

# Exercise Capacity in Pediatric Patients with Inflammatory Bowel Disease

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**Objective** To examine exercise capacity in youth with Crohn's disease (CD) and ulcerative colitis (UC).

**Study design** Eleven males and eight females with CD and six males and four females with UC participated. Patients performed standard exercise tests to assess peak power (PP) and mean power (MP) and peak aerobic mechanical power ( $W_{\text{peak}}$ ) and peak oxygen uptake ( $VO_{2\text{peak}}$ ). Fitness variables were compared with reference data and also correlated with relevant clinical outcomes.

**Results** Pediatric patients with inflammatory bowel disease had lower PP (~90% of predicted), MP (~88% of predicted),  $W_{\text{peak}}$  (~91% of predicted), and  $VO_{2\text{peak}}$  (~75% of predicted) compared with reference values. When patients with CD or UC were compared separately to reference values,  $W_{\text{peak}}$  was significantly lower only in the CD group. No statistically significant correlations were found between any exercise variables and disease duration ( $r = 0.01$  to  $0.14$ ,  $P = .47$  to  $.95$ ) or disease activity ( $r = -0.19$  to  $-0.31$ ,  $P = .11$  to  $.38$ ), measured by pediatric CD activity index or pediatric ulcerative colitis activity index. After controlling for chronological age, recent hemoglobin levels were significantly correlated with PP ( $r = 0.45$ ,  $P = .049$ ), MP ( $r = 0.63$ ,  $P = .003$ ),  $VO_{2\text{peak}}$  ( $r = 0.62$ ,  $P = .004$ ), and  $W_{\text{peak}}$  ( $r = 0.70$ ,  $P = .001$ ).

**Conclusions** Pediatric patients with inflammatory bowel disease exhibit impaired aerobic and anaerobic exercise capacity compared with reference values. (*J Pediatr* 2011;158:814-9).

Inflammatory bowel disease (IBD) describes inflammatory conditions of the small and large intestines,<sup>1</sup> most often diagnosed in the second and third decade of life with about a quarter of new cases occurring in children and adolescents.<sup>2,3</sup> The prevalence of IBD among children and youth in Canada has recently been estimated to be between 18 and 70 per 100 000 (depending on geographical location), making this condition a significant public health issue.<sup>4</sup>

The primary disease manifestations for IBD in children and adults do not differ extensively. However, the major difference is that children are at particular risk for extra intestinal manifestation including growth failure, weight loss, and anemia. The disease can have a great impact on a child's self-esteem, as puberty can be delayed.<sup>5</sup> In addition, these effects can be even more profound in children with Crohn's disease (CD) compared with ulcerative colitis (UC), for which anemia and growth failure are not common.

Epidemiologic studies report that adults with IBD tend to lead a sedentary lifestyle<sup>6</sup> – a choice that may lead to reduced exercise capacity, which is an important predictor of mortality.<sup>7</sup> In adults with CD, for example, aerobic fitness – a key measure of exercise capacity – was significantly lower than values for healthy adults, suggesting a need for these patients to participate in regular physical activity.<sup>8</sup> The extent to which exercise capacity is reduced in pediatric patients with IBD and therefore the extent to which physical activity should be counseled with these patients is unknown. It is also important to understand exercise capacity in patients with CD and UC to distinguish possible effects of disease type, given the differences between these conditions in anemia and growth failure.

As part of usual care, patients with IBD from our children's hospital performed exercise tests at the Children's Exercise and Nutrition Centre, creating the opportunity to retrospectively analyze fitness data on these patients. The aim of this study was to report anaerobic and aerobic exercise capacity in pediatric patients with IBD and to determine whether there are differences between patients with CD and UC.

## Methods

Twenty-nine patients with IBD from the pediatric gastroenterology clinic of the McMaster Children's Hospital performed exercise tests to assess general fitness levels. All testing was conducted by the same clinical exercise physiologist according to

APHV	Age at peak height velocity	PP	Peak power
BMI	Body mass index	PUCAI	Pediatric ulcerative colitis activity index
CD	Crohn's disease	UC	Ulcerative colitis
FFM	Fat-free mass	$VO_{2\text{peak}}$	Peak oxygen uptake
HR	Heart rate	WAnT	Wingate anaerobic cycling test
IBD	Inflammatory bowel disease	WC	Waist circumference
MP	Mean power	$W_{\text{peak}}$	Peak aerobic mechanical power
PCDAI	Pediatric Crohn disease activity index		

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standard protocols. The results of 19 patients with CD and 10 patients with UC are included in this study, which was approved by the Hamilton Health Sciences/Faculty of Health Sciences Research Ethics Board. Both groups had similar characteristics (Table I). Disease activity was assessed by the pediatric CD (PCDAI) or ulcerative colitis (PUCAI) disease activity index.<sup>9,10</sup> Patients were in remission or had mild disease (PCDAI; mean = 6.71, range = 0 to 20 and PUCAI; mean = 0.50, range = 0 to 5). The mean disease duration in patients with CD was  $2.5 \pm 1.9$  years and in patients with UC  $3.7 \pm 2.55$  years. Time spent in remission since the last flare-up was available in 14 patients with CD and 8 patients with UC and was, respectively,  $0.8 \pm 0.9$  and  $1.3 \pm 1.1$  years (not significantly different based on independent *t* test; *P* = .23). Information on medication intake was available in 23 patients (6 CD missing), all patients were receiving medication (CD/UC: 5-aminosalicylic acid 10/8, azathioprine 6MP 7/4, methotrexate 2/1, flagyl 4/2, infliximab 2/1, prednisone 9/4, entocort 0/1). All prednisone-exposed children were treated starting with 40 mg of prednisone per day; the dose was then decreased by 5 mg per week over 8 weeks. At the time of exercise testing, recent hemoglobin concentrations were available in 22 patients (14 CD and 9 UC patients) and were  $129 \pm 17$  g/L and  $133 \pm 8$  g/L, respectively.

### Anthropometry

Height, sitting height (Harpender wall-mounted Stadiometer 2109, CMS Weighing Equipment, Ltd, London, United Kingdom), waist circumference (WC, measured 4 cm above the naval using a standard anthropometry tape), body mass (Mott electronic scale, model LC 2424, 20-g accuracy, Santa Rosa, California) and percentage body fat by bioelectrical impedance (InBody520, Biospace Co, Ltd, Seoul, Korea) were assessed. Body mass index (BMI) was calculated as  $\text{weight} \div \text{height}^2$ , BMI percentiles were calculated using Centers for Disease Control growth charts, and WC percentiles were calculated using reference values from 11- to 18-year-old Canadian children<sup>11</sup> and 9- to 10-year-old Austra-

lian children,<sup>12</sup> because Canadian WC percentiles are not available for this age group. Z-scores for BMI were calculated according to the Centers for Disease Control. Anthropometric measures and chronological age were used to estimate years from peak height velocity (PHV) according to Mirwald et al<sup>13</sup>; this value was used as a marker of biological development.

### Anaerobic Power

After the anthropometric assessment, anaerobic power of the legs was measured using the Wingate Anaerobic Cycling Test (WAnT) performed on a cycle ergometer (Metabo-Fleisch, Basel, Switzerland).<sup>14</sup> The WAnT was preceded by a 3-minute warm-up exercise (cycling at a low resistance). The warm-up was interspersed with short sprints at maximal speed. After 5 minutes of rest or when the heart rate (HR) returned to resting level (whichever came first), the test was started, with the patient pedaling at maximal speed for 30 seconds against a braking force (ie, resistance) set at  $45 \text{ g} \cdot \text{kg}^{-1}$  body mass. Two performance variables were calculated: peak mechanical power (PP), which is the highest power output (in Watts) over any 3-second period, and mean mechanical power (MP), which is the average power output (in Watts) over the 30-second test. The fatigue index was also calculated as the difference between PP and the lowest power during the test divided by PP and expressed as a percent.

### Aerobic Power

Approximately 40 minutes after the WAnT, each patient performed a graded exercise test on the same cycle ergometer (Metabo-Fleisch) to determine peak oxygen uptake ( $\text{VO}_{2\text{peak}}$ ). The McMaster All-Out Progressive Continuous Cycling Test was used with the initial work load and increments based on the patient's height.<sup>14</sup> Work load was increased every 2 minutes until the patient could no longer pedal at the prescribed cadence (50 rpm), despite strong encouragement. During the test, expired gas concentrations were continuously monitored ( $\text{Vmax}$ ; Sensormedics,

**Table I.** Patient characteristics

	n	CD		n	UC		n	Total	
		Mean ± SD			Mean ± SD			Mean ± SD	
Age (years)	19	13.9 ± 2.2		10	13.3 ± 2.6		29	13.7 ± 2.3	
Years from PHV	18	0.7 ± 1.9		8	-0.6 ± 2.1		26	0.3 ± 2.0	
APHV	18	13.5 ± 1.2		8	13.5 ± 0.7		26	13.5 ± 1.0	
Sex (F/M)	19	8/11		10	4/6		29	12/17	
Height (cm)	19	162.0 ± 13.0		10	157.4 ± 13.8		29	160.4 ± 13.2	
Sitting height (cm)	19	83.3 ± 6.9		10	80.9 ± 7.5		29	82.5 ± 7.0	
Weight (kg)	19	52.4 ± 13.1		10	47.0 ± 11.6		29	50.6 ± 12.7	
% Body fat	19	17.8 ± 9.8		10	17.1 ± 11.7		29	17.6 ± 10.3	
FFM (kg)	19	42.8 ± 10.9		10	38.6 ± 10.3		29	41.4 ± 10.7	
BMI ( $\text{kg}/\text{m}^2$ )	19	19.7 ± 3.1		10	18.7 ± 2.5		29	19.3 ± 2.9	
BMI percentile	19	43.5 ± 28.0		10	41.5 ± 22.7		29	42.8 ± 25.9	
BMI z-scores	19	-0.2 ± 1.0		10	-0.3 ± 0.6		29	-0.3 ± 0.9	
WC (cm)	19	69.9 ± 8.3		10	65.3 ± 6.8		29	68.3 ± 8.0	
WC percentile	19	56.3 ± 31.0		10	45.8 ± 24.1		29	52.7 ± 28.8	

PHV, peak height velocity.

Anaheim, California). Minute ventilation and  $O_2$  uptake were calculated and registered at intervals of 20 seconds. Heart rate was measured continuously using a Polar Vantage XL HR monitor (Polar Electro OY, Kempele, Finland). The following performance variables were calculated:  $VO_{2peak}$  ( $L \cdot \text{min}^{-1}$  and  $\text{mL} \cdot \text{kg} \text{ body mass}^{-1} \cdot \text{min}^{-1}$ ) taken as the highest 20-second value, peak aerobic mechanical power ( $W_{peak}$  in Watts and  $\text{Watts} \cdot \text{kg} \text{ body mass}^{-1}$ ) taken as the last work load achieved and prorated if the full 2-minute stage was not completed, and peak HR ( $HR_{peak}$  in  $\text{beats} \cdot \text{min}^{-1}$ ) taken as the highest HR. The clinical protocol to have the aerobic fitness test follow the anaerobic fitness test is the standard protocol in our clinic, used for patients with cystic fibrosis and those recovering from cancer, and is also used by other clinics for children with juvenile idiopathic arthritis.<sup>15</sup>

### Statistical Analyses

Peak power, MP, and  $W_{peak}$  values were compared with reference data from age- and sex-matched healthy youth provided by Bar-Or and Rowland.<sup>14</sup>  $VO_{2peak}$  values were compared with data from age- and sex-matched healthy youth tested in our laboratory. To account for the generally smaller size of patients with IBD, we also made  $VO_{2peak}$  comparisons based on age, sex, and height; however, the results were identical to matching for age and sex alone, and the former results (age- and sex-matched) are therefore presented. Using reference data generated with the same protocols, a percentage of predicted value was calculated for each exercise variable. Data were normally distributed and parametric tests were used when  $n \geq 10$ . Differences between patients with CD and UC were tested using independent-samples  $t$  tests. Differences between patients and reference data were compared using paired-samples  $t$  tests or Wilcoxon signed-rank tests when  $n < 10$ . Associations between variables were tested using Pearson correlation coefficients. An  $\alpha$  level of  $<0.05$  was considered as statistically significant. All analyses were performed using SPSS (SPSS Inc, Chicago, Illinois, version 13).

## Results

One boy with CD felt unwell after the WAnT (nausea and vomiting); therefore no aerobic power test was performed

by this patient. One girl with CD could not tolerate the mouthpiece, therefore  $VO_{2peak}$  could not be determined. All other patients completed both exercise tests without issue, and there were no unexpected events during the testing. The results of the anaerobic and aerobic exercise test (both presented as mean  $\pm$  standard deviation and as a percent of predicted for age- and sex-matched values) are shown in **Table II** and **Figures 1** and **2**.

### Anaerobic Power

As a group, anaerobic power was significantly lower in the patients compared with reference values and were 90 and 89% predicted for PP ( $\text{Watts} \cdot \text{kg}^{-1}$ ) and MP ( $\text{Watts} \cdot \text{kg}^{-1}$ ), respectively. No significant differences between patients with CD and UC were found. Given the more than 4 kg of difference in fat-free mass (FFM) between patients with CD and UC (albeit nonsignificant), we compared exercise values normalized for FFM, but no significant differences between the groups were found for PP ( $P = .10$ ) or MP ( $P = .20$ ). Given the muscle wasting effects of corticosteroids, we also compared patients using versus patients not using prednisone, but we did not find significant differences for PP ( $P = .72$ ) or MP ( $P = .19$ ). The fatigue index was not different between patients with CD and UC ( $P = .51$ ).

### Aerobic Power

The average  $HR_{peak}$  was  $186 \pm 10 \text{ beats} \cdot \text{min}^{-1}$  for patients with CD and  $189 \pm 12 \text{ beats} \cdot \text{min}^{-1}$  for patients with UC.  $RE_{R_{peak}}$  averaged  $1.15 \pm 0.05$  in patients with CD and  $1.16 \pm 0.09$  in patients with UC. These values for  $HR_{peak}$  and  $RE_{R_{peak}}$  confirm that patients provided a maximal effort.

As a group, indices of aerobic power were significantly lower in patients compared with reference values and were 91%, 75%, and 79% predicted for  $W_{peak}$  ( $\text{Watts} \cdot \text{kg}^{-1}$ ) and ( $L \cdot \text{min}^{-1}$  and  $\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ ), respectively. When patients with CD or UC were compared separately with reference values,  $W_{peak}$  was significantly lower only in the patients with CD. However, when actual values from the anaerobic and aerobic tests were compared between patients with CD and UC, no significant group differences emerged. When values were normalized for FFM, no significant group differences were found for  $W_{peak}$  ( $P = .20$ ) or  $VO_{2peak}$  ( $P = .19$ ).

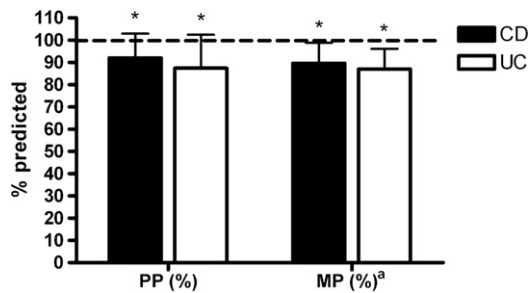
**Table II.** Anaerobic and aerobic exercise measurements

	CD		UC		Total	
	n	Mean $\pm$ SD	n	Mean $\pm$ SD	n	Mean $\pm$ SD
<b>Anaerobic power test</b>						
PP ( $\text{Watts} \cdot \text{kg}^{-1}$ )	19	$8.9 \pm 1.4^*$	10	$8.1 \pm 1.2^*$	29	$8.6 \pm 1.3^\dagger$
MP ( $\text{Watts} \cdot \text{kg}^{-1}$ ) <sup>‡</sup>	19	$6.6 \pm 1.2^*$	10	$6.2 \pm 1.0^*$	29	$6.5 \pm 1.1^*$
Fatigue index (%)	19	$46.2 \pm 10.0$	10	$43.6 \pm 10.5$	29	$45.3 \pm 10.0$
<b>Aerobic power test</b>						
$W_{peak}$ ( $\text{Watts} \cdot \text{kg}^{-1}$ )	18	$2.9 \pm 0.7^*$	10	$3.1 \pm 0.6$	28	$3.0 \pm 0.7^*$
$VO_{2peak}$ ( $L \cdot \text{min}^{-1}$ )	17	$1.9 \pm 0.6^\dagger$	10	$1.8 \pm 0.5^*$	27	$1.8 \pm 0.6^\dagger$
$VO_{2peak}$ ( $\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ )	17	$34.9 \pm 6.5^\dagger$	10	$37.8 \pm 7.7^*$	27	$36.0 \pm 7.0^\dagger$

\* $P < .05$  compared with reference values.

<sup>†</sup> $P < .001$  compared with reference values.

<sup>‡</sup>Level of significance based on CD,  $n = 11$ ; UC,  $n = 7$ .

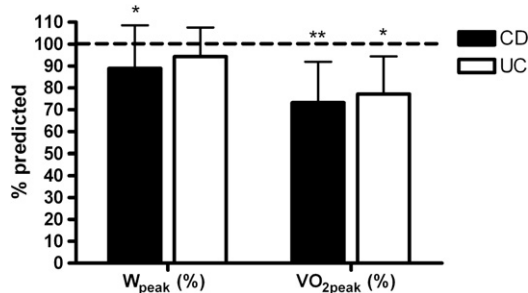


**Figure 1.** Anaerobic exercise variables as percent predicted ( $\pm$  SD). Dashed line is 100%; \* $P < .05$  compared with 100%; <sup>a</sup>reference data based on children younger than 15 years; Crohn disease,  $n = 11$ ; ulcerative colitis,  $n = 7$ .

Comparisons between patients using prednisone and not using prednisone revealed a significant difference for  $W_{\text{peak}}$  ( $P = .048$ ) but not for  $VO_{2\text{peak}}$  ( $P = .06$ ).

### Correlations

To determine whether disease duration and disease activity (measured by PCDAI or PUCAI) were associated with our indices of exercise capacity, Pearson correlational analysis was performed. No statistically significant correlations were found between any exercise variable and disease duration ( $r = 0.01$  to  $0.14$ ,  $P = .47$  to  $.95$ ) or disease activity ( $r = -0.19$  to  $-0.31$ ,  $P = .11$  to  $.38$ ). Hemoglobin concentrations, which might serve as a disease activity variable in patients with IBD,<sup>16</sup> was found to be below the age- and sex-based laboratory reference values in 5 of 22 patients (4 CD and 1 UC). Hemoglobin correlated with PP ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = 0.50$ ,  $P = .014$ ), MP ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = 0.65$ ,  $P = .001$ ),  $VO_{2\text{peak}}$  ( $\text{L}\cdot\text{min}^{-1}$ ;  $r = 0.69$ ,  $P = .001$ ),  $VO_{2\text{peak}}$  ( $\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ;  $r = 0.45$ ,  $P = .039$ ), and  $W_{\text{peak}}$  ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = 0.66$ ,  $P = .001$ ). No statistically significant difference in hemoglobin was found between patients with CD and UC. To control for the possible influence of chronological age on hemoglobin, Pearson partial correlational analysis was performed. Af-



**Figure 2.** Aerobic exercise variables as percent predicted ( $\pm$  SD). Dashed line is 100%; \* $P < .05$  compared with 100%; \*\* $P < .001$  compared with 100%.

ter controlling for age, hemoglobin remained significantly correlated with PP ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = 0.45$ ,  $P = .049$ ), MP ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = 0.63$ ,  $P = .003$ ),  $W_{\text{peak}}$  ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = .70$ ,  $P = .001$ ),  $VO_{2\text{peak}}$  ( $\text{L}\cdot\text{min}^{-1}$ ;  $r = 0.60$ ,  $P = .006$ ), and  $VO_{2\text{peak}}$  ( $\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ;  $r = 0.62$ ,  $P = .004$ ).

To determine whether patients who performed well on the WAnT also performed well on the test of aerobic power, correlational analysis was performed on these variables and found positive and significant relationships for all exercise variables ( $r = 0.45$  to  $0.85$ ,  $P = .023$  to  $.001$ ). Given the importance of muscle mass for exercise performance, we also determined the association between FFM and exercise variables. There was a strong association between FFM and PP ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = 0.66$ ,  $P = .001$ ), MP ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = 0.68$ ,  $P = .001$ ) and  $W_{\text{peak}}$  ( $\text{Watts}\cdot\text{kg}^{-1}$ ;  $r = 0.48$ ,  $P = .010$ ), and ( $\text{L}\cdot\text{min}^{-1}$ ;  $r = 0.93$ ,  $P = .001$ ).

### Discussion

Although impaired exercise capacity has been reported in adults with IBD, the extent of this problem in pediatric patients is unknown. We report that measures of both anaerobic and aerobic capacity (PP, MP,  $W_{\text{peak}}$ , and  $VO_{2\text{peak}}$ ) were significantly lower in pediatric patients with IBD compared with reference values from healthy youth, which is in accordance with previous results for aerobic capacity<sup>17</sup> and anaerobic capacity<sup>18</sup> in adults with CD. Patients with IBD that showed lower aerobic capacity were most likely also to show low anaerobic capacity, suggesting a general deficiency in exercise capacity and not an impairment in one body system (eg, cardiovascular) over another (eg, skeletal muscle).

Compared with reference values, aerobic fitness was slightly lower in patients with CD than UC; however, differences in actual values were not statistically significant between the two disease groups. Additional post hoc calculations based on our data revealed that at least 100 patients in each group would have to be tested for these results to be statistically significant with a statistical power of 80%. In light of these estimations, it is likely that the clinical approach to pediatric patients with CD or UC would not have to be different in terms of exercise testing. That aerobic fitness, as measured by the gold standard  $VO_{2\text{peak}}$ , was lower in youth with CD ( $\sim 75\%$  of predicted) is worrisome because exercise capacity is a strong indicator for the development of future cardiovascular disease risk factors.<sup>19</sup> There is strong scientific evidence that youth with low aerobic fitness are more likely to display additional risk factors for cardiovascular disease such as elevated blood pressure.<sup>20</sup> Our new findings in youth with IBD suggest that their reduced aerobic fitness make them at even greater risk for cardiovascular disease than their peers without IBD and that interventions are needed.

One possible explanation for this lower-than-predicted exercise capacity might be the low hemoglobin concentrations in the patients. We found a significant correlation between the aerobic fitness indices and hemoglobin in those patients for whom recent hemoglobin levels were available. Low

hemoglobin concentrations are a common problem in IBD. It is related to a loss of weight, low tolerance to the underlying disease, and a poor growth rate in children.<sup>21</sup> Thus, the issue of possible anemia should be more closely investigated and iron supplementation, when warranted, may be one strategy to help improve exercise endurance in these patients.

It is also possible that a lower exercise capacity could be related to increased baseline levels of inflammatory mediators (eg, tumor necrosis factor- $\alpha$ ) that characterize IBD. Tumor necrosis factor- $\alpha$  is associated with cachexia, which can lead to lower levels of aerobic capacity independent of the type of inflammatory disease.<sup>22</sup> High baseline levels of pro-inflammatory cytokines in patients with chronic heart failure and chronic obstructive pulmonary disease have been associated with an impaired exercise capacity and low anaerobic and aerobic capacity independent from the primary disease location (eg, impaired heart or lung function).<sup>23,24</sup> Although we did not measure inflammation in our patients, resting levels of pro-inflammatory cytokines in patients both in remission and with active disease have been found to be elevated<sup>25-27</sup> and might therefore be partly an explanation for the lower than predicted anaerobic and aerobic exercise values.

In this study, we found evidence that medication use could contribute to low levels of exercise capacity. Because corticosteroids are known for their myopathic effects,<sup>28</sup> we performed a comparison between patients using corticosteroids and patients not using corticosteroids. Aerobic capacity tended to be lower in patients using corticosteroids (prednisone), with a significant difference in  $W_{peak}$ . Recent studies<sup>29,30</sup> in youth with CD showed persistent deficits in lean tissue, with corticosteroid use and chronic inflammation as possible mechanisms responsible for these deficits. In our patients, FFM did not differ significantly from reference values nor were differences seen between patients on and off corticosteroids (results not shown), suggesting that impaired exercise capacity in these patients may not be related to relative differences in FFM.

Exercise training and the promotion of daily physical activity seem indicated in pediatric patients with IBD. However, no information exists about the effects of acute or chronic exercise on the underlying inflammation associated with the pathology of IBD.<sup>31</sup> High-intensity exercise might lead to gastrointestinal ischemia<sup>32</sup> because splanchnic blood flow is reduced during exercise compared with resting conditions.<sup>33</sup> Besides enhancing exercise capacity, exercise training might be a possible anabolic stimulus to decrease levels of inflammation and might therefore also have a positive effect on growth factors (eg, IGF-I).<sup>34</sup> To date, several randomized, controlled studies in various pediatric patient groups have shown improvements in exercise capacity in children with conditions ranging from cerebral palsy to cystic fibrosis.<sup>14</sup> The optimal training paradigm (sufficient efficacy without adverse effects on disease activity) for youth with IBD remains to be determined. However, our findings indicate that close clinical monitoring of markers of fitness seems warranted in youth with IBD and may serve as a surrogate

for clinical outcomes and quality of life, as reported for other pediatric conditions.<sup>35</sup>

A limitation of this study is that we did not test the complete patient population at our children's hospital. Moreover, reference values were unavailable for MP values in children older than 15 years. Therefore, our results may not be applicable to the general pediatric IBD population, particularly those with active disease. A prospective study investigating exercise capacity and its association with hemoglobin levels and inflammation in pediatric patients with IBD is warranted. In addition, the treatment of low hemoglobin concentrations with iron supplementation, when warranted, might potentially improve exercise capacity.<sup>36</sup> However, this has not yet been studied in pediatric patients with IBD.

Pediatric patients with IBD exhibited impaired aerobic and anaerobic exercise capacity even when in remission from their disease. Clinicians who specialize in pediatric IBD should consider referring patients with IBD for exercise testing and involvement of an activity therapist or physiotherapist in the clinical management of these children and youth. ■

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