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

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Objective: To determine the relationship between aerobic and anaerobic physical fitness and functional ability in children with juvenile idiopathic arthritis (JIA).
Methods: Eighteen children with JIA (age 7 to 14 yr., 3 male/15 female) performed a maximal aerobic exercise test and a Wingate 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 ($r = 0.0$ to 0.4, $p > 0.05$, except for eating $r = 0.46$, $p < 0.05$). The correlations between anaerobic physical fitness and functional ability in JIA patients were strong ($r = 0.5$ to 0.75, $p < 0.05$). This 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.

Key words: physical fitness, exercise, functional ability, juvenile idiopathic arthritis, activities of daily living, functional limitations

Children with a chronic disease often have a lower physical fitness than healthy controls. They also have more problems in performing all kinds of activities of daily living (functional ability) compared to healthy controls. This finding has also been confirmed for children with juvenile idiopathic arthritis (JIA), they perform less activities of daily living, have a lower functional ability, and aerobic and anaerobic physical fitness compared to active healthy children (1 – 5). Bar-Or suggested a link between a low physical fitness and a low functional ability in pediatric chronic diseased patients (6). However, little data exist linking physical fitness and functional ability in children with JIA. Only two studies suggesting a moderate relationship between isometric muscle strength and functional ability in juvenile arthritis patients exist (7, 8). No data has been found on whether aerobic and anaerobic physical fitness, as measured during a well-standardized 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 for 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.

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Materials and Methods

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 into 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 I. All patients were receiving a local and/or a systemic arthritis related therapy consisting of non-steroidal anti-inflammatory drugs

Table I. Patients Characteristics.

	JIA patients (N = 18)
Age (years: mean ± SD)	10.7 (±1.7)
Body Mass Index (in $kg \cdot m^{-2}$: mean ± SD)	18.5 (±2.8)
Weight (in kg: mean ± SD)	39.1 (±10.2)
Σ7-Skinfolds (in mm: mean ± SD)	110.3 (±43.6)
Disease subclass	9 OJIA/7 PJIA/2 SJIA
pEPMROM (mean ± SD)	0.2 (±0.21)
Number of swollen joints (mean ± SD)	2.4 (±3.1)
Years of Arthritis (in years: mean ± SD)	6.3 (±2.3)

Pediatric Escola Paulista de Medicina Range of Motion Scale (pEPMROM): range of motion score.

and/or disease modifying anti-rheumatic drugs and/or immunosuppressive drugs/corticosteroids in the last 6 months prior to 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.

Joint range of motion was assessed using the pediatric Escola Paulista de Medicina range of motion scale (pEPMROM; (9). 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. (10). 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 (11).

The maximal oxygen uptake (VO_{2peak}) attained during a graded maximal exercise to volitional exhaustion (MXT) is considered as the single best indicator of aerobic physical fitness by the WHO (12) and is a reliable test in JIA patients (13). VO_{2peak} reflects the maximal capacity of the respiratory and cardiovascular systems to supply oxygen to the working muscles. Subjects performed a MXT using a cycle ergometer (Lode Examiner, Lode BV, Groningen, the Netherlands) and a calibrated metabolic cart (Oxycon Champion, Jaeger, Breda, the Netherlands) as previously described (13). Absolute VO_{2peak} was taken as the average value over the last 30 sec during the maximal exercise test. Relative VO_{2peak} was calculated as absolute VO_{2peak} divided by body mass. Usually, only relative VO_{2peak} is reported, to remove the influence of body size on VO_{2peak}. However, as some of our patients have an increased body mass due to the corticosteroid medication, this would result in a lower VO_{2peak} due to a higher body mass, and not due to a reduced capacity of the muscles to consume oxygen. Therefore, VO_{2peak} was reported in both absolute and relative VO_{2peak} values.

The Wingate Anaerobic Test (WaNT) was also performed on the bicycle ergometer (14). The external resistance was controlled and the power output was measured using the Lode Wingate software package. The external load (torque; in N·m) was determined, dependent of bodyweight (at $0.53 \times$ bodyweight and $0.55 \times$ 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 (15) and valid against other measures of anaerobic performance (14).

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. The Wingate reflects the ability of the leg muscles to use energy-rich phosphates for its contraction. Peak power is considered as an indication of the maximum rate of usage of energy-rich phosphates, mean power is an indication the total capacity of the energy-rich phosphates in the muscle (14).

The Dutch translation of the CHAQ was used as a self-administered pencil and paper questionnaire for the parents (proxy), as an index of functional ability. The CHAQ was recently cross-culture adapted and validated for the Dutch language (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; timeframe 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 scale (range 0 to 3).

All data were entered and analyzed in SPSS 9.0 for Windows. Spearmans 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 II. The wide range of subject characteristics shows the variation in physique of

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

	Mean	SD	Range	Normative values
Absolute VO_{2peak} (in $L \cdot min^{-1}$)	1.21	0.33	0.73–2.0	1.6±0.3
Relative VO_{2peak} (in $ml \cdot min^{-1} \cdot kg^{-1}$)	31.98	8.5	14.6–50.0	41.6±2.5
Peak Power WaNT (in Watt)	316.4	148.8	105–633	346±118
Mean Power WaNT (in Watt)	195.4	75.6	91–349	207±64
CHAQ disability index	0.8125†		0.3750–1.625*	0.2±0.4

†: median, *: interquartile range, Normative values from (2, 30).

JIA patients and reflect an overall moderately impaired function.

Spearmans correlations between parameters of aerobic and anaerobic physical fitness and CHAQ disability scores and its subscales are displayed in Table III 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.

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 such 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, 16). In juvenile arthritic patients, the relationship between aerobic and anaerobic physical fitness and functional ability has to our knowledge never been explored before.

No relationship could be observed between VO_{2peak} and CHAQ disability scores. This is surprising as the current goal for exercise programs for JIA patients is the improvement in aerobic physical fitness which have more long-term benefits than short-term benefits in terms of an improved functional ability. In contradistinction 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 might need a certain level of anaerobic physical fitness for performing a wide variety of activities of daily living. The results of the current study must be interpreted with caution since this was a cross sectional study, in which cause and effect are only speculative.

Observations of children's activity patterns suggest that the majority of these activities can be characterized by short intense bursts of activities (17). An impaired anaerobic 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 pattern 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

Table III. Spearman correlation coefficients between functional ability and physical fitness.

	Absolute VO_{2peak}	Relative VO_{2peak}	Peak Power WaNT	Mean Power WaNT
CHAQ disability index	−0.289	0.132	−0.528*	−0.527*
Subscales:				
Dressing and Grooming	−0.440	−0.020	−0.530*	−0.600*
Arising	0.004	0.280	−0.444	−0.475*
Eating	−0.469*	0.093	−0.464	−0.536*
Walking	0.003	0.307	−0.457	−0.473*
Hygiene	−0.452	0.200	−0.782*	−0.765*
Reach	0.079	0.153	−0.258	−0.299
Grip	0.140	0.199	−0.246	−0.224
Activities	−0.025	0.203	−0.380	−0.357

*$p < 0.05$.

of the patients. JIA patients often have a lower muscle bulk compared to healthy subjects (18, 19). 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 (19). A lower muscle mass means less muscle mass to consume oxygen and to generate a certain power output during the 30 second sprint test. The cause of the diminished muscle mass may be inactivity, disease activity, (inflammatory parameters such as TNF alpha (20)), and medication, (for example Cyclosporine A (21) and prednisone (22)).

Muscle biopsy studies in children with JIA have, to our knowledge, not been 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 type II (23). 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 show an improvement in anaerobic physical fitness or muscle strength after performing an aerobic training program (16, 24, 25). Moreover, aerobic physical fitness is a strong indicator of functional ability and mortality in adulthood (26, 27). However, recently Hakkinen et al (28) found that RA patients with a normal level of habitual physical activities show a normal level of aerobic physical fitness, but still showed deficits in the explosive strength characteristics of the leg extensors.

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 longitudinal studies are indicated to better understand the relation between physical fitness and functional ability.

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