Motor training of sixty minutes once per week improves motor ability in children with congenital heart disease and retarded motor development: a pilot study

Jan Müller,1,2 Milka Pringsheim,1 Andrea Engelhardt,1 Juliana Meixner,1 Martin Halle,3,4 Renate Oberhoffer,1,2 John Hess,1 Alfred Hager1

1Department of Pediatric Cardiology and Congenital Heart Disease, Deutsches Herzzentrum München; 2Institute of Preventive Pediatrics; 3Preventive and Rehabilitative Sports Medicine, Technische Universität München; 4Munich Heart Alliance, Munich, Germany

Abstract Objective: Delay and impairment of motor development is reported in patients with congenital heart disease. This pilot study addressed the feasibility and effect of a low-dose motor training programme of 60 min once per week on motor ability in preschool children with congenital heart disease. Patients and methods: In all, 14 children – including four girls, in the age group of 4–6 years – with various types of congenital heart disease performed the motor developmental test MOT 4–6 before and after 3 months of a playful exercise programme of 60 min once a week. Results: At baseline, the motor quotient ranged from normal to slightly impaired (median 92.0; Quartile 1: 83.75; Quartile 3: 101.25). After intervention, motor quotient did not change significantly for the entire group (95.0 (88.0, 102.5); p = 0.141). However, in the subgroup of nine children with retarded motor development at baseline (motor quotient lower 100), seven children had an improved motor quotient after 3 months of intervention. In this subgroup, motor quotient increased significantly (p = 0.020) by 5%. Conclusions: Overall, a short intervention programme of 60 min only once a week does not improve motor ability in all children with congenital heart disease. However, those with retarded motor development profit significantly from this low-dose intervention.

Keywords: Congenital heart disease; intervention; training; motor development

Received: 14 June 2012; Accepted: 10 October 2012; First published online: 21 November 2012

Physical activity is a basic need in children. Their perceptual and motor experiences determine their physical and motor development and also affect their emotional, psychosocial, and cognitive development.1,2 In the majority of children with congenital heart disease, there is a delay in motor development compared with healthy peers.3–9 The reason for a reduced motor development is manifold. The severity of disease including long-standing cyanosis in early childhood,7,8 time on the intensive care unit,5 duration of circulatory arrest, and age at surgery5,8,10,11 are known risk factors. In addition, a reduced daily activity,12–13 often advised by physicians and enhanced by parental overprotection,1,12,16 contribute to this phenomenon. If left untreated, these motor deficits usually persist into adulthood.5,6,10,11

However, optimal rehabilitative, social, and environmental support might improve the children’s motor competence and prevent health problems later in life. Until now, only pilot studies with few participants have been published, which have shown that motor training improves motor ability7,9 and quality of life in children with congenital heart disease.17 However, a training of several times a week is not achievable in most cases primarily because of
logistical problems. Thus, this study addresses the feasibility and effectiveness of a simple playful motor training once a week to improve motor ability in children with congenital heart disease within a period of 3 months.

Patients and methods

Study design

From April, 2007 to July, 2011, we recruited 4–6-year-old preschool children with various types of congenital heart disease for a supervised motor training at the Department of Preventive and Rehabilitative Sports Medicine of our University. Before inclusion, a detailed medical examination was performed by a paediatric cardiologist including physical examination, resting and ambulatory electrocardiogram, and echocardiography. The detailed exclusion criteria for the safety of the study are published online (see Supplementary Materials).

After inclusion, all patients performed a baseline test to assess motor developmental abilities. Then, the children participated in a special training programme aimed at motor ability improvement. After 3 months and at least 12 sessions, the children underwent the motor development assessment again.

The study was prospectively designed and in accordance with the declaration of Helsinki (revision 2007). The study protocol was approved by the local ethics board (project number 1750/07). All patients’ parents gave written informed consent.

Motor development assessment

Motor ability was quantified with the MOT 4–6 from Zimmer et al.18 This test is designed to assess motor deficits in preschool children and is reliable in the age group of 4–6 years. There are 18 different exercise tasks that address several domains of motor skills such as agility, coordination, reaction, jumping power, balance, as well as speed and control of motion. Each task, except the first one, is rated with zero, one, or two points according to predefined landmarks for that single task. All task points are summed up to a score that is transformed to a motor ability index (motor quotient) according to the corresponding reference value for boys and girls in half-year age groups.18 A motor quotient of 100 resembles the expected reference value with a standard deviation of 15.

Full test time with prearrangement takes about 30 min. All tests were conducted by the same examiner in our institution.

Intervention programme

Children were trained in small groups by a sport scientist once per week for 60 min in a playful manner. The aim of the exercise programme was to improve motor ability in a playful manner. Parents were not allowed to stay in the gym during the session.

The programme started with a short gathering where children reported on their health status in the previous week. Afterwards, the trainer introduced a motto of the session with a short story and started with a playful warm-up. The main part with the aim to enhance motor competence contained several obstacles that had to be passed either alone or in the group. For example, when the topic of the session was “jungle”, the adventurer (child) had to get over a river (swinging on a rope), cross a canyon on a small bridge (balancing on a bar), and pick bananas from a tree (climbing wall bars).

Data analyses

Owing to the fact that data were skewed, all descriptive data are expressed in median values and interquartile ranges (Quartile 1; Quartile 3). Non-parametric Wilcoxon signed-rank test was performed to compare the motor ability at baseline with that after intervention.

All analyses were performed using PASW 18.0 software (SPSS Incorporation, Chicago, Illinois, United States of America). p-values <0.05 were considered significant.

Results

From April, 2007 to July, 2010, 14 children with various types of congenital heart disease could be recruited from our outpatient department (Table 1). Median motor quotient at baseline was 92.0 (83.75, 101.25). Of the 14 patients, 9 were below the reference value of 100. After the training programme, motor quotient increased slightly to 95.0 (88.0, 102.5) but failed to reach statistical significance in the whole group (p = 0.141; Fig 1).

In a subgroup analysis of the nine children with a less than normal motor development at baseline (motor quotient lower 100), there was an increase in motor ability in seven of the nine children. In the whole subgroup, motor quotient increased significantly (p = 0.020) about 5% from 87.0 (79.0, 92.0) to 88.0 (86.5, 95.5) after 3 months of motor training (Fig 2).

Discussion

This study showed that even a short intervention programme of 60 min once per week improves the motor ability of children with congenital heart disease and a retarded motor development within 3 months.
motor training once a week was too low to lead to an improvement in the whole study group of children with congenital heart disease. There is consensus that motor development is often delayed and impaired in children with congenital heart disease. Several deficits in gross motor skills almost one-third of children with congenital heart disease to have moderate to severe deficits, according to motor screening tests. Children with congenital heart disease differ in motor development compared to children without congenital heart disease. Motor skills in children at baseline and follow-up testing are shown in Figure 1. Changes in motor quotient in children at baseline and follow-up testing are shown in Figure 2. Children with a less than normal motor development show an increase in motor quotient after 3 months of motor training (Wilcoxon signed-rank test, p = .020).

Table 1. Study subjects and MOT 4–6 results from baseline and follow-up testing.

<table>
<thead>
<tr>
<th>Number</th>
<th>Diagnosis</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Therapeutic procedures</th>
<th>MQ (baseline)</th>
<th>MQ (follow-up)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pulmonary stenosis</td>
<td>F</td>
<td>4.0</td>
<td>Dilation with a balloon</td>
<td>75</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Hypoplastic left heart</td>
<td>M</td>
<td>4.1</td>
<td>Extracardiac total cavopulmonary connection</td>
<td>78</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tetralogy of Fallot</td>
<td>M</td>
<td>5.0</td>
<td>VSD closure and transatrial patch</td>
<td>80</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Abnormal origin of the subclavia arteria</td>
<td>M</td>
<td>5.1</td>
<td>Implantation of the right Arteria subclavia</td>
<td>85</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Coarctation of the aorta</td>
<td>F</td>
<td>4.6</td>
<td>Resection and end-to-end anastomosis</td>
<td>87</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Ventricular septal defect</td>
<td>F</td>
<td>5.2</td>
<td>Surgical closure with a patch</td>
<td>88</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mild aortic stenosis</td>
<td>M</td>
<td>4.5</td>
<td>None</td>
<td>90</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Ventricular septal defect</td>
<td>M</td>
<td>4.1</td>
<td>None</td>
<td>94</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Pulmonary atresia with ventricular septal defect</td>
<td>F</td>
<td>4.1</td>
<td>VSD closure and relief of right outflow tract</td>
<td>94</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Atrioventricular septal defect</td>
<td>M</td>
<td>6.1</td>
<td>Corrective surgery with two patches</td>
<td>101</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Pulmonary stenosis</td>
<td>M</td>
<td>5.3</td>
<td>Dilation with a balloon</td>
<td>101</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Tetralogy of Fallot</td>
<td>M</td>
<td>4.7</td>
<td>VSD closure and transatrial patch</td>
<td>102</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Dysplastic aortic valve</td>
<td>M</td>
<td>4.2</td>
<td>None</td>
<td>106</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Transposition of the great arteries</td>
<td>M</td>
<td>4.8</td>
<td>None</td>
<td>107</td>
<td>113</td>
<td></td>
</tr>
</tbody>
</table>

F = female; M = male; MOT = motor developmental test; MQ = motor quotient; VSD = ventricular septal defect
reach an improvement in motor ability. Nevertheless, a positive effect of this low-dose exercise training is seen in those patients with a delay in their motor competence. Therefore, it is important to initiate further exercise programmes to evaluate whether a low-dose intervention programme has a positive effect in a larger group of children with congenital heart disease.

Conclusions

Children with congenital heart disease should be screened for a diminished motor development as early as possible in the clinical follow-up routine. Even when only slightly retarded, a participation in a special motor training programme should be aspirated after sound check-up by a paediatric cardiologist. These programmes should, however, be performed at least twice per week to improve motor ability. This will hopefully facilitate a normal social integration and school sport participation. Moreover, more education from medical doctors regarding the potential benefit of exercise is needed. Children and their families should be encouraged to an active lifestyle and to participate in leisure sport to avoid overprotection. Prospective studies with a randomised controlled design in a larger, probably multi-centre cohort are needed to confirm these conclusions.

Acknowledgement

This study was supported by grants from the “Deutsche Herzstiftung e.V.”, “Wilhelmine Holzapfel Stiftung” of the Landeshauptstadt München, and the “Landes—Arbeitsgemeinschaft für kardiologische Prävention und Rehabilitation und Prävention in Bayern”. There was no conflict of interest.

Supplementary materials

For supplementary material referred to in this article, please visit http://dx.doi.org/doi:10.1017/S1047951112001941

References

4. Hovels-Gurich HH, Seghaye MC, Dubritz S, Mesmer BJ, von Bernuth G. Cognitive and motor development in preschool and...