Relationship between functional ability and physical fitness in juvenile idiopathic arthritis (jia) patients

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Abstract

Objective
To determine the existence of a relationship between aerobic and anaerobic physical fitness and functional ability in children with JIA.

Methods
Eighteen children with JIA (age 7 to 14 yr., 3 male / 15 female) performed an aerobic and anaerobic exercise test. Functional ability was concurrently assessed using the Childhood Health Assessment Questionnaire (CHAQ).

Results
A low relationship between aerobic fitness and functional ability was found. The correlations between anaerobic physical fitness and functional ability in JIA patients were strong. This is indicated a good relationship between anaerobic fitness and functional ability.

Conclusion
The strong association between anaerobic physical fitness and functional ability showed the importance of anaerobic physical fitness for children with JIA.
Introduction

Children with a chronic disease often have a lower physical fitness compared to healthy controls. They also have more problems in performing all kinds of activities of daily living (functional ability) compared to healthy controls. This finding also has been confirmed for children with JIA, they perform less activities of daily living, have a lower functional ability and aerobic and anaerobic physical fitness compared to active healthy children. Bar-Or suggested a link between a low physical fitness and a low functional ability in pediatric chronic diseased patients. However, little data exist linking physical fitness and functional ability in children with JIA. Only two studies exists suggesting a moderate relationship between isometric muscle strength and functional ability in juvenile arthritis patients. No data exists whether aerobic and anaerobic physical fitness, as measured during a well-controlled laboratory exercise test, could be related to functional ability in JIA patients.

Patients lacking the requisite physical fitness may not be able to perform various activities of daily living that are important determinants of independence. Therefore the purpose of this study was to determine the existence of a relationship between aerobic and anaerobic physical fitness and functional ability in children with JIA.

Methods

Patients

Eighteen patients (age 7 to 14 yr., 3 male / 15 female) participated in this study. JIA was diagnosed by a pediatric rheumatologist, and the patients were divided in three distinct types of JIA: oligoarticular JIA (OJIA; arthritis present in four or fewer joints); polyarticular JIA (PJIA; 5 or more joints affected with arthritis without systemic manifestations); systemic JIA (SJIA; characterized by intermittent fever, rheumatoid rash, and arthritis). The characteristics of the patients at baseline are presented in Table 1. All patients were receiving a local and/or a systemic arthritis related therapy consisting of non-steroid anti-inflammatory drugs and/or disease modifying anti-rheumatic drugs and/or immunosuppressive drugs/steroids in the last 6 months prior inclusion. All subjects were recruited from the pediatric rheumatology outpatient clinic of the Wilhelmina Children’s Hospital, University Medical Center Utrecht, the Netherlands. Parents gave their
informed consent for participating in the study. All procedures were approved by the local medical ethical committee.

Table 1. Patients Characteristics.

<table>
<thead>
<tr>
<th>JIA Patients (N=18)</th>
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</thead>
<tbody>
<tr>
<td>Age (years: mean ± SD)</td>
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<tr>
<td>Body Mass Index (in kg · m^2: mean ± SD)</td>
</tr>
<tr>
<td>Weight (in kg: mean ± SD)</td>
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<tr>
<td>Σ7-Skinfolds (in mm: mean ± SD)</td>
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<tr>
<td>Disease Subclass</td>
</tr>
<tr>
<td>pEPMROM (mean ± SD)</td>
</tr>
<tr>
<td>Number of Swollen Joints (mean ± SD)</td>
</tr>
<tr>
<td>Years of Arthritis (in years: mean ± SD)</td>
</tr>
</tbody>
</table>

pEPMROM = Pediatric Escola Paulista de Medicina Range of Motion Scale.

Joint range of motion
Joint range of motion was assessed using the pediatric Escola Paulista de Medicina range of motion scale (pEPMROM). Ten joint movements (cervical spine [rotation], shoulder [abduction], wrist [flexion and extension], thumb [flexion metacarpophalangeal], hip [internal and external rotation], knee [extension], and ankle [dorsiflexion and plantar flexion]) were examined using a goniometer and classified on a 4-point Likert scale (0 = no limitation to 3 = severe limitation). The final score was calculated as the sum of the mean joint score at each movement divided by 10, providing a final range of scores for joint movement from 0 to 3.

Anthropometry
The patient’s body mass and height were determined using an electronic scale and a measuring stick. Body composition was assessed using the sum of seven skinfolds method according Pollack et al. The measurements were taken at 7 sites (at the right side of the body); triceps, biceps, subscapular, suprailiac, mid-abdominal, medial calf and thigh by the test leader in accordance with the American College of Sports Medicine guidelines.
Aerobic Physical Fitness
The maximal oxygen consumption attained during a graded maximal exercise to volitional exhaustion (MXT) is considered as the single best indicator of aerobic physical fitness by the WHO\textsuperscript{12} and is a reliable test in JIA patients\textsuperscript{13}. Subjects performed a MXT using an electronically braked cycle ergometer (Lode Examiner, Lode BV, Groningen, the Netherlands). The seat height of the ergometer was adjusted to the patient’s leg length. Three minutes of unloaded cycling preceded the application of resistance to the ergometer. Thereafter, the workload was increased by the constant increment of 20 Watts every 3 minutes. This protocol continued until the patient stopped because of volitional exhaustion, despite strong verbal encouragement of the experimenters. During the MXT, subjects breathed through a facemask (Hans Rudolph Inc, USA) connected to a calibrated metabolic cart (Oxycon Champion, Jaeger, Mijnhart, Bunnik, the Netherlands). Expired gas was passed through a flowmeter, an oxygen (O\textsubscript{2}) analyzer and a carbon dioxide (CO\textsubscript{2}) analyzer. The flow meter and gas analyzers were connected to a computer, which calculated breath-by-breath minute ventilation (V\text{e}), oxygen consumption (V\text{O}_{2}), carbon dioxide production (V\text{CO}_{2}), and respiratory exchange ratio (RER) from conventional equations. Heart rate (HR) was measured continuously during the MXT by a bipolar electrocardiogram. Absolute peak oxygen consumption was taken as the average value over the last 30 sec during the maximal exercise test. Relative VO\textsubscript{2peak} was calculated as absolute VO\textsubscript{2peak} divided by body mass.

Anaerobic Physical Fitness
The Wingate anaerobic test (WaNT) as described by Bar-Or\textsuperscript{14} was performed on a recently calibrated electromagnetic braked bicycle ergometer (Lode Examiner, Lode BV, Groningen, the Netherlands). The ergometer was upgraded by the manufacturer to a maximal resistance of 800 Watt instead of the standard 400 Watt. The external resistance was controlled and the power output was measured using the Lode Wingate software package. The external load (torque; in Nm) was determined, dependent of bodyweight (at 0.53 × bodyweight and 0.55 × bodyweight for girls and boys respectively) according to the user manual. This test has been used in different pediatric patient groups, and has been shown to be reliable\textsuperscript{15,16} and valid against other measures of anaerobic performance\textsuperscript{17}. The seat height was adjusted to the patients leg length (comfortable cycling height). Thereafter the patients’ feet were put in the Velcro toe-straps and the exercise protocol was explained. The patients were instructed to exercise for 1
minute at the cycle ergometer with an external load of 15 Watt at 50 Rpm’s. Hereafter the sprint protocol started. The patients were instructed to cycle all-out for 30 seconds. Obtained variables (mean power and peak power) were corrected for the inertia of the mass of the flywheel.

Functional Ability
The Dutch translation of the Childhood Health Assessment Questionnaire (CHAQ) was used as a self-administered pencil and paper questionnaire for the parents (proxy), as an index of functional ability. The CHAQ\textsuperscript{29} has been adapted from the Stanford Health Assessment Questionnaire so that at least one question in each domain is relevant to children aged 0.6 to 19 years. The CHAQ was recently cross-culturally adapted and validated for the Dutch language\textsuperscript{2}. The question with the highest score within each domain (range 0 to 3; able to do with no difficulty = 0, able to do with some difficulty = 1, able to do with much difficulty = 2, unable to do = 3, time frame was last week) determined the score for that domain, unless aids or assistance was required (raising the score for that domain to a minimum of 2). The mean of the scores on the eight domains provided the CHAQ disability score (range 0 to 3).

Statistics
All data were entered and analyzed in SPSS 9.0 for Windows (SPSS, Chicago, Ill). Spearman’s correlation coefficients were calculated to describe the relationships between aerobic and anaerobic physical fitness and the CHAQ disability score. Alpha level was set at $p < 0.05$ for all analyses.

Results
Descriptive statistics for the aerobic and anaerobic physical fitness tests and CHAQ disability score are displayed in Table 2. The wide range of subject characteristics shows the variation in physique of JIA patients and reflect an overall moderately impaired function. Spearman’s correlations between parameters of aerobic and anaerobic physical fitness and CHAQ disability scores and its subscales are displayed in Table 3 and show a low relationship between aerobic fitness and functional ability. On the other hand, the correlations between the two indices of anaerobic performance and functional ability in JIA patients were large for the CHAQ disability scores.
and dressing/grooming and hygiene subscales and moderate for eating, walking and arising subscales. This indicated the good relationship between anaerobic fitness and functional ability.

The relationship between peak power on the WaNT and the CHAQ disability score is shown in Figure 1A and indicates a negative relationship between these

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Table 2. Descriptive statistics for peak values of the aerobic and anaerobic exercise tests.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Sd</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute VO₂peak (L·min⁻¹)</td>
<td>1.21</td>
<td>0.33</td>
<td>0.73 - 2.0</td>
</tr>
<tr>
<td>Relative VO₂peak (ml·min⁻¹·kg⁻¹)</td>
<td>31.98</td>
<td>8.5</td>
<td>14.6 - 50.0</td>
</tr>
<tr>
<td>Peak Power WaNT (Watt)</td>
<td>316.4</td>
<td>148.8</td>
<td>105 - 633</td>
</tr>
<tr>
<td>Mean Power WaNT (Watt)</td>
<td>195.4</td>
<td>75.6</td>
<td>91 - 349</td>
</tr>
<tr>
<td>CHAQ Disability Score</td>
<td>0.81 †</td>
<td></td>
<td>0.37 - 1.6*</td>
</tr>
</tbody>
</table>

† = Median; * = Interquartile range.

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Figure 1A-B.

Relationship between functional ability (CHAQ disability score) and Peak Power (left panel) and functional ability (CHAQ disability score) and Mean Power on the WaNT (right panel).
variables. The relationship between mean power on the WaNT and the CHAQ is shown in Figure 1B, and also suggests a negative relationship between these two variables, with a floor effect at approximately 300 Watts. Patients with a lower anaerobic physical fitness show a higher degree of functional disability compared to the patients who perform better on the WaNT.

**Discussion**

The purpose of this study was to determine whether there is a relationship between aerobic and anaerobic physical fitness and functional ability in children with JIA. Although factors related to functional ability and disability could be explored using aerobic and anaerobic physical fitness tests, it is not common to perform these fitness tests in children with JIA, because most rheumatology health professionals are not trained in performing these kind of exercise tests. There is a paucity of research investigating the aerobic physical fitness of children with Juvenile Arthritis\(^5\); the anaerobic physical fitness of juvenile arthritic patients is even less investigated\(^3,4,19\). In juvenile arthritic patients, the relation-

### Table 3. Spearman correlation coefficients between Functional Ability and Physical Fitness.

<table>
<thead>
<tr>
<th></th>
<th>AbsoluteVO(_{2\text{peak}})</th>
<th>RelativeVO(_{2\text{peak}})</th>
<th>Peak Power WaNT</th>
<th>Mean Power WaNT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHAQ Disability Score</strong></td>
<td>-0.289</td>
<td>0.132</td>
<td>-0.528(^*)</td>
<td>-0.527(^*)</td>
</tr>
<tr>
<td><strong>Subscales:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dressing and Grooming</td>
<td>-0.44</td>
<td>-0.020</td>
<td>-0.530(^*)</td>
<td>-0.600(^*)</td>
</tr>
<tr>
<td>Arising</td>
<td>0.004</td>
<td>0.28</td>
<td>-0.444</td>
<td>-0.475(^*)</td>
</tr>
<tr>
<td>Eating</td>
<td>-0.469(^*)</td>
<td>0.093</td>
<td>-0.464</td>
<td>-0.536(^*)</td>
</tr>
<tr>
<td>Walking</td>
<td>0.003</td>
<td>0.307</td>
<td>-0.457</td>
<td>-0.473(^*)</td>
</tr>
<tr>
<td>Hygiene</td>
<td>-0.452</td>
<td>0.2</td>
<td>-0.782(^*)</td>
<td>-0.765(^*)</td>
</tr>
<tr>
<td>Reach</td>
<td>0.079</td>
<td>0.153</td>
<td>-0.258</td>
<td>-0.299</td>
</tr>
<tr>
<td>Grip</td>
<td>0.14</td>
<td>0.199</td>
<td>-0.246</td>
<td>-0.224</td>
</tr>
<tr>
<td>Activities</td>
<td>-0.025</td>
<td>0.203</td>
<td>-0.380</td>
<td>-0.357</td>
</tr>
</tbody>
</table>

\(^*\) = \( p < 0.05 \)
ship between aerobic and anaerobic physical fitness and functional ability has to our knowledge never been explored before.

Surprisingly no relationship could be observed between VO2peak and CHAQ disability scores as the current goal for exercise programs for JIA patients is the improvement of aerobic physical fitness. The improvement in aerobic physical fitness might have more long-term benefits for these patients than short-term benefits in terms of an improved functional ability. On the contrary to aerobic physical fitness, there was a strong relationship between anaerobic physical fitness and functional ability. Especially dressing/grooming, hygiene and walking were correlated to anaerobic physical fitness. Thus children need a certain level of physical fitness for performing all kinds of activities of daily living. Observations of children’s activity patterns are suggesting that the majority of these activities can be characterized by short intense bursts of activities. An impaired physical fitness means that certain activities cannot be performed at the same pace as healthy children, or cannot be performed at all.

This type of activity patterns in children might explain the better relationship between anaerobic physical fitness compared to aerobic physical fitness. In adulthood, the activity patterns shift towards an aerobic activity pattern. This would make aerobic physical fitness more important with increasing age of the patients.

As shown in Figures 1A and 1B, there seems to be a floor effect in the relationship between anaerobic physical fitness and functional ability at around 300 Watt mean power over the 30 sec all-out sprint of the WaNT. The CHAQ seems to be insensitive to detect small levels of disability.

JIA patients often have a lower muscle bulk compared to healthy subjects. This atrophy is still evident after some years without disease flares, and is more pronounced in children with a disease onset before the age of 3. A lower muscle mass implies a smaller muscle mass to consume oxygen and to generate a certain power output during the 30 second sprint test. Suggestions for the cause of the diminished muscle mass are inactivity, disease activity, (inflammatory parameters such as TNF alpha), and medication, (for example Cyclosporine A and prednisone).

Muscular biopsy studies in children with JIA are, to our knowledge, not performed. Available evidence from studies with adult Rheumatoid Arthritis patients, suggests an atrophy in both type I and type II muscle fibers, however the atrophy is most pronounced in the type II muscle fibers. As the anaerobic exercise performance is heavily dependent on number and size of type II muscle...
fibers, it is not surprising that the anaerobic physical fitness of JIA patients is impaired. This current finding does not imply that we should no longer focus on aerobic physical training programs. Recent (pilot) studies from both healthy children and patients with JIA are showing an improvement in anaerobic physical fitness after performing an aerobic training program\textsuperscript{19,28,29}. Moreover, aerobic physical fitness is a strong indicator of functional ability and mortality in adulthood\textsuperscript{10,31}. Long-term follow-up studies into adulthood might confirm this transition in the relationship between physical fitness and functional ability.

In conclusion, this study significantly adds to the body of knowledge on the relationship between physical fitness and functional ability in JIA patients. The strong association between anaerobic physical fitness and functional ability shows the importance of anaerobic physical fitness for children with JIA. These results may give further directions to exercise training interventions in this patient group. Further long-term follow-up studies are indicated to better understand the relation between physical fitness and functional ability with increasing age of patients.
References


