

# Validity of the 6-Minute Walking Test in Juvenile Idiopathic Arthritis

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## Introduction

Lower physical activity levels and decreased physical fitness levels have been reported in children with juvenile idiopathic arthritis (JIA) (1). Physical fitness includes 4 components: muscular endurance and strength, flexibility, body composition, and cardiorespiratory endurance or aerobic fitness (2). Cardiorespiratory endurance or aerobic fitness is most strongly associated with health benefits in the general population and is therefore the primary focus of most exercise programs (3,4). Children with JIA have a moderate to large impairment in aerobic fitness as represented by peak oxygen uptake ( $\text{VO}_{2\text{peak}}$ ) compared with healthy children (5).  $\text{VO}_{2\text{peak}}$  has been described as the golden standard for aerobic fitness and is frequently examined using symptom limited bicycle ergometry (SLBE) in combination with a metabolic cart to analyze respiratory gases (6). However, bicycle ergometry and metabolic measurements are not always feasible in pediatric patients. It may be difficult to motivate nonathletic children to an exhaustive effort, intensive exercise may pose a risk to children with cardiopulmonary or musculoskeletal disease, and metabolic measurements systems may not be available, particularly in a field setting (7). Therefore, there is need for simple and inexpensive measurement tools to measure aerobic fitness. The 6-Minute Walking Test (6-MWT), a simple and inexpensive measurement tool, is a good candidate (8).

The 6-MWT is a self-paced and submaximal endurance test. In adult patients the 6-MWT has been widely used, most often in patients with pulmonary or cardiac diseases (9,10). Literature provides support for the reliability, validity, and responsiveness of the 6-MWT for a wide spec-

trum of adult individuals (9). In addition, the 6-MWT is described as easy to administer, better tolerated, and more reflective of activities of daily living than other walking tests and has therefore been described as the test of choice when using a functional walk test for clinical or research purposes (10). In pediatric patients, only 2 studies report the use of the 6-MWT (11,12). Gulmans et al found that for this group the 6-MWT is a valid and useful test to assess the exercise tolerance and endurance in children with cystic fibrosis (11). Nixon et al suggested that the 6-MWT might provide an alternative method for assessing functional exercise capacity in severely ill children (12). Despite these promising results, the validity of the 6-MWT in children with rheumatic disease has, to our knowledge, never before been examined.

Validity refers to the question as to whether an instrument appears to measure what it purports to measure, i.e., endurance. In addition, validity indicates whether a variable can be correlated with the “gold standard” for cardiorespiratory endurance, i.e.,  $\text{VO}_{2\text{peak}}$ . The aim of the present study was to examine the validity of the 6-MWT in children with JIA.

## Patients and Methods

**Patients.** Patients participating in a randomized controlled trial (RCT) on the effectiveness of an aquatic training program were selected for this study (13). Eligible patients for the RCT were those with a diagnosis of JIA from a pediatric rheumatologist using European League Against Rheumatism and International League of Associations for Rheumatology Criteria (14), and had an age range of 5 to 12 years. Patients were recruited from the pediatric rheumatology outpatient clinics of the Beatrix Children Clinic of the University Hospital Groningen and the Wilhelmina Children Hospital of the University Medical Center Utrecht. All patients were receiving a local and/or systemic arthritis-related therapy consisting of nonsteroidal antiinflammatory drugs, and/or disease-modifying antirheumatic drugs, and/or immune-suppressive drugs in the last 6 months prior to inclusion. Patients were excluded if they had minor surgery <14 days prior to inclusion, or major surgery <6 weeks prior to inclusion.

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**Outcome measurements.** Walking distance was assessed with the 6-MWT, which was performed on an 8-meter track in a straight corridor. Patients were instructed to cover the largest possible distance in 6 minutes at a self-chosen walking speed. Turns were made on both ends of the 8-meter track. Standard encouragement was given: “Keep going,” “You are doing well,” and “Everything is going well.” Time was measured with a stopwatch. The patient was kept informed about the progress of the time. The total distance was calculated as the counted repetitions and multiplied by 8 meters. The total outcome of walking distance was taken for analysis.

Aerobic capacity was assessed with SLBE using an electronically braked cycle ergometer (Lode Examiner; Lode BV, Groningen, The Netherlands). The seat height was adjusted to the patient’s leg length. The workload was increased in constant increments during the exercise test until the patient stopped due to volitional exhaustion, despite strong verbal encouragement from the experimenters. Maximal effort occurred when 1 of 3 criteria was met: ratings of perceived exertion (RPE) of 10 on a scale from 1–10; heart rate (HR) >180 beats per minute; or a respiratory exchange ratio (RER) >1.0.

During the test the patients breathed through a face mask (Hans Rudolph Inc., Kansas City, MO) connected to a calibrated metabolic cart (Oxycon Champion; Jaeger, Mijnhart, Bunnik, The Netherlands). Expired gas was passed through a flow meter, an oxygen analyzer, and a carbon dioxide analyzer. The flow meter and gas analyzer were connected to a computer, which calculated breath-by-breath minute ventilation, oxygen consumption, carbon dioxide production, and RER from conventional equations. HR was measured continuously during the maximal exercise test by a bipolar electrocardiogram. RPE were recorded during exercise on a Borg CR-10 scale, in which 0 reflected no exertion and 10 maximal exertion.  $VO_{2peak}$  measured as the average value over the last 30 seconds during the maximal exercise test was taken for analysis.

**Joint status.** The number of affected joints of the lower extremities was determined. Tenderness and swelling were scored for the hip, knee, ankle, and toes. Tenderness was scored using a 2-point scale (1 = pain, and 2 = no pain.) Swelling was scored using a 4-point Likert scale (0 = no swelling, and 4 = severe swelling). The range of motion (ROM) was scored using the paediatric Escola Paulista de Medicina Range of Motion (pEPM-ROM) scale. Measurements were made using a goniometer and classification was done using a 4-point Likert scale (0 = no limitation and 4 = severe limitation) (15).

**Procedure.** Patients were selected from the RCT, but only patients who met the criteria of a maximal bicycle ergometry and a 6-MWT were included in the study. Therefore, patients who performed “maximal” during a graded exercise test to exhaustion (HR > 180, RER > 1.0) and patients who performed a 6-MWT were included to assess the validity of the 6-MWT. Additionally, to examine the consistency of the results, we took 2 independent samples of the study population. Samples were taken from

**Table 1. Baseline characteristics\***

	Sample 1 (n = 22)	Sample 2 (n = 21)
No. male/female	6/16	5/16
Age, mean $\pm$ SD years	8.2 $\pm$ 2.1	8.6 $\pm$ 2.0
JIA type		
Oligoarticular	7	12
Polyarticular	12	9
Systemic	3	0
Joint score†		
0	7	9
1	2	2
2	6	4
3	6	2
4	1	3
6	0	1

\* Except where indicated otherwise, values are the number. JIA = juvenile idiopathic arthritis.  
† Number of joints with swelling, tenderness, and/or joint limitation.

the baseline measurements. Both groups consisted of different patients (i.e., none of the patients were included in both groups).

**Statistical analysis.** For statistical analysis the Statistical Package for Social Sciences (Version 10; SPSS, Chicago, IL) was used. Descriptive statistics were used for patient’s characteristics of all samples and for walking distance and  $VO_{2peak}$ . Chi-square tests and independent *t*-samples were used to compare sample 1 and 2 on differences with respect to sex, age, and number of affected joints. Pearson’s product-moment correlation coefficient (*r*) were performed to assess the relationship between  $VO_{2peak}$  and 6-MWT, in both independent samples. A Pearson correlation coefficient between 0.26 and 0.49 reflects poor agreement, those between 0.50 and 0.69 moderate agreement, and  $\geq 0.70$  high agreement (16). *P* values less than 0.05 were considered statistically significant.

## Results

**Patients/baseline characteristics.** There were 22 patients (6 boys, 16 girls) in sample 1. The mean  $\pm$  SD age was 8.2  $\pm$  2.1 years. There were 7 children with oligoarticular JIA, 12 with polyarticular JIA, and 3 children with systemic JIA. Seven children had no pain, swelling, or joint limitation in any of the measured lower extremity joints. Fifteen children had pain, swelling, and/or joint limitation in at least 1 of the lower extremity joints.

There were 21 patients (5 boys, 16 girls) in sample 2. The mean  $\pm$  SD age was 8.6  $\pm$  2.0 years. Twelve of the children had oligoarticular JIA, and 9 polyarticular JIA. Nine children had no pain, swelling, or joint limitation in any of the measured lower extremity joints. Twelve children had pain, swelling, and/or joint limitation in at least 1 of the lower extremity joints (Table 1).

Independent *t*-sample for age showed no difference between sample 1 and 2 (*P* = 0.54). Independent *t*-sample for number of affected joints showed no difference between

**Table 2. Comparison of walking distance, absolute, and relative  $\text{VO}_{2\text{peak}}$  in samples 1 and 2\***

	Sample (n = 22)†	Sample 2 (n = 21)‡
6-MWD, meters	463 ± 63	468 ± 57
$\text{VO}_{2\text{peak}}$ , liters/minute	1.08 ± 0.29	1.13 ± 0.29
$\text{VO}_{2\text{peak}}$ , ml/kg/minute	35.4 ± 5.6	34.0 ± 6.3
Pearson's correlation for 6-MWD and absolute $\text{VO}_{2\text{peak}}$	0.43	0.51
Pearson's correlation for 6-MWD and relative $\text{VO}_{2\text{peak}}$	0.41	0.32

\* Except where indicated otherwise, values are mean ± SD. 6-MWD = 6-minute walking distance;  $\text{VO}_{2\text{peak}}$  = peak oxygen uptake.  
† For sample 1,  $P = 0.05$  and  $P = 0.06$  for the comparison of the 6-MWD and absolute  $\text{VO}_{2\text{peak}}$ , and 6-MWD and relative  $\text{VO}_{2\text{peak}}$ , respectively.  
‡ For sample 2,  $P = 0.02$  and  $P = 0.16$  for the comparison of the 6-MWD and absolute  $\text{VO}_{2\text{peak}}$ , and 6-MWD and relative  $\text{VO}_{2\text{peak}}$ , respectively.

sample 1 and 2 at the first ( $P = 0.72$ ) and second ( $P = 0.17$ ) baseline measurement. Chi-square test showed no differences in sample 1 and 2 with respect to sex ( $\chi^2 = 0.07$ ,  $P = 0.80$ ).

The mean ± SD walking distance of the 6-MWT in sample 1 was  $463 \pm 63$  meters. The mean ± SD absolute  $\text{VO}_{2\text{peak}}$  in this sample was  $1.08 \pm 0.30$  liters/minute and mean ± SD relative  $\text{VO}_{2\text{peak}}$  was  $35.40 \pm 5.58$  ml/kg/minute bodyweight. The mean ± SD walking distance of the 6-MWT in sample 2 was  $468 \pm 57$  meters. The mean ± SD absolute  $\text{VO}_{2\text{peak}}$  in sample 2 was  $1.13 \pm 0.29$  liters/minute and the mean ± SD relative  $\text{VO}_{2\text{peak}}$  was  $34.04 \pm 6.30$  ml/kg/minute bodyweight.

Pearson's correlation coefficient ( $r$ ) in sample 1 between walking distance and absolute  $\text{VO}_{2\text{peak}}$  was 0.43 ( $P = 0.05$ ). Pearson's correlation coefficient between walking distance and relative  $\text{VO}_{2\text{peak}}$  in sample 1 was 0.41 ( $P = 0.06$ ). Pearson's correlation coefficient in sample 2 between walking distance and absolute  $\text{VO}_{2\text{peak}}$  was 0.51 ( $P = 0.02$ ). Pearson's correlation coefficient between walking distance and relative  $\text{VO}_{2\text{peak}}$  in sample 2 was 0.32 ( $P = 0.16$ ) (Table 2).

**Post-hoc analysis.** We divided the patient population in 2 groups representing less extensive joint involvement and more extensive joint involvement. Therefore, we created a new dichotomous variable: joint involvement. Less extensive joint involvement ( $n = 20$ ) represented those children with 0 or 1 joint of the lower extremity involved, and more extensive joint involvement ( $n = 23$ ) represented those children with  $\geq 2$  joints involved. The less extensive group had a mean ± SD walking distance of  $477 \pm 14.3$  meters while the more extensive group had a mean ± SD walking distance of  $456 \pm 11.6$  meters. Although there was a 21-meter difference between the groups, independent samples tests showed no significant difference in walking distance between the 2 groups ( $P = 0.86$ ).

## Discussion

The aim of the present study was to determine the validity of the 6-MWT in children with JIA. The results of the study showed a statistically significant low to moderate correlation between walking distance and absolute  $\text{VO}_{2\text{peak}}$  in the first and second sample, suggesting a low to moderate validity of the 6-MWT. Furthermore, we found a low and a non-significant correlation between walking distance and relative  $\text{VO}_{2\text{peak}}$  in the first and second sample, respectively, indicating a low validity of the 6-MWT as indicator of  $\text{VO}_{2\text{peak}}$  in JIA patients.

The differences in correlation between relative and absolute  $\text{VO}_{2\text{peak}}$  and walking distance are in accordance with observations made by Rowland (7). Rowland showed that both biologic maturation and body composition could profoundly affect the validity of  $\text{VO}_{2\text{peak}}$  per kilogram as an indicator of endurance fitness. Therefore  $\text{VO}_{2\text{peak}}$  is only useful as a marker in samples of children that are strictly homogeneous in terms of body fat as well as biologic maturity, which is not the case in our 2 samples. The same difference between absolute and relative  $\text{VO}_{2\text{peak}}$  is seen in the population of Gulmans et al (11) who also found a significant correlation between walking distance and absolute  $\text{VO}_{2\text{peak}}$  but a nonsignificant correlation between walking distance and relative  $\text{VO}_{2\text{peak}}$ . This also indicates a low validity of the 6-MWT as an indicator of  $\text{VO}_{2\text{peak}}$  in children with cystic fibrosis.

The results of the present study were not in accordance with the high correlation of walking distance and relative  $\text{VO}_{2\text{peak}}$  in children with severe cardiorespiratory disease (Table 3). These differences might be explained by disease-specific factors. In musculoskeletal diseases like JIA, endurance performance might be negatively influenced by joint status. This negative influence is more prominent during weight-bearing activities like walking compared with nonweight-bearing activities like cycling. In walking, the body weight has to be moved upwards and forwards, while in cycling the workload is provided by the wheel resistance and is therefore body-mass independent. In both samples of our study population, tenderness, swelling, and/or limited ROM in one or more lower extremity joints was generally present, indicating poor joint status. This poor joint status is also reflected in the low walking distance of the JIA group compared with the cystic fibrosis group. However, a post-hoc analysis in our study population indicated that more or less joint involvement does not have a significant influence on walking distance. Apparently, other factors such as coping strategy, kinesiphobia, development, or others may contribute to walking distance. We did not include these factors in our study, and we think it would be interesting to study these factors in the future. Gas exchange measurements during 6-MWT in children with JIA should elucidate the physiologic responses during this test in JIA patients.

Disease-specific factors may also be present in the group with severe cardiorespiratory disease, but from a different origin. Mean relative  $\text{VO}_{2\text{peak}}$  values of 19.0 ml/kg/minute in this group indicate severely impaired cardiorespiratory function. With such severely impaired cardiorespiratory function even a submaximal endurance test will push a

**Table 3. Comparison of walking distance, absolute, and relative  $\text{VO}_{2\text{peak}}$  in studies by Lelieveld (Sample 1, Sample 2), Gulmans et al (reference 11), and Nixon et al (reference 12)\***

	Sample 1 n = 22†	Sample 2 n = 21‡	Gulmans n = 15§	Nixon n = 17¶
Group	JIA	JIA	Moderate CF	Severe CR
Age, mean $\pm$ years	8.2 $\pm$ 2.1	8.6 $\pm$ 2.0	14.5 $\pm$ 2.0	14.8 $\pm$ 2.6
Walking distance, mean $\pm$ meters	463 $\pm$ 63	468 $\pm$ 57	697 $\pm$ 104	407 $\pm$ 143
Absolute $\text{VO}_{2\text{peak}}$	1.08 $\pm$ 0.29	1.13 $\pm$ 0.29	1.69 $\pm$ 0.50	Not reported
Relative $\text{VO}_{2\text{peak}}$	35.4 $\pm$ 5.6	34.0 $\pm$ 6.3	40.2 $\pm$ 9.1	19.0 $\pm$ 5.1
Pearson's correlation for 6-MWD and absolute $\text{VO}_{2\text{peak}}$	0.43	0.51	0.76	Not reported
Pearson's correlation for 6-MWD and relative $\text{VO}_{2\text{peak}}$	0.41	0.32	0.58	0.70

\* JIA = juvenile idiopathic arthritis; CF = cystic fibrosis; CR = cardiorespiratory disease; 6-MWD = 6-minute walking distance.  
† For sample 1,  $P = 0.05$  and  $P = 0.06$  for the comparison of the 6-MWD and absolute  $\text{VO}_{2\text{peak}}$ , and 6-MWD and relative  $\text{VO}_{2\text{peak}}$ , respectively.  
‡ For sample 2,  $P = 0.02$  and  $P = 0.16$  for the comparison of the 6-MWD and absolute  $\text{VO}_{2\text{peak}}$ , and 6-MWD and relative  $\text{VO}_{2\text{peak}}$ , respectively.  
§ For Gulmans et al,  $P < 0.001$  and  $P =$  not significant for the comparison of the 6-MWD and absolute  $\text{VO}_{2\text{peak}}$ , and 6-MWD and relative  $\text{VO}_{2\text{peak}}$ , respectively.  
¶ For Nixon et al,  $P =$  not reported and  $P = 0.05$  for the comparison of the 6-MWD and absolute  $\text{VO}_{2\text{peak}}$ , and 6-MWD and relative  $\text{VO}_{2\text{peak}}$ , respectively.

patient to maximal effort. This changes the character of the 6-MWT from submaximal to maximal, which can explain the high correlation between the 6-MWT and the SLBE. Therefore, in children with severe cardiorespiratory disease, the 6-MWT is a much better predictor of  $\text{VO}_{2\text{peak}}$  than in children with JIA.

We can conclude that the 6-MWT seems to be a poor predictor of  $\text{VO}_{2\text{peak}}$  in children with JIA. Walking distance of the 6-MWT in children with JIA reflects more joint status than aerobic fitness. The 6-MWT might therefore be a possible instrument to measure walking ability in children with JIA in a field setting.

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