

# Training Program to Improve Exercise Capacity in Children after Cardiac Surgery

Janneke C. van Egmond-van Dam<sup>1</sup>, Nico A. Blom<sup>2,3</sup>, Arend D.J. ten Harkel<sup>2</sup>

<sup>1</sup>Department of Orthopaedics, Rehabilitation and Physical Therapy, Leiden University Medical Center<sup>1</sup>, Leiden, The Netherlands

<sup>2</sup>Department of Pediatrics, Division of Pediatric Cardiology, Leiden University Medical Center, Leiden, The Netherlands

<sup>3</sup>Department of Pediatrics, Division of Pediatric Cardiology, Academic Medical Center, Amsterdam, The Netherlands

## Article Info

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### \*Correspondence:

Janneke C. van Egmond-van Dam, Department of Orthopaedics, Rehabilitation and Physical Therapy, Leiden University Medical Center, Leiden, The Netherlands; Email: J.C.van\_Egmond-van\_Dam@lumc.nl.

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## Abstract

**Purpose:** Postoperative training of children with congenital heart disease is not as common as in adults, but its importance is indicated by many reports. Aim of this article is to inform other practitioners of a detailed description of a post-operative training, now in use at the Leiden University Medical Center.

**Methods:** As part of the postoperative standard care, children are invited to voluntarily participate in a physical training program. Children are eligible if they are 6-18 years old, live in the Netherlands, are at least six weeks after their surgery, and have permission of the treating pediatric cardiologist. Goals for participating in the training program were improving physical condition, diminishing fatigue, not caused by heart problem, and diminishing fear in child/parent to move. Changes before and after the workouts are recorded with a maximum exercise test and questionnaires.

**Training program:** The fixed training program lasts three months, three times a week. It is based on high-intensity interval training with short dynamic training exercises. During these three months, the training intensity increases from 50 to 80% of the heart rate reserve, the exercise time increases and breaks between exercises decreases.

**Conclusion:** The present postoperative rehabilitation program gives an important addition to current literature. Further research to evaluate the present program will provide more insight into the effectiveness of the present rehabilitation program.

## Introduction

At present time most patients with congenital heart disease (CHD) can be operated with a good postoperative outcome and relatively low complication rates<sup>1</sup>. Worldwide, around 20 million children as well as 20 million adults suffer the consequences of their congenital heart defect<sup>2</sup>. In The Netherlands, each year around 1400 children are born with a CHD, of which around 50% undergo any intervention in the first year of life<sup>3</sup>. Despite the good present operative results, during long-term follow up increasing morbidity can develop, including pulmonary hypertension, rhythm disorders and heart failure. Most complications have a correlation with decreased exercise performance<sup>4</sup>. This reduced exercise capacity, which is correlated to long-term outcome parameters may negatively influence daily-life activities<sup>5</sup>. The Dutch advice for physical activities in children include one hour of moderate to vigorous physical activity daily. However, since many healthy subjects nowadays live a sedentary lifestyle nearly 50% of healthy children do not meet current exercise norms. In patients with congenital heart disease

the activity pattern might even be lower than in the normal population, resulting in limited exercise performance<sup>6,7</sup>. One of the critical periods for a patient with congenital heart disease to remain active is shortly after surgery. Unlike in adults, postoperative rehabilitation is uncommon after pediatric surgery<sup>8</sup>. Many reports underscore the need for stimulating exercise after surgery in both children and adults. Most studies describe the use of exercise programs long-term after surgery<sup>9</sup>. In Fontan patients it has been shown that preserved exercise capacity results in a lower incidence of cardiovascular events<sup>10</sup>. In another study the use of rehabilitation interventions in the immediate postoperative period is described. Different strategies were used according to age and complexity of the postoperative period<sup>11</sup>. Another study described the effect on gross motor development in a group of cyanotic and acyanotic infants<sup>12</sup>. While most authors agree that postoperative cardiac rehabilitation after congenital heart surgery may help people recover to an active lifestyle, an actual and accurate description of such a program is lacking. In addition, children and their parents also indicate that they need more information about physical training and sport<sup>7</sup>. In the present paper we describe a postoperative rehabilitation program which has now been in use for the last two years. This detailed description may help others to develop their own program and change certain activities according to local circumstances. Detailed description of the exercises may give further inspiration for using this program.

## Methods

In the Leiden University Medical Center (LUMC) postoperative children with a CHD are invited to participate in a physical training program. Children are eligible if they are 6-18 years old, living in the Netherlands, have had at least six weeks of recovery after their surgery, and if they have permission of the treating pediatric cardiologist.

This training program is part of the standard care for postoperative children with CHD at our institution. Participants were invited to participate in the training program at a regular hospital visit to the pediatric cardiologist.

Eligibility criteria for the training program:

- (reduced) physical condition
- fatigue not caused by heart problem
- fear in child and parents to move

Non-eligibility criteria for the program:

- cardiac contra-indications for cardiac rehabilitation (cardiac arrhythmias, significant heart failure) which is determined by the treating pediatric cardiologist
- inability to walk independently (walking with aid is allowed)

- severe behavioral problems that make training ineffective

End goals of the physical training program:

- improving the child's physical exercise capacity
- educate child to recognize his or her physical possibilities and limits
- educate parents to recognize their child's physical capabilities and limits
- increase self confidence in child and parents in the options that the child has after heart surgery
- decrease of fear of strenuous activities for both child and parents
- help child obtain or maintain pleasure get/keep pleasure in physical exercise
- start with a sport of your own choice at a sports club after the training period

The physical exercise capacity was measured in the LUMC before and after the training program by a maximum exercise test on the bicycle ergometer according to the Godfrey protocol on a Lode Corival Pediatric (Pro Care, Groningen), a bicycle ergometer especially for children. The protocol to be followed is determined in advance on the basis of the length of the body<sup>13</sup>.

To measure the end goals and the differences as a result of the training, pen-and-paper questionnaires were completed by child and/or parents before and after the training program.

To determine the level of physical activity, we used standardized questions on the time spent on moderate intensity or vigorous intensity physical activity. A moderate physical activity is an activity such as walking briskly or cycling. A vigorous physical activity is an activity resulting in sweating and breathing faster.

Changes before and after the training program of fatigue, self-confidence, and fear of strenuous activities were measured by the Pediatric Quality of Life Inventory (PedsQL), the Family impact Module, the Multidimensional Fatigue Scale, and the OMNI score<sup>14-17</sup>.

## Training Program

The training program is derived from a fitness training program in children with previous correction of congenital anatomical anomalies and/or neonatal Extra Corporeal Membrane Oxygenation (ECMO) which yielded significant improvement in exercise capacity<sup>18</sup>. This program has been adapted for children with CHD who do not fully use their cardiac capabilities and who are sometimes anxious to move. The training lasts a total of 3 months, and the intensity of the training increases every 4 weeks (Fig.1).

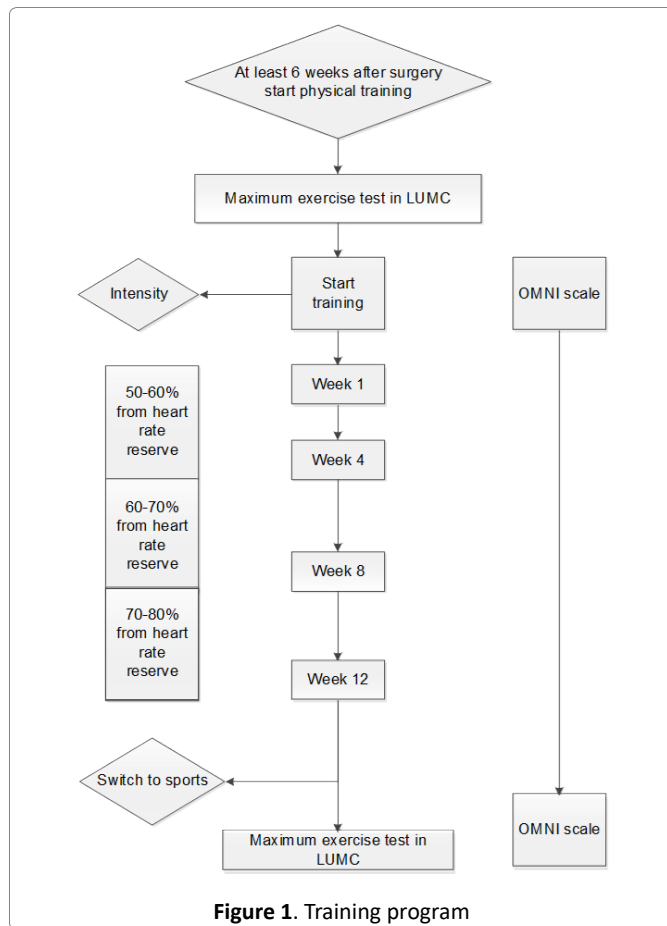


Figure 1. Training program

For a maximum result and to learn the child’s physical possibilities, parents will be involved in the training as much as possible and will be asked to actively participate in their child’s exercises.

**Start moment and principles of the fitness training**

At least 6 weeks after cardiac surgery, the individual training may be started with a (paediatric) physical therapist near the child’s place of residence.

The written training program is sent to the local community based physical therapist together with the resting heart rate, the achieved maximum heart rate, percentage of the expected heart rate, the saturation at rest and at maximum exercise. Training limitations will be noted and there will be an oral consultation between the pediatric physiotherapists.

**Schedule of fitness training**

Table 1 shows the fitness training which is based on the HIT (High-intensity Interval Training) principles and using the FITT factors (frequency, intensity, time, and type)<sup>13</sup>.

**Frequency of training**

The optimal number of training sessions is three times per week<sup>13</sup>. If a child is already doing sports at an official institution, this counts for one session. So, if a child has swimming lessons once a week, it is recommended to

Table 1. Training schedule

Week	Minimum Intensity at % heart rate reserve (HRres)	Warm up (1)	Duration exercise at max effort x sec. (2)	Duration of activity after exercise, y sec. (3)	Number (z) of repetitions of 1 exercise (4)	Activity between exercise 1 and 2 and 3 (5)	Number of set exercises per workout (6)	Cooling down (7)
1	50	5 min	10 sec.	60 sec. walking	5 x		2	5 min
2	50	5 min	15 sec.	60 sec. walking	5 x		2	5 min
3	50	5 min	20 sec.	60 sec. walking	5 x		2	5 min
4	50	5 min	25 sec.	60 sec. walking	5 x		2	5 min
5	60	5 min	25 sec.	50 sec. walking	4 x		3	5 min
6	60	5 min	25 sec.	50 sec. walking	4 x		3	5 min
7	60	5 min	30 sec.	60 sec. walking	5 x		2	5 min
8	60	5 min	30 sec.	60 sec. walking	5 x		2	5 min
9	70	5 min	30 sec.	45 sec. walking	6 x		2	5 min
10	70	5 min + 30 sec jogging	30 sec.	45 sec. walking	6 x	5 min activity at 70% HRres	2	5 min
11	70	5 min + 45 sec jogging	30 sec.	30 sec. walking	8 x	5 min activity at 70% HRres	2	5 min
12	70	5 min + 45 sec jogging	30 sec.	30 sec. walking	10 x	5 min activity at 70% HRres	2	5 min

1. Each workout starts with a 5-minute warm up (e.g., ball game). In weeks 10 to 12 you start jogging for a few seconds after the warmup.
2. The exercise should be performed on the % minimum cardiac reserve intensity (HRres) on schedule and a selected exercise is performed x sec according to the weekly schedule.
3. After the exercise follows a quiet activity of y sec. such as walking.
4. This exercise is repeated z times
5. In weeks 10 to 12 there is an extra activity between the different exercises. After the first series of exercises, an activity of 5 min at 70% HRres is done (ball game, jogging or cycling on home trainer) before the start of the 2nd set of exercises.
6. The number of blocks of exercises for this workout
7. Cooling down of 5 minutes (easy ball game, walking, cycling on an exercise bike) after finishing 2 or 3 sets of exercises.

give fitness training twice a week. If due to circumstances it is not possible to train 3 times a week, it is advised to do homework exercises, so that (with the help of parents) training is done 3 times a week.

**Intensity of training**

To increase activity level and improve fitness, at the end of the training period, the optimal training intensity (Heart Rate training/HR training) should be set at 70%-80% of the heart rate reserve (HR reserve). The minimum heart rate during a training to reach the training target of 50/60/70/80% is calculated according to the Karvonen formula<sup>19</sup>.

The maximum heart rate is determined with a maximum exercise test. Or calculated in the absence of a (properly performed) maximum exercise test<sup>20</sup>. HR training is based on the following Karvonen formula

$$\text{HR reserve} = \text{HRmax (max Heart Rate)} - \text{HR rest (resting HR)}$$

$$\text{HR training} = (\text{HR reserve} \times 50/60/70/80\% \text{ training target}) + \text{HR rest}$$

To indicate the intensity of the training, the child can indicate a score on the Children’s OMNI Perceived Exertion Scale (1-10), which indicates the child’s fatigue<sup>14,15</sup>.

For an optimal result, the score should be higher at the end than at the beginning of the workout session. The training courses themselves should not differ much in terms of OMNI score. A score of 6 or

higher on the OMNI scale at the end of the training session indicates that the child has been able to make sufficient effort.

**Time**

The training intensity is built up according to a fixed schedule (fig 1). In the first 4 weeks, training is carried out on 50-60% of the HR reserve. In week 5 to week 8 at 60-70% and in week 9 to week 12 at 70-80% of the HR reserve. In the first weeks the training will be possible within half an hour, from week 9 the training will take a little longer.

**Type**

Table 2 shows the exercises, all with a dynamic character. Quick short actions that are also constantly alternated, which are based on the HIIT principles. In the 3-month training period there is a shift from anaerobic to aerobic training and from low to high intensity.

Table 1 shows the scheduled fitness training. Each training starts with a 5-minute warm up (1) and ends with a 5-minute cooling down (7). After the warming up the child has chosen an exercise which is executed for x seconds (2) at the predetermined HRres. Then the child can walk or jog for y sec (3). Per session, this exercise is repeated several times (4). Then the child can start with the next exercise session (6).

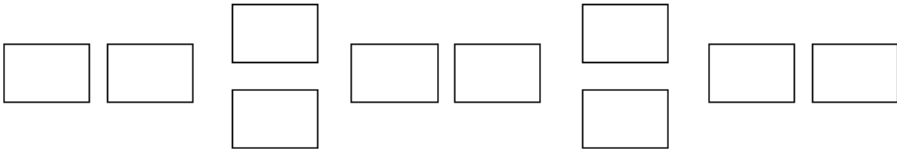
At the end of the fitness training in week 10-12 the time between the exercises is filled by an exercise at 70% HRres (5).

**Table 2.** Exercises

**1. Sprinting**

Necessities	2 lines or markers at a distance of 5 meters Stopwatch
Exercise	Stand behind one line and run as fast as you can to the other line. Tap it with your foot and go to the other line as soon as possible
Score	Number of times you touch the line is one point. How many points can you get within the agreed time?

**2. Hopscotch**

Necessities	
Exercise	Hop on the 1 leg single squares and the 2 leg double squares. At the end of the sequence, switch legs.
Score	Try to hop back and forth as much as possible within a certain amount of time. How many times can you hop a whole row?

### 3. Transfer balls

Necessities	Two hoops or large bins 5 meters apart. Three different coloured balls Place 2 balls in 1 hoop and 1 ball in the other hoop Stopwatch
Exercise	Start at the hoop with 2 balls and try to get 1 ball to the other hoop as quickly as possible. Take the other ball from this hoop and bring it to the other hoop.
Score	Try as much as possible to get a ball from one hoop to another within the agreed time. How many times can you move a ball? Each ball movement is 1 point.

### 4. Jumping trampoline

Necessities	Trampoline Stopwatch
Exercise	Jump on the trampoline as much as possible in the agreed time, but you have to jump at least 10 centimetres up
Score	Every time you land on the trampoline this is a point

### 5. Running/ Dribbling

Necessities	Stopwatch
Exercise	Try to run/dribbling in place as fast as possible in a certain amount of time
Score	Each pass is a point

### 6. Raise your knees

Necessities	Stopwatch
Exercise	Try to lift your knees as much as possible and touch your knee to the physiotherapist's hand standing in front of you.
Score	Every time you tap the physiotherapist's hand with your knee, a point is awarded

### 7. Jumping rope

Necessities	Skipping rope Stopwatch
Exercise	Jump rope and try to jump over the rope as much as possible.
Score	Each revolution is a point.

### 8. Boxing

Necessities	Punching ball, firm mat or thick cushion Stopwatch
Exercise	Try to box against the punching bag / firm mat or pillow as much as possible
Score	Point if you hit the punching bag/mat or pillow

### 9. Tap head, shoulder, knee, and toe

Necessities	Stopwatch
Exercise	Try to touch your head, shoulders, knees and feet with your hands and back in the opposite directions as often as possible
Score	Period when you have tapped everything from your head to your feet and back to your head.

### 10. Mats and run

Necessities	4-6 mats Stopwatch
Exercise	Try to tap a mat with at least 1 foot as much as possible in the agreed time before moving on to another mat. The mats should be 3-3 meters apart.
Score	The number of mats tapped

### 11. Up and down

Necessities	Platform Stopwatch
Exercise	Stand in front of the platform, step on the platform and off again. Turn around and repeat again
Score	Point if you go back and forth

### 12. Skating

Necessities	Stopwatch
Exercise	Put your hands behind your back and bend your knees slightly. Make a side jump step to the left front and then to the right front and again to the left front so that you imitate a skating move
Score	Point for a side jump

### 13. Frog leap

Necessities	Two lines or other marking at a distance of 5 meters Stopwatch
Exercise	Jump from one line to another with a frog jump, trying to make as many jumps as possible within the agreed time
Score	Point for every jump

### 14. Running the ball passing

Necessities	Ball Stopwatch
Exercise	Running in a circle around the physiotherapist or running from one side of the room to the other with the physiotherapist while throwing a ball
Score	Point for every successful catch of ball

### 15. Jumping hoops

Necessities	2 hoops Stopwatch
Exercise	Put the 2 hoops next to each other and jump as often as you can with both feet from one hoop to the other
Score	Point for every time you jump in a hoop

### 16. Ring hockey

Necessities	Two lines or other marking at a distance of 5 meters, stick and rings Stopwatch
Exercise	Stand behind a line and run as fast as you can to the other line with the stick in your hand and sliding the ring along. Slide the ring over the other line and go back to the other line as quickly as possible to get the next ring.
Score	Point for each ring passed over the line

### 17. Squat jump in the air

Necessities	Stopwatch
Exercise	Tap the ground with your hands and then jump as high as you can, do this as many times as you can within the agreed time.
Score	Point for each time you tap the ground.

### 18. Jump wide-close

Necessities	Stopwatch
Exercise	Stand with your legs apart with your arms down. Jump both feet together and clap your hands above your head and back at the same time. Do this as often as you can within the agreed time.
Score	Point for every time you clap over your head.

### 19. Tap platform

Necessities	Platform Stopwatch
Exercise	Stand in front of the platform and tap as fast as you can with your right foot and then your left foot alternately on the platform and try to repeat this as often as possible.
Score	Point for each time you alternately touch the platform with both feet.

### 20. Grab the rolling ball as soon as possible

Necessities	Ball and two lines or other marking at a distance of 5 meters Stopwatch
Exercise	Stand behind the line with the therapist, the therapist rolls the ball to the other side of the line and try to grab the ball as quickly as possible. Throw the ball behind the line back to the therapist and run back to the therapist as fast as you can. Repeat this as many times as you can within the agreed time.
Score	Point for each time the ball and you are back at the therapist.

### 21. Zig zag run

Necessities	4 pawns and two lines or other marking at a distance of 8 meters Stopwatch
Exercise	Place a pawn zigzagging every two meters. Run zigzagging (running sideways) from one pawn to another as fast as you can. Turn around and run zigzagging back. Run back and forth as often as possible.
Score	Point for every time you start at the pawns.

## 22. High jump dribbling

Necessities	Hoop Stopwatch
Exercise	Stand in the hoop and dribble 10x as fast as you can, then do a high jump on both legs. Repeat this as often as you can.
Score	Point for each high jump after 10 dribbles.

## 23. Burpees

Necessities	Stopwatch
Exercise	Stand with both legs slightly apart, lower both hands to the floor as quickly as possible and jump your legs back so that you are on all fours. Jump on both feet again, come up and jump into the air. Repeat this as many times as you can within the agreed time.
Score	Point for every time you jump in the air and do a burpee.

## 24. Slalom pawns

Necessities	4 pawns and two lines or other marking at a distance of 5 meters Stopwatch
Exercise	All pawns are distributed one after the other between the lines. Slalom between the pawns as fast as you can, tap the line with your foot and run as fast as you can in a straight line back to the start of the pawns. Repeat this as often as you can.
Score	Point for every time you start at the pawns.

## 25. Dribbling

Necessities	Stopwatch
Exercise	Try to dribble on the spot as hard as you can
Score	Point if your left or right leg lifts off the ground within the agreed time

## Discussion

The importance of postoperative rehabilitation after pediatric surgery is indicated in many studies, however a postoperative rehabilitation program is uncommon<sup>5,7-12</sup>. In addition, parents and children clearly indicate that they have a greater need for information about and individual physiotherapy to optimize the physical fitness and condition<sup>7</sup>.

This detailed description of a postoperative rehabilitation program, based on the HIT principles and using the FITT factors may help others to develop their own program and change certain activities according to local circumstances. The fitness training fits in well with the sports interests of children aged 6-18 who like fast short intensive moments. They often experience long assignments as boring, and it takes too long to reach their goal.

HIT training for adults has been extensively researched and described with positive results<sup>21,22</sup>. Takken et al, indicates that using the FITT factors, this training is also suitable for children<sup>13</sup>.

The postoperative rehabilitation program that has been applied at the LUMC is derived from a HIT fitness training program in children with previous correction of congenital anatomical anomalies and/or neonatal Extra Corporeal Membrane Oxygenation (ECMO), which yielded significant improvement in exercise capacity<sup>18</sup>. Similar training of children with physical disabilities also showed positive results<sup>23</sup>. With this training schedule, parents are also

actively involved in what can be stimulating and gives them more clarity and certainty about the physical capabilities of their child. By gradually building up the intensity of the effort, the child can experience what he/she can do in a positive way and the fear of moving can be reduced. The training schedule also gives the (pediatric) physiotherapist more guidance regarding the structure of the training. The training can take place at a pediatric physiotherapist near the child's place of residence, which saves a lot of travel and time.

If halfway through the training there is no clear progress for no apparent reason, then a more extensive exercise test including ECG can be considered.

Of course, further research is necessary to evaluate the effectiveness of the current program and evaluate the more long-term effects e.g., exercise performance and sports participation.

We realize that a change in exercise behavior requires a good follow-up from these children in addition to this training and a close collaboration between pediatric cardiologist and physical therapist will be of crucial importance, but this rehabilitation program will be a first step for improvement of physical activity and exercise capacity.

## Limitations

Since we present a rehabilitation program that has not been evaluated yet, its effectiveness cannot yet be given. However, positive feedback from children and parents have been given.

In conclusion, the present paper describes a postoperative rehabilitation program for children with congenital heart disease. Although future evaluation is necessary this study can give a basis for the rehabilitation of CHD children.

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- All authors have read the manuscript and agree to it being submitted.
- All authors meet the appropriate authorship criteria and nobody meeting these criteria has been omitted from the list of authors.
- This manuscript has not been submitted for publication elsewhere.

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### Abbreviations

CHD: congenital heart disease

LUMC: Leiden University Medical Center

ECMO: Extra Corporeal Membrane Oxygenation

PedsQL: Pediatric Quality of Life Inventory

HIT: High-intensity Interval Training

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