Nordic walking.

During these weeks, strength training will be based on anatomical adaptation with the aim of learning technical execution, breathing technique, and carrying out prophylaxis of the soft tissue. In this stage, large muscles groups of the lower limb will be trained with plyometric training. It will start with jumps without countermovement (long jump) and once the technical execution is corrected, patients will start doing jumps without countermovement with progressive gradual overloads.

Weightlifting and chest passes will be used for training the upper limb and trunk. Firstly, they will start doing chest passes and weightlifting with a softball with the purpose of learning techniques. Once it is correct, the weight will start increases.

Each exercise will be started at an intensity of 3 series of 60 seconds with 60 seconds of resting (3x60'' resting 60'') with self-bodyweight until the patient's subjective feeling of fatigue value is under 12 in the Borg scale. At that point, the intensity will increase with 5 series of 60 seconds with 60 seconds of resting (5x60'' resting 60'').

As it has been said in the control group, upper limb and trunk exercise will be introduced after eight weeks if there is a recent cardiac surgery involved.

All exercises will be adapted in the personal basal state. Patients that have an implantable cardioverter-defibrillator will not do exercises that overcome the scapula-humeral plane.

The anatomical adaptation period will end up when the patient masters the execution and breathing technique of each exercise, and once patient's subjective feeling of fatigue value is under 12 in the Borg scale for each exercise in the absence of clinical symptoms.

FROM 3 – 5 WEEKS TO THE END

In the main part of the session from week 3 – 5, the intensity of the aerobic resistance exercise will progressively increase with four work intervals of three minutes over the aerobic threshold, 75 – 90% peak, and four active recovery intervals of 5 minutes between 65 – 70% HR peak. Nordic walking will be the aerobic exercise elected.

Passive rest will be avoided at all times unless there is electricity that justifies it. Likewise, a continuous harmonic method of constant intensity will also be avoided.

From weeks 3-5 the intensity of the muscle training also increases. In the lower limb, as we will perform plyometric training, patients will incorporate drop-jumps and rebound jumps as muscular toning. In upper limb and trunk muscles, the load of the weightlifting and chest passes will increase. Medicine balls will be introduced.

Intensity will follow 5 series of 60 seconds with 60 seconds of resting (5x60'' resting 60'').

The progression will follow the nature of the proper load according to the training theory. It will be established on the basis of the subjective sensation of fatigue, without reaching values higher than 15, telemetry is normal, and no clinical symptoms or hypotensive or hypertensive responses to the effort are present.

CALM-DOWN

All sessions will have a progressive return to calm with 3 intervals of 2 minutes until reaching 60% HR peak and or values below 10 in the sensation of dyspnoea.

Finally, all sessions will end with 10 minutes of passive stretching involving the large peripheral muscles groups.

GAMIFICATION

With the intention to increase adherence and motivation with the rehabilitation program, which may result in greater engagement, the experimental group rehabilitation program will follow a unifying thread based on a game.

The unifying thread that will be used is defined in ANNEX 7 and it is followed by a letter that will be given to the child on the first day of the program for exposing and presenting the game.

In game designing, analysing the group and adapting the unifying thread to each group is essential. Thus, it will be used the answers that every group will manifest during the first group therapy with the psychologist, in the question: "*what would you like to do that you are not able to do now due to your disease?".*

It is important to emphasise, that the implementation of that common thread will not affect the execution of physical training.

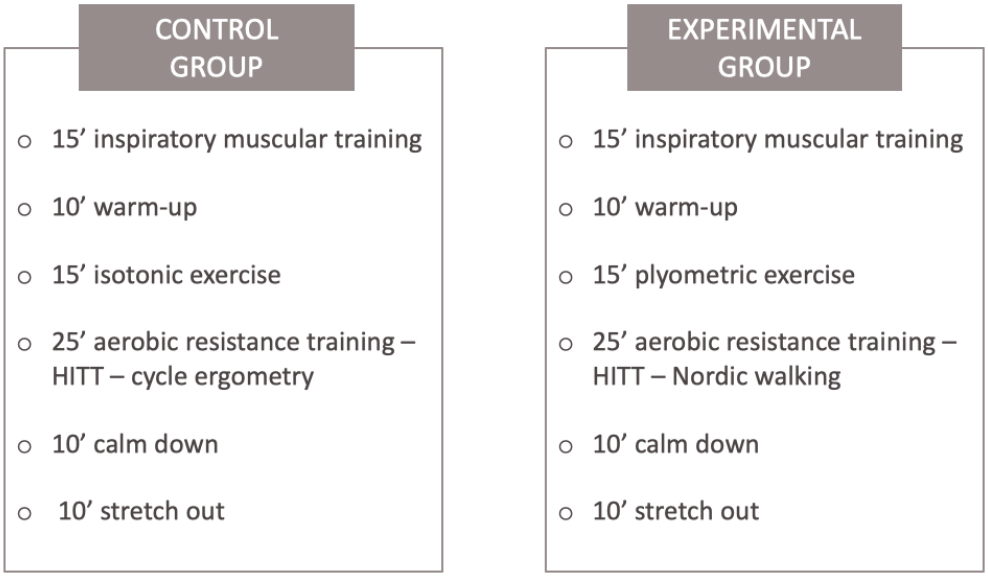


Figure 5. Exercise training scheme. Own elaboration.

7.6. SAFETY

Systematic reviews show that cardiac rehabilitation programs in patients with congenital heart disease are safe, and it has already been applied in some countries around the world.

Plyometric training and Nordic walking have also demonstrated safety for patients. As well as cyclometric and strength isotonic exercises with overload.

Complications have been taken into account in this clinical trial. The main complications of CRP are arrhythmias, drops in blood pressure, and reflex syncope. All that situations are controlled as all patients will be monotonized throughout all sessions by telemetry and blood pressure will be measured at baseline, maximal effort and after return to a calm state, as well as, once the strength training has finished. Moreover, Borg scale will be used for monotonizing subjective sensations.

In all sessions HR, blood pressures, and Borg scale measurements will be gathered in a database created with Excel software, to have a monitorization of all patients as well as to adapt next training individually depending on her progression.

Any drawback during the training will be immediately assessed by a cardiologist.

7.7. DATA COLLECTION

Data information will be collected from the assessments and medical history in five different times:

- In the preliminary assessment, before starting the cardiologic rehabilitation program.
- In the middle of the CRP
- Once the patient finishes the CRP
- In the 6-month follow-up after the patient has finished the CRP
- In the 12-month follow-up after the patient has finished the CRP

All the information and data will be recorded in the case report form (ANNEX 8) and registered into a database created for the clinical trial with the Excel software.

The information sheet about this study and invitation to participate must be handled to the patient before entering into the trial. Only If parents or legal guardian signs an informed consent, the acceptance will be valid. The information sheet about the trial and the informed consent are attached in ANNEX 9 and ANNEX 10.

7.7.1. TRIAL ENTRY

As it was said above, the people responsible for contacting the patients who met the inclusion criteria will be the paediatric cardiologist, or if not her general practitioner. They will be informed about the clinical trial and will purpose the chance to take part in it giving them the information sheet and the informed consent.

Once parents or legal guardian have signed up the documentation, the patient will have a **preliminary cardiologic assessment** done by paediatric cardiologist and/or cardiologist (specialized in ergospriometry).

To confirm that the patient is suitable for the trial, in that preliminary assessment will proceed to do an anamnesis, a physical examination, and all the complementary tests needed to verify that the patient doesn't meet exclusion criteria.

This complementary test will include an ECG, an echocardiography, an ergospirometry, a 6MWT, and a respiratory pressure examination. The Questionnaire PAQ-C will also be performed.

All that information obtained from the cardiologic assessment will be gathered as the first data collection.

Apart from the cardiological assessment, before starting the exercise training, there will also be a **nutritional assessment** with a nutritionist that will test the KIDMED questionnaire to the parents and child together, as well as a bioelectrical impedance analysis.

More than that, the psychologist will also do a **psychological assessment** where questionnaires test PCQLI and STAI-C test will be performed. PCQLI parents-proxy will be also performed even though the score will not be used in our study.

7.7.2. INTERVENTION PROGRAM

During the intervention program, there will be two different data collections, one in week 6 approximately. The other one, once the 12-week program has finished.

There will also be the same assessments: cardiological, nutritional, and psychological one, each one with their pertinent professional.

7.7.3. FOLLOW-UP

Lastly, there will be two follow-up visits, one in 6 months and the other one in 12 months post-intervention.

The same routine assessments will be done in both follow-ups in order to collect all data and register to our database.

7.8. FLOW CHART

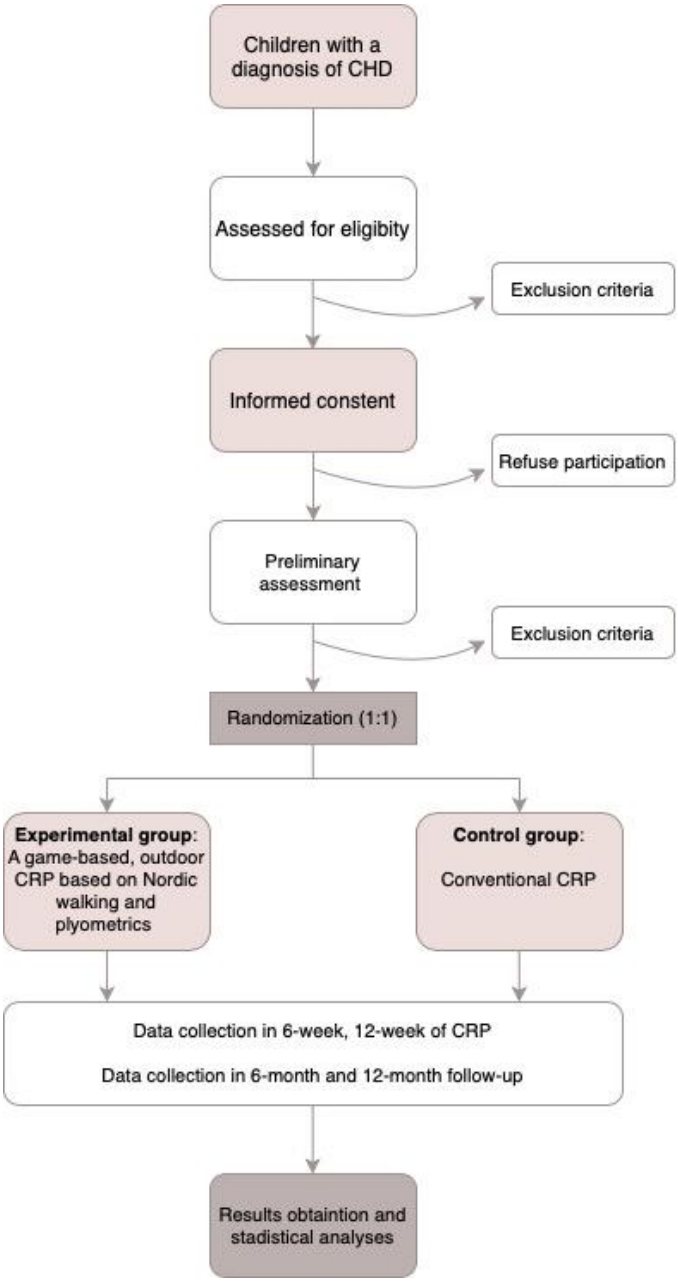


Figure 6. Clinical trial flow chart

8. STATISTICAL ANALYSIS

Statistical analysis will be performed by a statistician, using IMP Statistical Package for Social Sciences (SPSS) available for the Windows program.

For all analyses, a P- value of 0.05 will be set to indicate statistical significance. Confident intervals will be expressed as 95 %.

To perform the statistical analysis of the data, all the variables will be defined as qualitative (categorical) or quantitative (numeric). The type of variable has been already classified in **Table 3** and **Table 4.**

8.1. UNIVARIANT ANALYSIS

The univariate analysis will be used for the analytical description of the sample.

Mean and SD will be used to express results for quantitative variables and covariables with a normal distribution. Otherwise, quantitative variables and covariables without a normal distribution will be expressed as median and interquartile ranges.

Qualitative variables and covariables will be described using percentages or proportions.

8.2. BIVARIANT ANALYSIS

The bivariant analysis will be performed to assess the impact of our intervention on our dependent variables. As our main outcome is quantitative (a score obtained in the PCQLI questionnaire), and data will be obtained from the questionnaires at 4 different times, to progressively assess the quality of life in children: in the preliminary assessment, once the CRP will be finished, after 6 months and 12 months, ANOVA test will be elected for analyzing data.

About our secondary outcomes, they are also quantitative variables (VO_2 peak, LVEF, dyspnea perceived post effort, walking distance in 6MWT and lean body mass), and they will also be obtained in 5 different times (in the preliminary cardiologic assessment, in the middle of the CRP program, once it will be finished and in the follow-up visits in 6 months and 12 months) the analysis will be also done with ANOVA test.

8.3. MULTIVARIANT ANALYSIS

The multivariate analysis will be done to adjust the result of the outcome variable for the potential confounders covariables. Even though groups will be done randomly so these endpoints variables will be balanced in both groups so there should not be any cofounding.

An ANOVA test and linear regression will be used to assess the relationship between both groups of cardiac rehabilitation programs, taking into consideration the effect of confusion variables.

9. FEASIBILITY

The medical team for this study will be composed of physical therapists, cardiac rehabilitators, paediatric cardiologists, cardiologists, nutritionists, psychologists and, nurses, all of them experienced enough to attend to the necessities of the included patients and to execute the study's procedures.

The principal investigator of the clinical trial is an experimented paediatric cardiologist with wide knowledge and experience in the treatment and rehabilitation of patients with congenital heart disease. The only person that will indeed be necessary to recruit is the statistical analyser who processes all the data and interpret the results. As this study will be carried out in the Cardiac Rehabilitation Unit a paediatric cardiologist should be incorporated into the team.

The clinical trial takes place in Parc Hospitalari Martí i Julià as is the only health centre in the region of Girona that carries out cardiac rehabilitation. As an estimation, there will be around 310 patients from 8 to 12 in 2022 with congenital heart disease in Girona (**Table 2**) that even if we consider a low tax of responses as it is a paediatric population, we have enough sample.

All procedures and interventions use are well-known for our medical team. Anyway, there will be some training workshops to unique knowledge and steps.

There are not many extra materials required for carrying out the intervention apart from what the unit already has. Extra material has been taken into account when calculating the budget for the study (see 10. BUDGET).

Concerning patient's assessment and follow-up, the centre disposes of the necessary means to proceed with the right follow-up, so all the study phases are able to procure properly.

10. WORK PLAN AND CHRONOGRAM

The study will take approximately two years. The activities developed in this study will be carried out in the following way:

STAGE 0: ELABORATION OF THE PROTOCOL DESIGN (October 2021- December 2021)

- **Activity 1.** The first activity will consist of literature research and the protocol clinical trial elaboration.
- **Activity 2.** The principal investigator will present to the research team in order to ensure a good transfer of information and make any modifications.

STAGE 1: ETHICAL EVALUATION AND APPROBATION (December 2021 - February 2022)

- **Activity 3.** The protocol will be presented to the CEIC of the hospital. CEIC will evaluate, comment, give advice, and approve the protocol.
- **Activity 4.** Questionnaires that are used in the study are only available in English (PCQLI, STAI-CH, and Spanish (PAQ-C, KIDMED). As our population is Catalan-native and Spanish-native, we will need to traduce tests in Catalan and Spanish and they will have to follow a process of validation before the start of the clinical trial.

STAGE 2: COORDINATION AND TRAINING (February 2022)

- **Activity 5**. Once the protocol is approved, there will be another research team meeting to inform and coordinate the research team. Tasks will be in assignment and any problem or doubt will be solved.
- **Activity 6**. Training workshops will be done for all professionals that will participate in our clinical trial in order to unify and standardize intervention and avoid bias.

STAGE 3: SAMPLE RECRUITMENT, INTERVENTION, FOLLOW-UP VISITS, AND DATA COLLECTION (February 2022 – December 2023)

- **Activity 7.** Patient recruitment will be done by random simple sampling in a database of patients in Girona who accomplish the inclusion criteria and do not meet any exclusion criteria. Parents or legal guardian will be contacted by phoned by their paediatric

cardiologist or general physician and informed of the clinical trial. The information sheet and consent form will be handed to them.

- **Activity 8.** An external company will be responsible to assigned a random number and assigned to one of the intervention groups.
- **Activity 9**. Intervention. Cardiologist, nutritionist and psychologist preliminary assessments will start performing. If there are not any exclusion criteria, patients will start the cardiac rehabilitation program. It will last 12 weeks. Assessments in the middle of the program, once it will finish will be performed. Data of all process will be collected in a database. All specialists except physical therapists and cardiac rehabilitator will be blinded for intervention groups.
- **Activity 10.** 6-month and 12-month follow-up visits will also be performed. As well as in the other activity, data will be collected in a database.

STAGE 4: DATA ANALYSIS AND INTERPRETATION OF THE RESULTS (December 2023 - March 2024)

- **Activity 11**. Statistical analysis will be performed by a subcontracted statistician who will be blinded for intervention groups. She will perform the analysis once all the data has been collected.
- **Activity 12**. The main investigator will interpret data. Discussion and conclusion will be elaborated. Final results and conclusions will be exposed in a research team meeting.

STAGE 5: PUBLICATION AND DISSEMINATION OF THE RESEARCH FINDINGS (April 2024- May 2024)

- **Activity 13**. Once the clinical trial has been finished, it will be published by a scientific review. The main investigator will be in charge of contacting the review, publishing the clinical trial, and managing its publication.
- **Activity 14**. The results of the study will be published in a scientific journal.

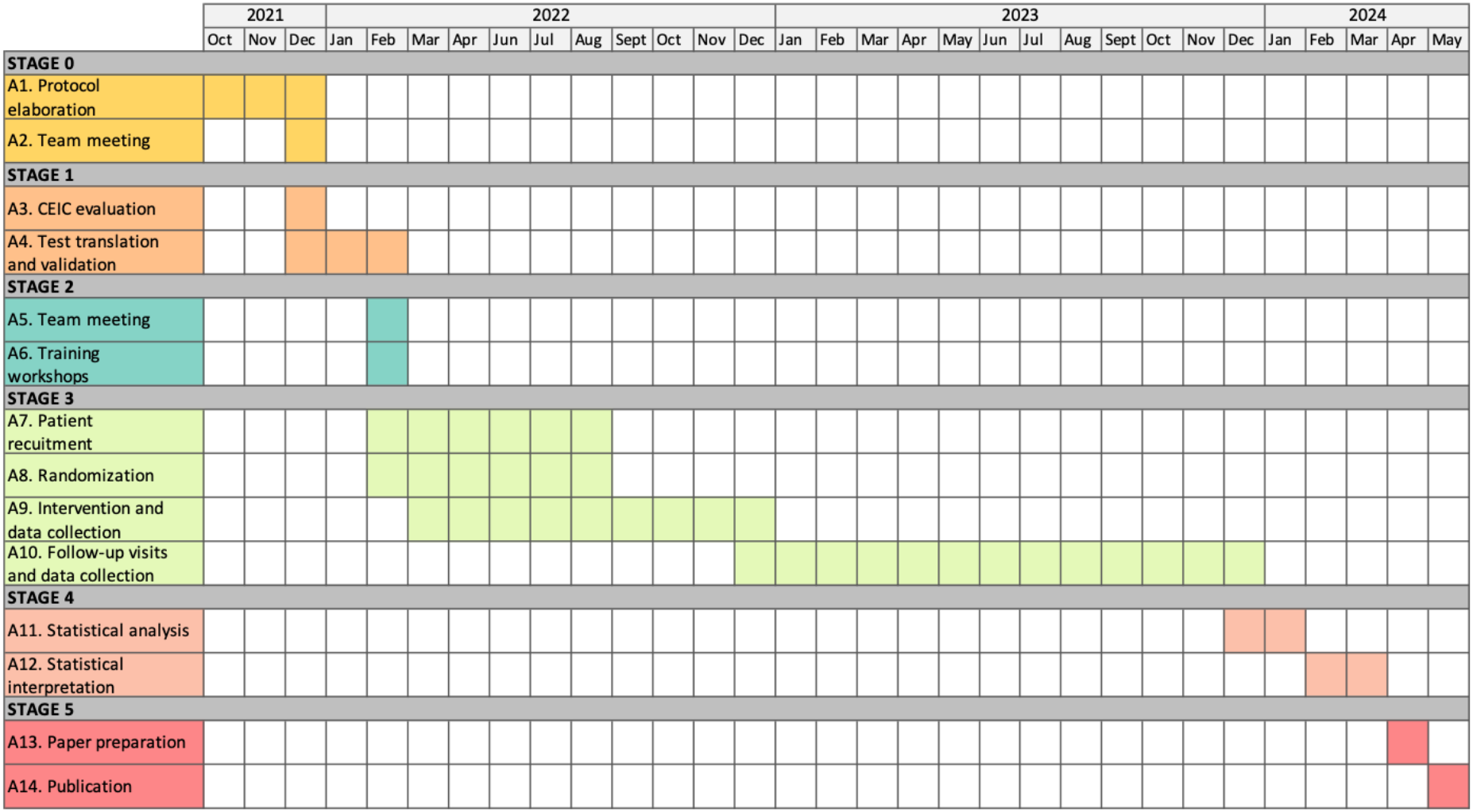


Figure 7. Chronogram

11. BUDGET

Table 6. Summarised budget

ITEM	Cost per unit	Nº of units	Subtotal
Material costs			
Telemetry	200 € / unit	16 units	3.200 €
Power Breath Medic	40 € / unit	106 units	4.240 €
Adjustable horizontal seat adapted for paediatrics	480 € / unit	8 units	3.840 €
Exercise material (softballs, medicinal balls, hurdles, jump ropes…)			300 €
Paediatric Nordic walking poles	60€ / pair	8 pairs	480 €
Adult Nordic walking poles for instructors	50 € / pair	2 pairs	100 €
STAI-C test licence	2,5 € / unit	530 tests	1.325 €
Total			13.385 €
Personnel costs			
Statiscians	35€ / hour	80h	2.800 €
Total			2.800 €
Subcontracted services			
Insurance trail policy	30 € / patient	106 patients	3.180 €
Total			3.180 €
Divulgation costs			
Publication costs			2.000 €
National congress			2.000 €
Total			4.000 €
TOTAL OF THE PROJECT			23.365 €

12. ETHICAL AND LEGAL CONSIDERATIONS

This clinical trial protocol will follow ethical aspects established by international and national standards.

The study will be designed according to World Medical Association Declaration of Helsinki for *Ethical Principles for Medical Research Involving Human Subjects* (last updated in October 2013). Moreover, "*Real decreto 1090/2015, de 4 de diciembre, de Investigaciones clínicas con productos sanitarios"* will be also considered as it includes medical devices.

The four basic ethical principles are accomplished in this trial.

To guarantee autonomy, all participants and their families will be provided with the information sheet containing all the information about the clinical trial (ANNEX 9). All doubts about the protocol details will be solved after reading the document, and if they agree, they will have to sign the informed consent, as it is stated on the "*Ley 41/2002, de 14 de noviembre, Básica reguladora de la autonomía del paciente y de derechos y obligaciones en materia de información y documentación clínica*".

As our study is with minors (below 16 years old in medical frame) and patients are from 8 to 12 years old, patient's agreement will be fundamental since it is considered that they can make reasonable decisions, while parents or legal guardians will be the ones that will have the responsibility of signing the consent form (ANNEX 10).

Personal data collected during the clinical trial is confidential and will guarantee personal data protection and fundamental rights of physical people in accordance to Regulation EU 2016/679 of Parliament and the European Council, April 27, 2016, concerning the protection of natural people with regard to the processing of personal data and the free movement of such data. As well as, "*Ley Orgánica 3/2018, de 5 de diciembre, de Protección de Datos Personales y garantía de los derechos digitales*" is considered.

To ensure beneficence, the clinical trial intervention has been designed following the current evidence of the potential of cardiac rehabilitation programs in paediatrics, taking into account the numerous benefits that have.

To make sure no maleficence, the study will follow all the safety precautions and will be monotonized all time during the exercise training. Nonetheless, all kinds of exercise used have proven to be safe, so patients will not be at more risk if they are part of one group or another.

Principal of justice will be also ensured as there will not be any kind of discrimination against patients as all will need to meet the inclusion criteria without meeting the exclusion criteria if they want to take part in the clinical trial.

Before beginning this study, the protocol will be presented to the Clinical Research Ethical Committee (CEIC) of the hospital, which will evaluate the study with the criteria for being approved. All objections and recommendations that the CEIC may give will be considered and introduced.

Lastly, all investigators will have to pronounce no conflict of inters to guarantee that clinical has no commercial bias or interest.

13. LIMITATIONS OF THE STUDY

Analysing this study, some limitations that may interfere have been detected and taken into consideration, especially potential bias and methodological and logistical limitations.

The main limitation that we have to consider is the variability of our target population. As has been mentioned above, there is a large range of different congenital heart disease with numerous anatomopathological characteristics that imply a variability of clinical manifestations, exercise responses, and quality of life. Nevertheless, to minimize this bias, inclusion, and exclusion criteria have been defined with the aim to represent thoroughly all the population. As well as randomization has been performed to help to distribute symmetrically the covariates. So future results will be able to be extrapolated on the general population.

Secondly, another remarkable aspect that we should consider is the impossibility of masking the patient and physical therapists from the intervention to be performed, and this fact may lead to a detection bias. To minimize this bias, the study will be an examiner-blind trial, as all the specialists who will collect data will be unaware of which kind of rehabilitation program are taking part in. With this in mind, it is essential to tell to the patients not to reveal the type of rehabilitation that are receiving to the other specialist emphasizing the importance of that fact.

Not only these biases will be considered but also, it is relevant to take into account that as it is a paediatric population and the intervention implies commitment for a long time, a low tax of responses is expected. Contemplating this possible effect, it has been considered when determining the sample needed for the trial. As well as, the possibility to replace losses during the recruitment period as intervention is expected to be done at least three times to include all patients.

Last but not least, there may be a possible bias when we think about variability in carrying out the intervention. Even though, all specialists will receive sufficient training to standardize the procedure and avoid variability.

14. IMPACT ON THE NATIONAL HEALTH SYSTEM

As a matter of fact, congenital heart diseases are the most frequent malformations that occur during birth. Thanks to the great advances in diagnosis and treatment, nowadays, a huge number of children reach adulthood. Notwithstanding, life expectancy of patients remains short and the quality of life low.

The implementation of a cardiac rehabilitation program for those patients would have an undoubtedly favourable impact on them. Even though, an insignificant percentage of children around the world take part in what of them. This fact may lay in the fact that those programs may not be enough motivational for children.

This clinical trial will have great prognosis importance if we improve the quality of life of children with congenital heart disease, as well as their cardiopulmonary capacity.

If the results are significant and our hypotheses are validated, a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics will be able to be implemented in the other hospitals. This could be a great change when we are talking about the future of those children.

In conclusion, we believe that a game-based outdoor cardiac rehabilitation program based on Nordic walking and plyometrics is an available, low-cost, child-adapted and, easy to carry out rehabilitation program with a huge potential in the prognosis of children.

15. BIBLIOGRAPHY

1. Cardiopatías Congénitas. Cardiología Pediátrica y Cirugía de CC [Internet]. [cited 2021 Sep 30]. Available from: https://cardiopatiascongenitas.net/

2. American Heart Association. Congenital Heart Defects [Internet]. [cited 2021 Sep 30]. Available from: https://www.heart.org/en/health-topics/congenital-heart-defects

3. Wren C, Irving CA, Griffiths JA, O'Sullivan JJ, Chaudhari MP, Haynes SR, et al. Mortality in infants with cardiovascular malformations. European Journal of Pediatrics. 2012 Feb;171(2):281–7.

4. Atenció a les cardiopaties congènites. Pediatria Catalana [Internet]. 2009 [cited 2021 Sep 30];69:46–53. Available from: http://pediatrcatalana.cat/nums_ant.php?idpub=3

5. Idescat. Anuari estadístic de Catalunya. Naixements. Per sexe. Comarques i Aran, àmbits i províncies. 2020 [Internet]. [cited 2021 Sep 30]. Available from: https://www.idescat.cat/pub/?id=aec&n=259&t=2020

6. Oster ME, Lee KA, Honein MA, Riehle-Colarusso T, Shin M, Correa A. Temporal trends in survival among infants with critical congenital heart defects. Pediatrics. 2013 May;131(5).

7. Farr SL, Downing KF, Riehle-Colarusso T, Abarbanell G. Functional limitations and educational needs among children and adolescents with heart disease. Congenital Heart Disease. 2018 Jul 1;13(4):633–9.

8. Sanz Pascular E, García-Guereta Silva L, Moreno Granado F. Epidemiología de las cardiopatías congénitas. In: Cardiología pediátrica y cardiopatías congénitas del niño y del adolescente. Madrid: Sociedad Española de Cardiología Pediátrica y Cardiopatías Congénitas; 2015.

9. Buijtendijk MFJ, Barnett P, van den Hoff MJB. Development of the human heart. American Journal of Medical Genetics, Part C: Seminars in Medical Genetics. 2020 Mar 1;184(1):7–22.

10. Sadler TW. Sistema cardiovascular. In: Langman Embriología médica . 13th ed. Philadelphia: Wolters Kulwer; 2016. p. 175–217.

11. Standford Children's Health. Congenital Heart Disease [Internet]. [cited 2021 Oct 12]. Available from: https://www.stanfordchildrens.org/en/topic/default?id=congenital-heart-disease-90-P02346

12. RongRong S, Liu M, Lu L, Zheng Y, Zhang P. Congenital Heart Disease: Causes, Diagnosis, Symptoms, and Treatments. Cell biochemistry and biophysics [Internet]. 2015 Jul 1 [cited 2021 Oct 12];72(3):857–60. Available from: https://pubmed.ncbi.nlm.nih.gov/25638345/

13. Liu S, Joseph KS, Lisonkova S, Rouleau J, van den Hof M, Sauve R, et al. Association between maternal chronic conditions and congenital heart defects: A population-based cohort study. Circulation. 2013 Aug 6;128(6):583–9.

14. Puigdevall Dalmau MÀ, Uriel Prat S. Clasificación y nomenclatura de las cardiopatías congénitas. In: Cardiología pediátrica y cardiopatías congénitas del niño y del adolescente. Madrid: Sociedad Española de Cardiologia Pediátrica y Cardiopatías Congénitas; 2015.

15. Colombo JN, McCulloch MA. Acyanotic Congenital Heart Disease: Left-to-Right Shunt Lesions. NeoReviews [Internet]. 2018 Jul 1 [cited 2021 Oct 12];19(7):e375–83. Available from: https://neoreviews.aappublications.org/content/19/7/e375

16. King TC. Cardiovascular Pathology. Elsevier's Integrated Pathology. 2007 Jan 1;169–95.

17. Stout KK, Daniels CJ, Aboulhosn JA, Bozkurt B, Broberg CS, Colman JM, et al. 2018 AHA/ACC Guideline for the Management of Adults With Congenital Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Journal of the American College of Cardiology. 2019 Apr 2;73(12):e81–192.

18. UpToDate. Identifying newborns with critical congenital heart disease [Internet]. [cited 2021 Oct 15]. Available from: https://www.uptodate.com/contents/identifying-newborns-with-critical-congenital-heart-disease

19. Arvind B, Saxena A. Timing of Interventions in Infants and Children with Congenital Heart Defects. Indian journal of pediatrics [Internet]. 2020 Apr 1 [cited 2021 Oct 12];87(4):289–94. Available from: https://pubmed.ncbi.nlm.nih.gov/31970668/

20. Geggel RL. Conditions leading to pediatric cardiology consultation in a tertiary academic hospital. Pediatrics. 2004 Oct;114(4).

21. Dolbec K, Mick NW. Congenital heart disease. Emergency medicine clinics of North America [Internet]. 2011 [cited 2021 Oct 12];29(4):811–27. Available from: https://pubmed.ncbi.nlm.nih.gov/22040709/

22. The International Society of Ultrasound in Obstetrics. ISUOG Practice Guidelines (updated): sonographic screening examination of the fetal heart. Ultrasound in obstetrics & gynecology : the official journal of the International Society of Ultrasound in Obstetrics and Gynecology. 2013 Mar;41(3):348–59.

23. Chitra N, Vijayalakshmi IB. Fetal echocardiography for early detection of congenital heart diseases. Journal of echocardiography [Internet]. 2017 Mar 1 [cited 2021 Oct 12];15(1):13–7. Available from: https://pubmed.ncbi.nlm.nih.gov/27530200/

24. NHS. Congenital heart disease - Diagnosis [Internet]. [cited 2021 Oct 12]. Available from: https://www.nhs.uk/conditions/congenital-heart-disease/diagnosis/

25. American Heart Association. Care and Treatment for Congenital Heart Defects [Internet]. [cited 2021 Oct 17]. Available from: https://www.heart.org/en/health-topics/congenital-heart-defects/care-and-treatment-for-congenital-heart-defects

26. Lopes SAVDA, Guimarães ICB, Costa SF de O, Acosta AX, Sandes KA, Mendes CMC. Mortality for critical congenital heart diseases and associated risk factors in newborns. A cohort study. Arquivos Brasileiros de Cardiologia. 2018 Nov 1;111(5):666–73.

27. Hinton RB, Ware SM. Heart Failure in Pediatric Patients with Congenital Heart Disease. Vol. 120, Circulation Research. Lippincott Williams and Wilkins; 2017. p. 978–94.

28. Bouma BJ, Mulder BJM. Changing Landscape of Congenital Heart Disease. Vol. 120, Circulation Research. Lippincott Williams and Wilkins; 2017. p. 908–22.

29. NHS. Pulmonary hypertension [Internet]. [cited 2021 Oct 17]. Available from: https://www.nhs.uk/conditions/pulmonary-hypertension/

30. PHA Europe. Classification and WHO functional class [Internet]. [cited 2021 Oct 17]. Available from: https://www.phaeurope.org/about-ph/classification-and-who-functional-class/

31. Pérez-Lescure Picarzo F, Crespo Marcos D. Endocarditis infecciosa. In: Cardiología pediátrica y cardiopatías congéntias del niño y del adolescente. Madrid : Sociedad Española de Cardiología Pediátrica y Cardiopatías Congénitas; 2015. p. 397–404.

32. Pinto NM, Marino BS, Wernovsky G, de Ferranti SD, Walsh AZ, Laronde M, et al. Obesity is a common comorbidity in children with congenital and acquired heart disease. Pediatrics. 2007 Nov;120(5).

33. Stefan MA, Hopman WM, Smythe JF. Effect of Activity Restriction Owing to Heart Disease on Obesity. Archives of Pediatrics & Adolescent Medicine [Internet]. 2005 May 1 [cited 2021 Oct 17];159(5):477–81. Available from: https://jamanetwork.com/journals/jamapediatrics/fullarticle/486006

34. Úbeda Tikkanen A, Albert Brotons DC. Ejercicio físico y deporte en niños con cardiopatías. In: Cardiología pediátrica y cardiopatías congénitas del niño y del adolescente. Madrid: Sociedad Española de Cardiología Pediátrica y Cardiopatías Congénitas; 2015. p. 535–45.

35. Roseman A, Morton L, Kovacs AH. Health anxiety among adults with congenital heart disease. Current Opinion in Cardiology [Internet]. 2021 Jan 1 [cited 2021 Oct 21];36(1):98–104. Available from: https://journals.lww.com/co-cardiology/Fulltext/2021/01000/Health_anxiety_among_adults_with_congenital_heart.17.aspx

36. Bellinger DC, Newburger JW. Neuropsychological, psychosocial, and quality-of-life outcomes in children and adolescents with congenital heart disease. Progress in Pediatric Cardiology. 2010 Aug;29(2):87–92.

37. Bjarnason-Wehrens B, Schmitz S, Dordel S. Motor Development in Children with Congenital Cardiac Diseases. Paedriatic Cardiology. 2008;92–6.

38. Takken T, Giardini A, Reybrouck T, Gewillig M, Hövels-Gürich HH, Longmuir PE, et al. Recommendations for physical activity, recreation sport, and exercise training in paediatric patients with congenital heart disease: a report from the Exercise, Basic & Translational Research Section of the European Association of Cardiovascular Prevention and Rehabilitation, the European Congenital Heart and Lung Exercise Group, and the Association for European Paediatric Cardiology. European journal of preventive cardiology [Internet]. 2012 [cited 2021 Oct 19];19(5):1034–65. Available from: https://pubmed.ncbi.nlm.nih.gov/23126001/

39. Physical activity strategy for the WHO European Region 2016 - 2025. 2016 [cited 2021 Nov 5]; Available from: https://www.euro.who.int/en/publications/abstracts/physical-activity-strategy-for-the-who-european-region-20162025

40. WHO Guidelines on physical activitiy and sedentary behaviour. [cited 2021 Nov 5]; Available from: https://www.who.int/publications/i/item/9789240015128

41. Sothern M, Loftin M, Suskind R, Udall J, Blecker U. The health benefits of physical activity in children and adolescents: implications for chronic disease prevention. European journal of pediatrics [Internet]. 1999 [cited 2021 Oct 21];158(4):271–4. Available from: https://pubmed.ncbi.nlm.nih.gov/10206121/

42. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Reports [Internet]. 1985 [cited 2021 Oct 19];100(2):126. Available from: /pmc/articles/PMC1424733/?report=abstract

43. Jetté M, Sidney K, Blümchen G. Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. Clinical cardiology [Internet]. 1990 [cited 2021 Oct 19];13(8):555–65. Available from: https://pubmed.ncbi.nlm.nih.gov/2204507/

44. Actividad fsica para la salud y la reducción del sedentarismo. Recomendaciones para la población. Estrategia de Promoción de la Salud y Prevención en el SNS. Madrid : Ministerio de Sanidad, Servicios Sociales e Igualdad; 2015.

45. Amedro P, Gavotto A, Bredy C, Guillaumont S. Réadaptation cardiaque de l'enfant et l'adulte avec une cardiopathie congénitale. La Presse Médicale. 2017 May 1;46(5):530–7.

46. Moola F, Fusco C, Kirsh JA. The perceptions of caregivers toward physical activity and health in youth with congenital heart disease. Qualitative health research [Internet]. 2011 Feb [cited 2021 Oct 21];21(2):278–91. Available from: https://pubmed.ncbi.nlm.nih.gov/20935236/

47. Caterini JE, Campisi ES, Cifra B. Physical Activity Promotion in Pediatric Congenital Heart Disease: Are We Running Late? The Canadian journal of cardiology [Internet]. 2020 Sep 1 [cited 2021 Oct 21];36(9):1406–16. Available from: https://pubmed.ncbi.nlm.nih.gov/32673643/

48. Longmuir PE, Brothers JA, Ferranti SD de, Hayman LL, Hare GF van, Matherne GP, et al. Promotion of Physical Activity for Children and Adults With Congenital Heart Disease. Circulation [Internet]. 2013 May 28 [cited 2021 Oct 21];127(21):2147–59. Available from: https://www.ahajournals.org/doi/abs/10.1161/cir.0b013e318293688f

49. Telama R. Tracking of Physical Activity from Childhood to Adulthood: A Review. Obesity Facts [Internet]. 2009 Jul [cited 2021 Oct 21];2(3):187. Available from: /pmc/articles/PMC6516203/

50. Gomes-Neto M, Saquetto MB, da Silva e Silva CM, Conceição CS, Carvalho VO. Impact of Exercise Training in Aerobic Capacity and Pulmonary Function in Children and Adolescents After Congenital Heart Disease Surgery: A Systematic Review with Meta-analysis. Pediatric

cardiology [Internet]. 2016 Feb 1 [cited 2021 Oct 26];37(2):217–24. Available from: https://pubmed.ncbi.nlm.nih.gov/26396114/

51. Feltez G, Correa Coronel C, Campos Pellanda L, Lukrafka JL. Exercise capacity in children and adolescents with corrected congenital heart disease. Pediatric cardiology [Internet]. 2015 Jun 16 [cited 2021 Oct 26];36(5):1075–82. Available from: https://pubmed.ncbi.nlm.nih.gov/25808364/

52. WHO. Prevention of Cardiovascular Disease Guidelines for assessment and management of cardiovascular risk. 2007 [cited 2021 Oct 26]; Available from: www.inis.ie

53. Ambrosetti M, Abreu A, Corrà U, Davos CH, Hansen D, Frederix I, et al. Secondary prevention through comprehensive cardiovascular rehabilitation: From knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology. Jessa Hospital Campus Virga Jesse [Internet]. [cited 2021 Oct 26];14. Available from: https://academic.oup.com/eurjpc/article/28/5/460/6145619

54. Arias Labrador E, Vilaró Casamitjana J, Blanco Díaz S, Ariza Turiel G, Paz Bermejo MA, Pujol Iglesias E, et al. Effects of an interdisciplinary program combining aerobic interval training and dynamic strength in acute coronary syndrome. Rehabilitacion. 2021;

55. Gauthier N, Curran T, O'Neill JA, Alexander ME, Rhodes J. Establishing a Comprehensive Pediatric Cardiac Fitness and Rehabilitation Program for Congenital Heart Disease. Pediatric cardiology [Internet]. 2020 Dec 1 [cited 2021 Oct 26];41(8):1569–79. Available from: https://pubmed.ncbi.nlm.nih.gov/32681180/

56. Sadek Z, Salami A, Joumaa WH, Awada C, Ahmaidi S, Ramadan W. Best mode of inspiratory muscle training in heart failure patients: a systematic review and meta-analysis. European journal of preventive cardiology [Internet]. 2018 Nov 1 [cited 2021 Oct 26];25(16):1691–701. Available from: https://pubmed.ncbi.nlm.nih.gov/30073849/

57. García-Cuenllas L, del Campo Bujedo F, Centeno Garrido MA, Oreja Sánchez C, Maroto Álvaro E, Medrano López C, et al. Protocolo de rehabilitación cardiorrespiratoria en pacientes con cardiopatías congénitas. Medicine (Spain). 2017 Nov 1;12(45):2713–21.

58. Tschentscher M, Niederseer D, Niebauer J. Health Benefits of Nordic Walking: A Systematic Review. American Journal of Preventive Medicine [Internet]. 2013 Jan 1 [cited 2021 Oct

26];44(1):76–84. Available from: http://www.ajpmonline.org/article/S0749379712007106/fulltext

59. Chu DA, Myer GD. Plyometrics. Leeds: Human Kinetics; 2013.

60. Johnson BA, Salzberg CL, Stevenson DA. A systematic review: plyometric training programs for young children. Journal of strength and conditioning research [Internet]. 2011 [cited 2021 Oct 26];25(9):2623–33. Available from: https://pubmed.ncbi.nlm.nih.gov/21849911/

61. Avery D. Plyometric Training for Children and Adolescents. American College of Sports Medicine [Internet]. 2017 [cited 2021 Oct 26]; Available from: https://www.acsm.org/docs/default-source/files-for-resource-library/smb-plyometric-training-for-children-and-adolescents.pdf?sfvrsn=fcc67055_2

62. Janssen J, Verschuren O, Renger WJ, Ermers J, Ketelaar M, van Ee R. Gamification in physical therapy: More than using games. Pediatric Physical Therapy. 2017;29(1):95–9.

63. Rutledge C, Walsh CM, Swinger N, Auerbach M, Castro D, Dewan M, et al. Gamification in action: Theoretical and practical considerations for medical educators. Academic Medicine [Internet]. 2018 Jul 1 [cited 2021 Nov 1];93(7):1014–20. Available from: https://journals.lww.com/academicmedicine/Fulltext/2018/07000/Gamification_in_Action__Theoretical_and_Practical.21.aspx

64. Kroll KH, Kovach JR, Ginde S, Jacobsen RM, Danduran M, Foster A, et al. Impact of a paediatric cardiac rehabilitation programme upon patient quality of life. Cardiology in the Young. 2021 May 1;31(5):804–11.

65. Czosek RJ, Kaltman JR, Cassedy AE, Shah MJ, Vetter VL, Tanel RE, et al. Quality of Life of Pediatric Patients with Long QT Syndrome. American Journal of Cardiology. 2016 Feb 15;117(4):605–10.

66. Serra-Grima R, Doñate M, Borrás X, Rissech M, Puig T, Albert DC, et al. Prueba de esfuerzo con función cardiopulmonar en niños operados de cardiopatía congénita. Recomendaciones de ejercicio físico en el ámbito escolar. Revista Española de Cardiología [Internet]. 2011 Sep 1 [cited 2021 Oct 25];64(9):780–7. Available from: http://www.revespcardiol.org/es-prueba-esfuerzo-con-funcion-cardiopulmonar-articulo-S0300893211005136

67. Rabinovich R, VIlaró J, Roca J. Evaluación de la tolerancia al ejercicio en pacientes con EPOC. Prueba de marcha de 6 minutos. Arch Bronconeumol [Internet]. 2004 [cited 2021 Oct

25];40(2):80–5. Available from: https://www.archbronconeumol.org/es-pdf-S0300289604754770

68. Cacau L de AP, Santana-Filho VJ de, Maynard LG, Neto MG, Fernandes M, Carvalho VO. Reference Values for the Six-Minute Walk Test in Healthy Children and Adolescents: a Systematic Review. Brazilian Journal of Cardiovascular Surgery [Internet]. 2016 Sep 1 [cited 2021 Oct 25];31(5):381. Available from: /pmc/articles/PMC5144571/

69. Manzano-Carrasco S, Felipe JL, Sanchez-Sanchez J, Hernandez-Martin A, Gallardo L, Garcia-Unanue J. Weight status, adherence to the mediterranean diet, and physical fitness in spanish children and adolescents: The active health study. Nutrients. 2020 Jun 1;12(6):1–14.

70. Harvard T.H. Chan School of Public Health. Kid's Healthy Eating Plate | The Nutrition Source [Internet]. [cited 2021 Oct 24]. Available from: https://www.hsph.harvard.edu/nutritionsource/kids-healthy-eating-plate/

71. Villanova DC, Leal DM. Educación Física y Deportes. 2011;71–83.

72. Solé Fortó J. Fundamentos del entrenamiento deportivo. Libro de ejercicios. Barcelona: Ergo; 2002.

16. ANNEXES

16.1. ANNEX 1. ACHD AP CLASSIFICATION

Table 7. ACHD AP CLASSIFICATION (CHD anatomy + physiological Stage). Source (17)

CHD ANATOMY	
I: Simple	
Native disease ○ Isolated small ASD ○ Isolated small VSD ○ Mild isolated pulmonic stenosis	**Repaired conditions** ○ Previously ligated or occluded ductus arteriosus ○ Repaired secundum ASD or sinus venosus defect without significant residual shunt or chamber enlargement ○ Repaired VSD without significant residual shunt or chamber enlargement
II: Moderate complexity	
Repaired or unrepaired conditions ○ Aorto-left ventricular fistula ○ Anomalous pulmonary venous connection, partial or total ○ Anomalous coronary artery arising from the pulmonary artery ○ Anomalous aortic origin of a coronary artery from the opposite sinus ○ AVSD (partial or complete, including primum ASD) ○ Congenital aortic valve disease ○ Congenital mitral valve disease ○ Coarctation of the aorta ○ Ebstein anomaly (disease spectrum includes mild, moderate, and sever variations) ○ Infundibular right ventricular outflow obstruction	○ Ostium primum ASD ○ Moderate and large unrepaired secundum ASD ○ Moderate and large persistently patent ductus arteriosus ○ Pulmonary valve regurgitation (moderate or greater) ○ Pulmonary valve stenosis (moderate or greater) ○ Peripheral pulmonary stenosis ○ Sinus of Valsalva fistula/aneurysm ○ Sinus venosus defect ○ Subvalvar aortic stenosis (excluding HCM) ○ Supravalvar aortic stenosis ○ Straddling atrioventricular valve ○ Repaired tetralogy of Fallot ○ VSD with associated abnormality and/or moderate or greater shunt
III: Great complexity (or Complex)	
○ Cyanotic congenital heart defect (unrepaired or palliated, all forms) n Double-outlet ventricle ○ Fontan procedure ○ Mitral atresia	○ Interrupted aortic arch ○ Pulmonary atresia (all forms) ○ TGA (classic or d-TGA; CCTGA or l-TGA) ○ Truncus arteriosus

○ Single ventricle (including double inlet left ventricle, tricuspid atresia, hypoplastic left heart, any other anatomic abnormality with a functionally single ventricle)	Other abnormalities of atrioventricular and ventriculoarterial connection (i.e., crisscross heart, isomerism, heterotaxy syndromes, ventricular inversion)
PHYSIOLOGICAL STAGE	
A	**B**
○ NYHA FC I symptoms ○ No hemodynamic or anatomic sequelae ○ No arrhythmias ○ Normal exercise capacity ○ Normal renal/hepatic/pulmonary function	○ NYHA FC II symptoms ○ Mild hemodynamic sequelae (mild aortic enlargement, mild ventricular enlargement, mild ventricular dysfunction) ○ Mild valvular disease ○ Trivial or small shunt (not hemodynamically significant) ○ Arrhythmia not requiring treatment ○ Abnormal objective cardiac limitation to exercise
C	**D**
○ NYHA FC III symptoms ○ Significant (moderate or greater) valvular disease; moderate or greater ventricular dysfunction (systemic, pulmonic, or both) ○ Moderate aortic enlargement ○ Venous or arterial stenosis ○ Mild or moderate hypoxemia/cyanosis ○ Hemodynamically significant shunt ○ Arrhythmias controlled with treatment ○ Pulmonary hypertension (less than severe) ○ End-organ dysfunction responsive to therapy	○ NYHA FC IV symptoms ○ Severe aortic enlargement ○ Arrhythmias refractory to treatment ○ Severe hypoxemia (almost always associated with cyanosis) ○ Severe pulmonary hypertension ○ Eisenmenger syndrome ○ Refractory end-organ dysfunction

16.2. ANNEX 2. PHYSICAL ACTIVITY RECOMMENDATIONS FOR CHD

Table 8. Summary of physical activity recommendations for CHD. Source (38).

		Cardiorespiratory	Musculoskeletal
Healthy children		60 min / day Participation in competitive sport, leisure sport and physical activity unrestricted	2 -3 days / week Intensity unrestricted within safe limits for injury prevention
Septal defects		Like healthy	
Aortic stenosis	Mild	Like healthy	
	Moderate	Limit to moderate intensity at competitive sport only	Limit to moderate intensity at only
Aortic regurgitation (to mild to moderate)		Like healthy	
Bicuspid aortic valve (isolated)		Like healthy	Avoid very high intensity
Coarctation of aorta		Like healthy	Limit to low or moderate intensity only
Aortic dilatation or aneurysm (stable)	Mild	Like healthy	Avoid very high intensity
	Moderated	Limit to low and moderate intensity at competitive sport only	Limit to low intensity only
Pulmonary stenosis	< 30 mmHg	Like healthy	
	30–50 mmHg	Limit to low and moderate intensity at competitive sport only	Limit to low and moderate intensity only
Tetralogy of Fallot (without significant regurgitation)		Like healthy	
Pulmonary or tricuspid valve regurgitation (significant)		Limit to low and moderate intensity at competitive sport only if right ventricular dysfunction	
Ebstein anomaly (without significant regurgitation)		Like healthy	

Transposition of the great arteries	Limit to low and moderate intensity at competitive sport only	
Functional single ventricle (Fontan)	Limit to low and moderate intensity at competitive sport only	Limit to low intensity at competitive sport only
Implanted devices (pacemaker, defibrillator)	Like healthy *Contact limitations if on anticoagulants, and avoid activities with risk of contact to device or leads*	
Eisenmenger or pulmonary hypertension	Individualize recommendations based on clinical status and exercise responses	
Heart transplantation	Individualize recommendations for competitive sports	

16.3. ANNEX 3. ORIGINAL BORG SCALE VS MODIFIED BORG SCALE

ORIGINAL BORG SCALE		MODIFIED BORG SCALE	
6		0	Nothing at all
7	Very very light	0,5	Very very light
8		1	Very light
9	Very light	2	Light
10		3	Moderate
11	Fairly light	4	Something hard
12		5	Hard
13	Somewhat hard	6	
14		7	Very hard
15	Hard	8	
16		9	
17	Very Hard	10	Very very hard
18			
19	Very very hard		

16.4. ANNEX 4. PEDIATRIC CARDIAC QUALITY OF LIFE INVENTORY (PCQLI)

PCQLI: Child, Age 8–12

	Excellent	Very Good	Good	Fair	Poor
In general, would you say your health is...	1	2	3	4	5

Because of my heart problem...		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	I take too much medicine.	1	2	3	4	5
2	I get special treatment at home or at school.	1	2	3	4	5
3	I miss too much school.	1	2	3	4	5
4	Adults around me are too protective.	1	2	3	4	5
5	Other people treat me differently.	1	2	3	4	5
6	I can't do the physical activities I want to do.	1	2	3	4	5
7	I look different from everybody in a bad way.	1	2	3	4	5
8	I am afraid of medical procedures.	1	2	3	4	5
9	I get unwanted attention.	1	2	3	4	5
10	I get tired easily.	1	2	3	4	5
11	I can't eat or drink what I want.	1	2	3	4	5
12	I miss social activities.	1	2	3	4	5
13	I feel different from everybody in a bad way.	1	2	3	4	5
14	I have too many doctors' appointments.	1	2	3	4	5
15	I feel sad for my parents.	1	2	3	4	5
16	I am afraid of dying.	1	2	3	4	5
17	I find it hard to make friends.	1	2	3	4	5
18	I take medicine that makes me feel bad.	1	2	3	4	5
19	School work is difficult for me.	1	2	3	4	5
20	I hang back when I am doing physical activities.	1	2	3	4	5
21	I feel life is unfair.	1	2	3	4	5
22	I worry about my future.	1	2	3	4	5
23	Other people pick on me.	1	2	3	4	5

PCQLI: Parent of Child, Age 8–12

	Excellent	Very Good	Good	Fair	Poor
In general, would you say your child's health is...	1	2	3	4	5

	Because of my child's heart problem...	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	He/she takes too much medicine.	1	2	3	4	5
2	He/she gets special treatment at home or at school.	1	2	3	4	5
3	He/she misses too much school.	1	2	3	4	5
4	Adults around him/her are too protective.	1	2	3	4	5
5	Other people treat him/her differently.	1	2	3	4	5
6	He/she can't do the physical activities he/she wants to do.	1	2	3	4	5
7	He/she looks different from everybody in a bad way.	1	2	3	4	5
8	He/she is afraid of medical procedures.	1	2	3	4	5
9	He/she gets unwanted attention.	1	2	3	4	5
10	He/she gets tired easily.	1	2	3	4	5
11	He/she can't eat and drink what he/she wants.	1	2	3	4	5
12	He/she misses social activities.	1	2	3	4	5
13	He/she feels different from everybody in a bad way.	1	2	3	4	5
14	He/she goes to too many doctors' appointments.	1	2	3	4	5
15	He/she feels sad for his/her parents.	1	2	3	4	5
16	He/she is afraid of dying.	1	2	3	4	5
17	He/she finds it hard to make friends.	1	2	3	4	5
18	He/she takes medicine that makes him/her feel bad.	1	2	3	4	5
19	School work is difficult for him/her.	1	2	3	4	5
20	He/she hangs back when he/she is doing physical activities.	1	2	3	4	5
21	He/she feels life is unfair.	1	2	3	4	5
22	He/she often worries about his/her future.	1	2	3	4	5
23	Other people pick on him/her.	1	2	3	4	5

SCORING

Respondent form	Subscale	Items in Subscale
Child or Parent of Child	Disease Impact	1-7, 9, 10, 12, 14, 18-20
	Psychosocial impact	8, 11, 13, 15-17, 21-23
	*Emotional environment subscale	1-5

The Disease Impact and Psychosocial Impact subscale score are calculated individually using the following formula:

$$\frac{\sum subscale\ item\ responses\ values - Number\ of\ subscale\ item}{4 \times Number\ of\ subscale\ items} \times 50 = subscale\ score$$

The numerator adjusts the values from the Likert scale of 1-5 to an absolute scale of 0-4.

The denominator represents the maximum number of points possible on an absolute scale.

The ratio is multiplied by the maximum subscale score of 50 to yield the subscale score.

The Total score is calculated from the Disease Impact and Psychosocial Impact subscales using the following formula:

$$Disease\ Impact\ subscale\ score + Psychosocial\ Impact\ subscale\ score = Total\ score$$

As the sum of these two subscale scores, the Total score has a maximum of 100 points possible.

Emotional Environment subscale is self-contained and its items are numbered separately. Emotional Environment and General Health Perception Question are not included in the scoring.

16.5. ANNEX 5. PHYSICAL ACTIVITY QUESTIONNAIRE (PAQ-C)

Physical Activity Questionnaire (Elementary School)

Name:_____ Age:_____

Sex: M_____ F_____ Grade:_____

Teacher:_____

We are trying to find out about your level of physical activity from ***the last 7 days*** (in the last week). This includes sports or dance that make you sweat or make your legs feel tired, or games that make you breathe hard, like tag, skipping, running, climbing, and others.

Remember:
1. There are no right and wrong answers — this is not a test.
2. Please answer all the questions as honestly and accurately as you can — this is very important.

---

1. Physical activity in your spare time: Have you done any of the following activities in the past 7 days (last week)? If yes, how many times? (Mark only one circle per row.)

	No	1-2	3-4	5-6	7 times or more
Skipping	❍	❍	❍	❍	❍
Rowing/canoeing	❍	❍	❍	❍	❍
In-line skating	❍	❍	❍	❍	❍
Tag	❍	❍	❍	❍	❍
Walking for exercise	❍	❍	❍	❍	❍
Bicycling	❍	❍	❍	❍	❍
Jogging or running	❍	❍	❍	❍	❍
Aerobics	❍	❍	❍	❍	❍
Swimming	❍	❍	❍	❍	❍
Baseball, softball	❍	❍	❍	❍	❍
Dance	❍	❍	❍	❍	❍
Football	❍	❍	❍	❍	❍
Badminton	❍	❍	❍	❍	❍
Skateboarding	❍	❍	❍	❍	❍
Soccer	❍	❍	❍	❍	❍
Street hockey	❍	❍	❍	❍	❍
Volleyball	❍	❍	❍	❍	❍
Floor hockey	❍	❍	❍	❍	❍
Basketball	❍	❍	❍	❍	❍
Ice skating	❍	❍	❍	❍	❍
Cross-country skiing	❍	❍	❍	❍	❍
Ice hockey/ringette	❍	❍	❍	❍	❍
Other:					
_____	❍	❍	❍	❍	❍
_____	❍	❍	❍	❍	❍

2. In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing)? (Check one only.)

I don't do PE .....❍
Hardly ever .....❍
Sometimes .....❍
Quite often .....❍
Always .....❍

3. In the last 7 days, what did you do most of the time *at recess*? (Check one only.)

Sat down (talking, reading, doing schoolwork)……❍
Stood around or walked around .....❍
Ran or played a little bit .....❍
Ran around and played quite a bit .....❍
Ran and played hard most of the time .....❍

4. In the last 7 days, what did you normally do *at lunch* (besides eating lunch)? (Check one only.)

Sat down (talking, reading, doing schoolwork)……...❍
Stood around or walked around .....❍
Ran or played a little bit .....❍
Ran around and played quite a bit .....❍
Ran and played hard most of the time .....❍

5. In the last 7 days, on how many days *right after school*, did you do sports, dance, or play games in which you were very active? (Check one only.)

None .....❍
1 time last week .....❍
2 or 3 times last week .....❍
4 times last week .....❍
5 times last week .....❍

6. In the last 7 days, on how many *evenings* did you do sports, dance, or play games in which you were very active? (Check one only.)

None .....❍
1 time last week .....❍
2 or 3 times last week .....❍
4 or 5 last week .....❍
6 or 7 times last week .....❍

7. *On the last weekend*, how many times did you do sports, dance, or play games in which you were very active? (Check one only.)

None ..... ❍
1 time ..... ❍
2 — 3 times ..... ❍
4 — 5 times ..... ❍
6 or more times ..... ❍

8. Which *one* of the following describes you best for the last 7 days? Read *all five* statements before deciding on the *one* answer that describes you.

A. All or most of my free time was spent doing things that involve little physical effort ..... ❍

B. I sometimes (1 — 2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics) ..... ❍

C. I often (3 — 4 times last week) did physical things in my free time ..... ❍

D. I quite often (5 — 6 times last week) did physical things in my free time ..... ❍

E. I very often (7 or more times last week) did physical things in my free time ..... ❍

9. Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week.

	None	Little bit	Medium	Often	Very often
Monday	❍	❍	❍	❍	❍
Tuesday	❍	❍	❍	❍	❍
Wednesday	❍	❍	❍	❍	❍
Thursday	❍	❍	❍	❍	❍
Friday	❍	❍	❍	❍	❍
Saturday	❍	❍	❍	❍	❍
Sunday	❍	❍	❍	❍	❍

10. Were you sick last week, or did anything prevent you from doing your normal physical activities? (Check one.)

Yes ..... ❍
No ..... ❍

If Yes, what prevented you? _____

SCORING

The scoring process has five easy steps, with the aim of finding an activity score between 1 and 5 for each item (excluding item 9)

1. Item 1 (Spare time activity): Take the mean of all activities ("no" activity being a 1, "7 times or more" being a 5) on the activity checklist to form a composite score for item 1.

2. Item 2 to 7 (PE, lunch, right after school, evening, weekends, describes you best): The answers for each item start from the lowest activity response and progress to the highest activity response.
   Simply use the reported value that is checked off for each item (the lowest activity response being a 1 and the highest activity response being a 5).

3. Item 8: Take the mean of all days of the week ("none" being a 1, "very often" being a 5) to form a composite score for item 8.

4. Item 9 Can be used to identify students who had unusual activity during the previous week, but this question is NOT used as part of the summary activity score.

5. How to calculate the final PAQ-A activity summary score: Once you have a value from 1 to 5 for each of the 8 items (items 1 to 8) used in the physical activity composite score, you simply take the mean of these 8 items, which results in the final PAQ-A activity summary score.
   A score of 1 indicates low physical activity, whereas a score of 5 indicates high physical activity.

16.6. ANNEX 6. KIDMED QUESTIONNAIRE

SCORE	CRITERION
+ 1	Takes a fruit every day
+ 1	Has a second fruit every day
+ 1	Has fresh and cooked vegetables regularly once per day
+ 1	Has fresh and cooked vegetables more than once per day
+ 1	Consumes fish regularly (at least 2-3 times per week)
- 1	Goes to a fast food (hamburger) restaurant more than once per week
+ 1	Likes pulses and eats them more than once per week
+ 1	Consumes whole-grain pasta or whole-grain rice almost every day (5 or more times per week)
+ 1	Has whole cereals or whole-grains (whole-meal bread, etc.) for breakfast
+ 1	Consumes nuts regularly (at least 2–3 times per week)
+ 1	Uses olive oil at home
- 1	Skips breakfast
+ 1	Has a dairy product for breakfast (yoghurt, milk, etc.)
- 1	Has commercially baked goods or pastries for breakfast
+ 1	Takes two yoghurts and/or some cheese (40 g) daily
- 1	Takes sweets and candy several times every day

16.7. ANNEX 7. UNIFYING THREAD: T'AGRADARIA AJUDAR ALS LILAPS?

On the first day, children will receive a letter, that will explain what is happening. This is attached to the next page.

The storyline will consist of the presentation of an alien that had contacted us as she need help. She will explain that her planet has a particularity, that due to a change in genetics and environment of the planet, now all children are born with a specific congenital heart defect. Citizens are sad as they think that those children cannot do the same as other population. But, she thought differently. For that reason, she went to another planet Zhìhuì, where everything is known, and she gave her an infinitive list of aspects that a child with congenital heart disease is able to do.

While she was coming back to her planet, she had a drawback, and her spacecraft broke down and twelve of those carts fall into the Earth.

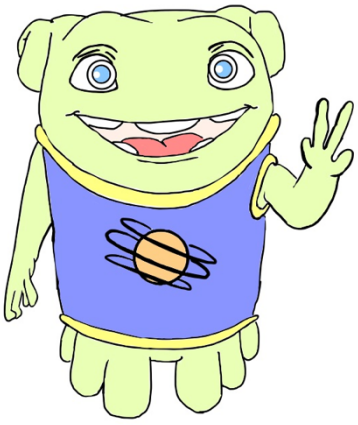
Under those circumstances, she will ask for their help for recollecting the twelve different aspects that she had lost and send them back to his planet.

Each week, when the session will be finished, children will find a note in the meeting point from the alien saying three places where the aspect may be, and children will go and look for ii. When they will find it, they will post it in a mural.

Finally, when the program will be finished and all twelve aspects will have been found they will send it back to the alien's house.

These aspects will be different in every group and will be defined during the first group therapy with the psychologist. It will depend on what they will answer in the question: *"what would you do that you can't do due to your disease?"*

Hola _____ !



Primer de tot em presento. Soc la Bibi i vinc del planeta E-14641, on vivim les lilops. N'havies sentit mai a parlar? Suposo que no, ja que és un planeta molt petit i està molt lluny de la Terra, concretament a 16 anys llum! Però la veritat és que no el canviaria per res!!

M'estaria dues hores parlant de tot el que m'encanta del meu planeta. Però aniré al gra, ja que necessito la teva ajuda.

Ja fa uns anys, mentre anava amb bicicleta amb els amics, de cop i volta va arribar un núvol de color lila que no havíem vist mai... Des de llavors van començar a passar coses molt rares: les flors es van fer grans, els arbres petits, els peixos van començar a volar i a l'aigua hi naixien ocells.

Però el més sorprenent és que els petits i petites lilops van començar a notar que el seu cor es feia diferent. Els metges van explicar que era perquè els gens i l'ambient havien canviat, i que a partir d'ara tots els lilops que naixessin tindrien el cor diferent.

I ja fa 20 anys que estem així. Però saps quin és el problema? Que tothom està molt trist i avorrit, perquè ja no saben què poden fer, a què poden jugar, si poden córrer o saltar sense fer-se mal.

Per això vaig decidir prendre el meu viatge cap al Planeta Zhìhuì, el planeta on tot se sap, a què em donessin una resposta.

Uf tot el que em van dir!

Em van donar una llista infinita de coses que podien fer els petits i petites lilops! Estava tan contenta!!!

Però al tornar cap al meu planeta E-14641, la nau espacial va començar a fer un soroll estrany, fins que vaig sentir un PUMP i un fum gris va començar a sortir del motor... Per sort, vaig arribar entera a casa, o això em pensava... M'havien caigut 12 paraules de la llista que havia aconseguit al planeta Zhìhuì!

Aquí és on entres tu, _____. El sensor de la meva nau espacial ha localitzat les 12 paraules i es troben al planeta Terra. Però és un procés tan complicat, que només un cop per setmana em dona 3 possibles llocs de la Terra on pot ser que estigui una d'aquestes paraules perdudes.

Jo cada setmana us faré arribar una nota amb aquests 3 llocs i em faríeu un gran favor, si m'ajudéssiu a trobar-les totes, i així poder ajudar a les habitants del meu planeta.

Una vegada les aconseguiu totes, us faré arribar una nota amb les indicacions per enviar-me-les cap al planeta E-14641.

M' AJUDES?

16.8. ANNEX 8. DATA COLLECTION DOCUMENT

DOCUMENT RECOLLIDA DE DADES	
Nom del projecte: The implementation of a cardiac rehabilitation program adapted to child's requirements in paediatric population with congenital heart disease	
Data de recollida de dades: __ / __ / ____ Número d'identificació del pacient:	
Data de naixement: __ / __ / ____	Diagnòstic (CC):
Sexe ☐ Masculí ☐ Femení	Ètnia ☐ Africà ☐ Asiàtic ☐ Caucàsic ☐ Llatinoamericà ☐ Altra: _____
DATA INICI PROGRAMA __ / __ / ____ DATA FI PROGRAMA __ / __ / ____	Moment de l'avaluació respecte el programa: ☐ Inici programa ☐ 6 setmanes ☐ Fi programa ☐ 6 mesos post programa ☐ 12 mesos post programa
AVALUACIÓ CARDIOLÒGICA - Persona que recull les dades:	
Estadi fisiològic segons l'ACHD AP ☐ A ☐ B ☐ C ☐ D Puntuació a PAQ – C:	Ergoespirometria: VO2 màxima: HR màxima: Ecocardiograma: FEVI

<table>
<tr><td colspan="2">AVALUACIÓ NUTRICIONAL
- Persona que recull les dades:</td></tr>
<tr><td>Pes:
Talla:</td><td>IMC:
Puntuació al KIDMED:</td></tr>
<tr><td colspan="2">AVALUACIÓ PSICOLÒGICA
- Persona que recull les dades:</td></tr>
<tr><td>Puntuació al PCQLI a l'infant:
– Puntuació Impacte Malaltia:
– Puntuació Impacte Psicosocial:
– Puntuació total:

Puntuació STAI – C : _____</td><td>Puntuació al PCQLI pares o tutor legal:
– Puntuació Impacte Malaltia:
– Puntuació Impacte Psicosocial:
– Puntuació total:</td></tr>
</table>

16.9. ANNEX 9. PATIENT'S PROTOCOL INFORMATION SHEET

Nom de l'estudi: The implementation of a cardiac rehabilitation program adapted to child's requirements in paediatric population with congenital heart disease

Centre assistencial: Parc Hospitalari Martí i Julià

Investigador / a principal:

INTRODUCCIÓ

Benvolgut/da,

Ens dirigim a vostè, com a pare/mare/tutor legal de l'infant, per informar-lo sobre un estudi d'investigació en el qual se'l convida a participar. Està portat a terme pels serveis de Rehabilitació Cardíaca del Parc Hospitalari Martí i Julià. Cal informar que aquest projecte ha estat aprovat pel Comitè d'Ètica Investigació Clínica (CEIC).

La nostra intenció és que vostè rebi la informació correcta i suficient perquè pugui decidir si accepta o no participar en aquest estudi. Si us plau, llegeixi aquest full informatiu amb atenció i nosaltres li aclariré els dubtes que li pugui sorgir.

PARTICIPACIÓ VOLUNTÀRIA

Ha de saber que la seva participació en aquest estudi és voluntària i que pot decidir que l'infant no participi o canviar la seva decisió i retriar el consentiment en qualsevol moment, sense que això alteri la relació amb el seu metge ni es generi cap conseqüència en l'atenció sanitària de l'infant.

Abans que l'infant participi en aquest estudi, vostè com a pare/mare/tutor legal, haurà de firmar un consentiment on corrobora que ha llegit el document explicatiu i està d'acord amb el projecte. SI en algun moment volgués que l'infant deixés de participar, ho podrà fer revocant el consentiment informat, document que pot demanar a qualsevol membre de l'estudi.

OBJECTIU DE L'ESTUDI

L'estudi al qual el convidem a participar té com a objectiu principal determinar si un programa de rehabilitació cardíaca dut a terme a l'aire lliure i basat en marxa Nòrdica i pliometria millora la qualitat de vida del seu infant diagnosticat prèviament d'una cardiopatia congènita, respecte a un programa cardíac rehabilitador convencional.

Generalment, els infants amb una cardiopatia congènita tenen una menor forma física que la resta d'infants de la mateixa edat. Aquest fet es pot deure a una falta de coneixement de la importància d'una bona activitat física, no només per l'efecte beneficiós cardiovascular que s'associa, sinó també per poder mantenir una vida similar a la resta d'infants de la mateixa edat, tant a l'escola com a fora d'ella.

És essencial pels infants amb una cardiopatia congènita mantenir-se actius en el seu dia a dia. D'aquesta manera, amb la introducció d'un programa de rehabilitació cardíaca dins del tractament no mèdic s'ha vist que millora el dia a dia dels infants amb una cardiopatia congènita i millora la seva forma física.

Tanmateix, aquest nou programa està pensat perquè sigui el més similar possible al que l'infant es trobarà a fora l'hospital, perdent la por a executar les mateixes activitats en què participen la resta d'infants de la mateixa edat.

DESCRIPCIÓ DE L'ESTUDI

En aquest estudi hi participaran aproximadament uns 106 participants, que de forma aleatoritzada, es formaran dos grups.

Un dels grups formarà part d'un programa de rehabilitació cardíaca dut a terme a l'aire lliure basat en marxa nòrdica i pliometria, mentre que l'altre grup realitzarà un programa de rehabilitació cardíaca convencional basat amb bicicleta estàtica i exercicis isomètrics de força. Els dos rebran entrenament respiratori.

Els dos programes tenen una durada de dotze setmanes, en les quals es realitzarà entrenament físic tres dies per setmana. També hi haurà una vista mensual amb una nutricionista i dues vistes mensuals individuals amb psicològica. A part de les visites individuals, durant el programa hi haurà tres hores de psicologia grupal i tres xerrades de

caràcter informatiu sobre les cardiopaties congènites amb l'objectiu de proporcionar estratègies a les famílies.

És important subratllar que tots els pacients rebran el mateix assessorament cardiològic, nutricional i psicològic. L'únic fet que els diferenciarà és el tipus d'entrenament físic que realitzaran.

Abans de començar el programa, sis setmanes després de l'inici, una vegada acabat el programa, al cap de sis mesos i als dotze mesos hi haurà un control per part de cardiologia, psicologia i nutrició en els quals s'avaluarà la milloria.

RISC DE L'ESTUDI

La rehabilitació cardíaca ha demostrat ser efectiva, segura i beneficiosa pels pacients amb cardiopaties congènites. Com que no s'utilitzen intervencions invasives ni farmacològiques no es preveu cap risc pels pacients.

Durant els entrenaments, tots els participants seran monitoritzats de forma continuada. I l'espai està altament preparat. Per tant, qualsevol alteració en el seu estat de salut serà identificada ràpidament i avaluada immediatament per cardiologia. Totes les intervencions seran efectuades per personal sanitari especialitzat i competent.

POSSIBLES BENEFICIS DE l'ESTUDI

Aquest estudi pretén ser una referència per tal d'implementar-se de manera estàndard la realització d'un programa de rehabilitació cardíaca en pacients amb cardiopaties congènites basat en marxa nòrdica i pliometria realitzat a l'aire lliure.

Si vostè ho desitgés, se li felicitarà un resum dels resultats de l'estudi.

CONFIDENCIALITAT

Si vostè com a pare, mare o tutor legal de l'infant, acceptés la seva participació, permetria a l'investigador registrar algunes dades de la seva història clínica. Tota la informació utilitzada a l'estudi serà codificada mantenint la dissociació de les seves dades, l'anonimat i tractades segons la Llei de Protecció de Dades Personals i garantia dels drets digitals, recollida a la Llei orgànica 3/2018. S'utilitzarà un nombre per poder identificar el seu infant, evitant noms o

dades que es permetin saber la identitat de l'infant. Tots els resultats dels exàmens complementaris i les dades de la història clínica seran tractades amb total confidencialitat.

Tant l'hospital com l'investigador són responsables respectivament del tractament de les seves dades i es comprometen a complir amb la normativa que està en vigor de protecció de dades.

D'acord amb el que s'estableix en la legislació esmentada, vostè pot exercir els drets d'accés, rectificació, oposició i cancel·lació de dades en qualsevol moment. També pot limitar el tractament de dades que sigui incorrectes, sol·licitar una còpia o que es traslladin a un tercer les dades que vostè ha facilitat per l'estudi.

DIFUSIÓ DELS RESULTATS

Un cop s'hagi completat tot l'estudi es preveu una anàlisi de les dades i una extracció dels resultats per part de professionals especialitzats. Les conclusions del projecte seran sotmesos a publicacions científiques, independentment del seu resultat.

COMPENSACIÓ ECONÒMICA

Com s'ha exposat, la participació en aquest estudi és voluntària. Per tant, si vostè i el seu fill/a decideixen que el participi, ell/a no rebrà cap mena de compensació econòmica.

CONTACTE

En cas de qualsevol dubte o pregunta durant la realització d'aquest estudi es podrà posar en contacte amb el responsable i coordinador de l'estudi.

16.10. ANNEX 10. CONSENT FORM

CONSENTIMENT INFORMAT DEL FAMILIAR RESPONSABLE O REPRESENTANT LEGAL

NOM DE L'ESTUDI: The implementation of a cardiac rehabilitation program adapted to child's requirements in paediatric population with congenital heart disease

Centre assistencial: Parc Hospitalari Martí i Julià

Investigador principal:

Jo, _____ amb DNI / NIE _____ , com a pare/mare/tutor legal de _____ afirmo que:

- He rebut una còpia del full d'informació pel pacient.
- He llegit i entès tota la informació que apareix en el document d'informació del pacient.
- He parlat amb _____ (investigador principal) i he pogut plantejar-li qualsevol dubte que m'ha sorgit i me l'ha resolt adequadament.
- Estic conforme amb la quantitat d'informació que se m'ha proporcionat.
- Entenc el paper de l'infant en l'estudi, i que la participació és voluntària i no remunerada.
- Entenc els potencials riscos i beneficis derivats de participar en aquest estudi.
- Comprenc que puc decidir retirar al pacient de l'estudi, demanant la revocació del consentiment, en qualsevol moment sense que això repercuteixi al tractament del meu fill/a ni que se'm demani una explicació al respecte.
- Accepto que els investigadors utilitzin les dades de l'infant i accedeixin a la història clínica, sempre respectant l'anonimat i confidencialitat.

En conseqüència, dono la meva conformitat perquè _____ participi en el present assaig clínic.

Signatura del pare/mare/tutor

Lloc i data:

Signatura de l'investigador/a

Lloc i data:

REVOCACIÓ DEL CONSENTIMENT INFORMAT

Jo, _____, amb DNI / NIE _____, com a pare/mare/ tutor legal de _____, REVOCO el consentiment prestat amb data _____ i no desitjo que el meu fill/a prossegueixi amb l'estudi que rep el nom "*The implementation of a cardiac rehabilitation program adapted to child's requirements in paediatric population with congenital heart disease"*, que dono amb aquesta data per finalitzat.

Signatura del pare/mare/tutor

Lloc i data:

Signatura de l'investigador/a

Lloc i data: