Lower extremity isometric strength in children with juvenile idiopathic arthritis

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Abstract

Objective

The aim of this study was to measure lower extremity isometric strength in patients with juvenile idiopathic arthritis (JIA) and to evaluate the usefulness of an adjustable dynamometer chair in the clinical work.

Methods

Twenty-five children with JIA and 25 healthy, age-matched controls, aged 7-12 (mean age 10.1) were studied. The isometric maximal strength of knee and ankle muscles was measured on both sides using the dynamometer chair. Before and after the measurements the Children's Effort Rating Table (CERT) was used to assess physical effort and feelings of exertion during the measurements.

Results

In all the tested muscle groups, there was a trend towards lower muscle strength values in the patients with JIA but significant differences were found only in knee extension (at 80° knee angle) on both sides and in ankle plantarflexion if both ankles had had arthritis. No difference was observed in perceived exertion between patients and controls, but both groups significantly sensed the exertion after the muscle strength measurement (mean exertion before, JIA/control 2.2/2.0, and after 5.9/5.8).

Conclusion

Isometric muscle strength in children with JIA can be close to normal when the disease is not active. However, especially in knee extensors and ankle plantarflexors, muscle weakness may occur. From technical standpoint, an adjustable dynamometer chair can be used for assessment of isometric maximal strength in children with JIA.

Key words

Juvenile idiopathic arthritis, muscle strength, fixed dynamometer, CERT.

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Introduction

Juvenile idiopathic arthritis (JIA) is a chronic disease which may have a profound effect on the life of a child, although the long-term prognosis at least in 40% of the children with JIA is favorable (1) with the disease often being self-limiting. Symptoms and signs at the onset of the disease include pain, swelling, stiffness and limitation of movement of a joint and fatigue. Pain and swelling typically lead to avoidance of joint loading. (1) Long duration of active disease may also be associated with shortening of muscle and tendon length that gives rise to flexion contractures (2-4). Beunen *et al*. (5), Hendersson *et al*. (6) and Klepper (7) have shown that muscle weakness can decrease the level of physical activity in children with JIA. Muscle strength in JIA has been assessed in a few studies with different methods, *e.g*., an isokinetic dynamometry, a hand-held dynamometry (HHD) and a computerized dynamometer (2, 8-11). Lindehammar and Sandstedt (12) assessed muscle mass with ultrasound. These studies have suggested that children with JIA have reduced muscle strength. On the other hand, Öberg *et al*. (13) reported no difference in muscle strength between children with JIA and healthy controls. A dynamometer chair has been used for testing muscle strength in healthy adults (14) and adolescents with cancer (15). In our hospital, the dynamometer chair has been studied by Lehtonen *et al*. (16) in muscle strength measurements of children with cerebral palsy (CP). The advantage of a dynamometer chair compared to other methods in assessing muscle strength is that the testing position can be standardized and maximal strength can be used, as there is no upper limit for measurable force values. Moreover, testing position is neutral, which is easy for children.

The present study was carried out to examine lower extremity isometric strength in patients with juvenile idiopathic arthritis (JIA) and to evaluate the usefulness of an adjustable dynamometer chair in the clinical work.

Methods

Participants

The participants were patients with JIA at the Department of Pediatric Rheumatology, Hospital for Children and Adolescents, Helsinki University Central Hospital (HUCH), who were studied during their scheduled out-patient visits between autumn 2003 and spring 2004. JIA was diagnosed according to the revised criteria set by the International League of Associations for Rheumatology (17). Twenty-five consecutive patients that had lower extremity articular involvement with no active arthritis in the lower extremities at the time of testing were included. 16 patients (64%) had oligoarticular and 9 (36%) had polyarticular disease course (Table I). At the time of the study the activity of the disease was assessed by the erythrocyte sedimentation rate (ESR), the Childhood Health Assessment Questionnaire (CHAQ) and pain by Visual Analogue Scale (VAS) (18, 19) (Table II). The age of the patients was 7-12 years. In 13 children, both knees, and in 12 children, both ankles were affected. In 7 children the left knee and in 3 children the left ankle were affected. In 7 children the right ankle was affected. Without knee symptoms were 5 children and without ankle symptoms 3 children. All children were without hip symptoms. All children were on anti-rheumatic medication (Table I). Intra-articular steroids had also been used during the active phase of the disease. None of the children had neurological problems or a history of gross motor delay. A control group of 25 age-, height-, weight- and gender-matched healthy children, most of them children of HUCH hospital staff members were chosen as controls (Table II). Frequency of physiotherapy in patients with JIA and frequency of leisure time sport activity in the patients and controls were collected with a questionnaire.

Procedure

A dynamometer chair (Good Strength, Metitur Ltd, Finland; www.metitur.com) (Fig. 1) was used to measure maximal isometric strength. The system consists of an adjustable chair with arm and leg supports to which strain gauge transducers are attached, an amplifier, an analog/digital converter (sampling frequency 100 Hz) and a personal computer (PC)

Table I. Characteristics of the patients with JIA.

Characteristics	Oligoarthritis (n=16)	Polyarthritis (n=9)
Gender, Male/Female	11/5	4/5
Duration of the disease, years*	6.2 (2.9)	3.2 (3)
Medication		
Nonsteroidal anti-inflammatory drugs	6/16	6/9
Hydroxychloroquine	5/16	2/9
Prednisolone	4/16	4/9
Tumor necrosis factor inhibitor	0/16	3/9
Methotrexate	10/16	8/9
Physiotherapy, times/week*	0.6 (0.5)	0.8 (0.7)

*Values are mean (±SD).

Table II. Characteristics of the patients with JIA and controls.

Characteristics	JIA group (n=25)	Control group (n=25)
Age, year	10.0 (1.7)	10.1 (1.5)
Gender, Male/Female	15/10	18/7
Height, cm	138 (0.1)	142 (0.1)
Weight, kg	35 (11.6)	35 (7.2)
BMI	17 (3.5)	17 (1.7)
CHAQ	0.13 (0.2)	
VAS	0.9 (0.01)	
ESR, mm/h	12 (6)	
Sport activity, times/week	0.8 (1.4)*	1.8 (1.5)
Physiotherapy, times/week	0.7 (0.5)	

Values are mean (±SD). Physiotherapy time of session ranged from 45 to 60 min. and sport activity from 45 to 90 min.
*p<0.05 between JIA patients and controls.

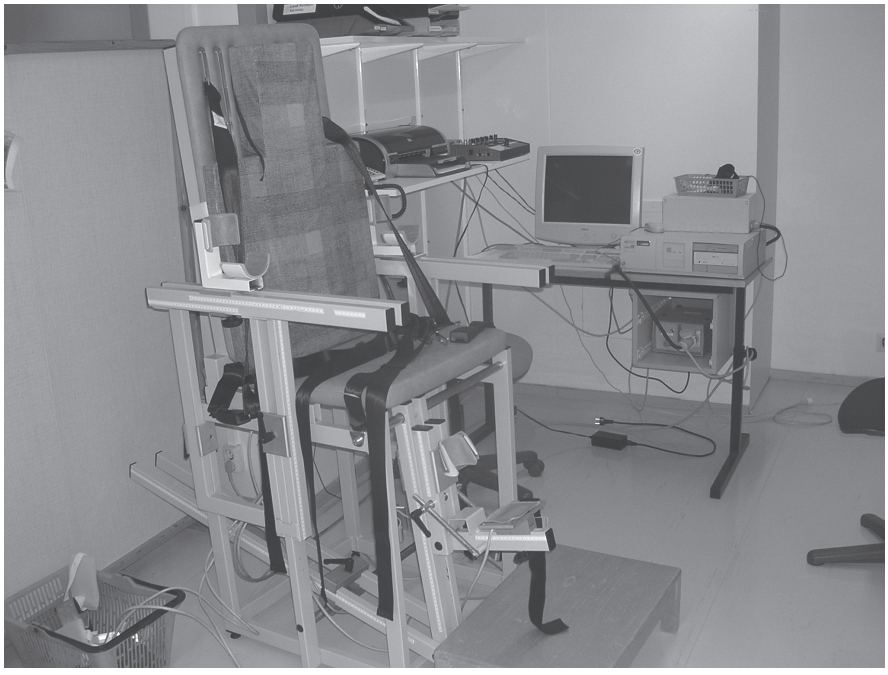

Fig 1. Good Strength dynamometer chair (Metitur Ltd., Finland), with ankle support and strain gauge.

for analyzing and storing the results. The test-retest reliability of this dynamometer chair in strength measurements of children with cerebral palsy (CP) showed correlations of r=0.89 - 0.97 (16). In healthy children knee extension at 80°, knee flexion and ankle plantarflexion test-retest correlations ranged from r=0.71 to 0.76 and knee extension at 30° ankle dorsiflexion ranged from r=0.83 to 0.89. In the present study, the isometric strength of knee extension and flexion and ankle dorsiflexion and plantarflexion were measured. The measurements in the control group were first performed by two examiners (JS and KL) to confirm reliability and reproducibility of the testing. Thereafter, the measurements in the JIA group were performed by one examiner (JS).

Before and after the measurements the Children's Effort Rating Table (CERT) (20) was used to assess physical effort and feelings of exertion. A variety of scales have been developed in an attempt to assess perceived exertion and CERT is validated for young children. The CERT is an illustrated perceived exertion 1-10 scale and it is an adaptation of the Borg Category-Ratio Rating of Perceived Exertion Scale (21-24).

Muscle strength

Maximal isometric strength (MVC, maximal voluntary contraction) was measured from both sides in a sitting position. The position was fixed using an adjustable belt around the pelvis and over the knees. The arms were held over the lap. Knee extension (KE) was measured in two positions, knee flexed at 80° (KE80°) and 30° (KE30°) from full extension. Knee flexion (KF) was measured as the knee flexed at 80° from full extension and ankle plantarflexion (APF) and ankle dorsiflexion (ADF) were measured with the knee in an 80° flexion and the ankle in the mid-position (90°). The ankle was fixed with two padded straps, one over the midfoot and one around the ankle above the malleoli. When measuring the knee, the strain gauge transducer was positioned 5 cm above the calcaneus and fixed with a padded strap. After practicing the movement, there were three trials, each lasting 6 sec., with a

30-sec. resting period between the trials. The subjects were encouraged to produce the force as rapidly as possible and relax instantly when told. In addition, encouragement was given during the trial. All the forces were recorded as a force-time curve on a computer. The best result from the three trials was used in the analyses. The results are given as Newton units (N).

Statistical analysis

All the analyses were performed with SPSS 11.5 for Windows. T-tests were used in the group comparisons and Wilcoxon Signed Ranks Test was used in the comparisons of the affected joints.

Ethical considerations

The Research Ethics Committee at the HUCH Hospital for Children and Adolescents approved this study. Written informed consent was obtained before participation from the children's parents, together with verbal consent from the children.

Results

Differences in muscle strength between the children with JIA and the controls

There was no difference in muscle strengths between patients with oligo- or polyarthritis. Subsequently, all patients with JIA were grouped together. Maximal muscle strength in both sides knee extension at 80° (KE80°) was significantly lower in the children with JIA than in the controls (p=0.04, Fig. 2a). Knee extensors and ankle plantarflexors were relatively stronger compared to their antagonists in both groups. In the children with JIA and the controls, the ratio was approximately 2/1 in both joints. In both the JIA and control groups, the mean strength values in all muscle groups tended to be higher on the right side compared to the left side (Table III, Fig. 2), but the differences were not significant. In all the tested muscle groups, there was a trend towards lower muscle strength values in the children with JIA, except in the right APF, but the differences were not significant.

In the JIA patients, the maximal muscle strength was reduced in ankles when both ankles were affected compared to the control group (p=0.006). There were no significant differences in the knee extensor and flexor strengths when both knees were affected compared to the control group (p=0.1).

The children's perceived exertion

There was no significant difference in perceived exertion between groups, but there was a highly significant difference (p<0.001) in perceived exertion in both groups before and after measurements (Table IV).

Discussion

The present study focused on evaluating muscle strength in children with JIA on a fixed dynamometer chair. The results indicate that the muscle strength in children with JIA when tested in inactive stage of the disease may be normal or close to normal. Lower muscle strength in patients with JIA was found only in the knee extension at 80° and in ankle plantarflexion if both ankles had had arthritis.

In the majority of previous studies, knee extension only was analyzed. Lindehammar and Bäckman (9) found reduced strength in the muscles with an inflamed joint, the strength being 45-65% of the expected value. In the muscles without an adjacent arthritis, the strength was slightly decreased, 80-90% of the expected value. The expected levels were derived from a previously established database for force in healthy children (25). They measured the isometric strength of knee extensors with a HHD and the knee in full extension. In another study the strength was measured in isometric knee extension but with a computerized dynamometer and at a knee angle of 60° (8). They also found reduced strength in the knee extensors. Vostrejs and Hollister (2) found localized muscle weakness and atrophy when using manual muscle testing and an isokinetic dynamometer. Using ultrasound, Lindehammar and Sandstedt (12) reported that the quadriceps muscles of the children with JIA were "thinner" than normal, irrespective of activity of knee inflammation. Their findings for peak isometric knee extension force, recorded every third month for two years, indicated muscle weakness. Opposite to these findings, Öberg *et al*. (13) found no difference in muscle strength between children with JIA and healthy children before or after training. Both groups showed the same trainability with regard to muscle strength. In the patient group, however, there was a reduced electromyographic response pattern to muscle fatigue that showed a tendency towards normalization after training. Concerning knee extensors the present results seem to concur with a previous study showing slightly decreased muscle strength as reported in muscles without an adjacent arthritis by Lindehammar and Bäckman (9). It can be speculated that differences in the methods used and in the patient characteristics, especially in the activity of the disease in these studies account for the minor discrepancies of the results.

Interestingly, when we compared both ankles, reduced strength in muscles of ankles was observed only when both ankles were affected. A recent study by Broström *et al*. (11) with isokinetic

Table III. Mean muscle strength values as Newton units in the JIA and control groups in knee extension 80º (KE 80º) and 30º (KE 30º), knee flexion (KF), ankle plantarflexion (APF) and ankle dorsiflexion (ADF).

Muscle groups	JIA (n=25)		Control group (n=25)	
	Right	Left	Right	Left
KE 80°	215.9 (73)*	205.7 (68)*	259.6 (72)	245.1 (60)
KE 30°	128.0 (40)	120.0 (45)	136.7 (37)	134.4 (34)
KF	117.0 (35)	113.0 (34)	122.4 (32)	114.1 (28)
APF	298.7 (172)	240.4 (116)	294.8 (105)	280.5 (91)
ADF	131.0 (38)	125.9 (40)	136.3 (26)	134.3 (28)

Values are mean (±SD).
* p<0.05 between JIA patients and controls.

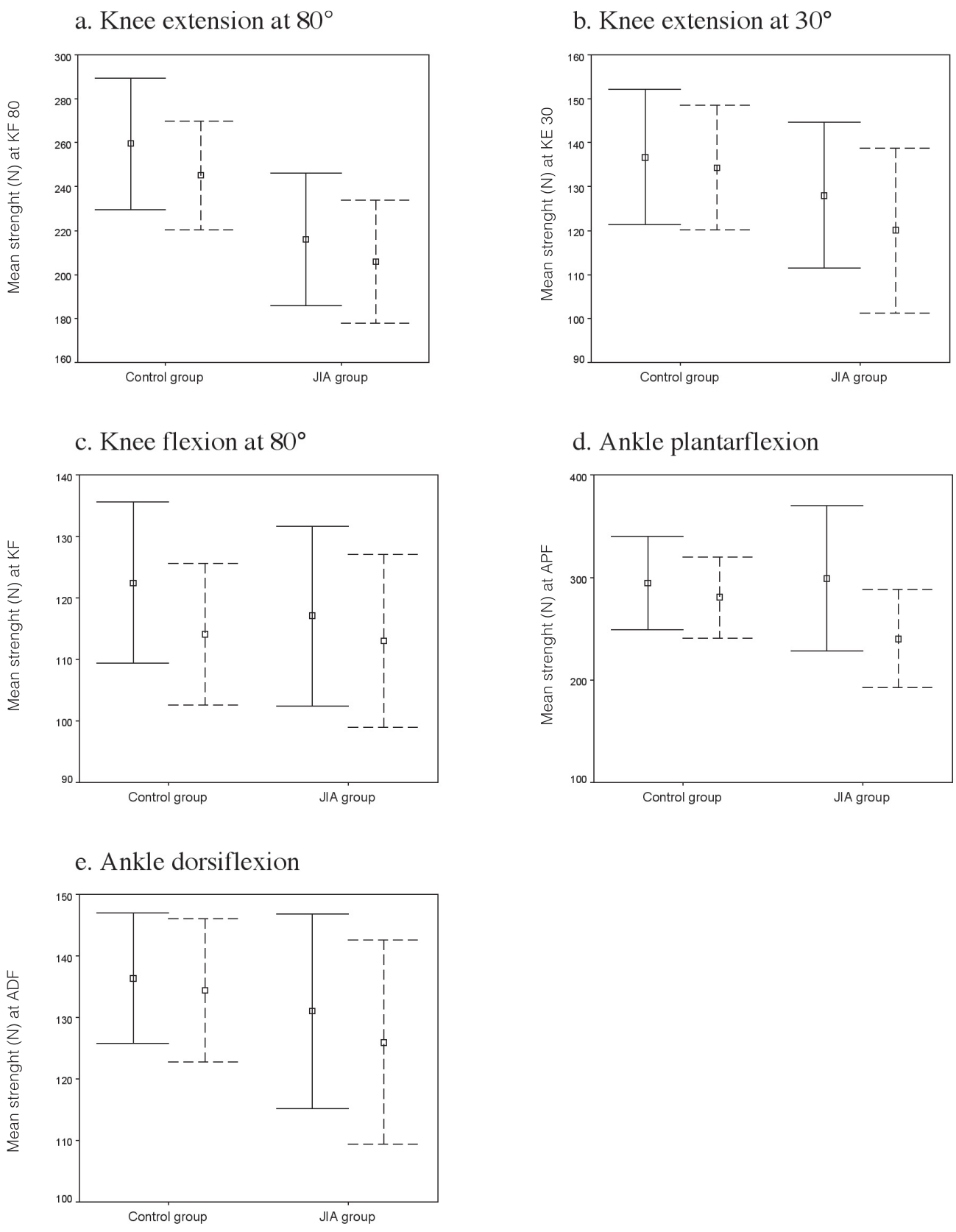

Fig 2. Muscle strength values as Newton units (N) (mean ±95% confidence intervals) in the right (straight line) and left (broken line) lower extremity in knee extension 80° (**a**), knee extension 30° (**b**), knee flexion 80° (**c**), ankle plantarflexion (**d**) and ankle dorsiflexion (**e**). 25 patients with JIA and 25 controls were examined.

Table IV. Perceived exertion before and after measurement assessed by CERT.

	Before	After
JIA group (n=24)	2.2 (1.2)	6 (1.6)
Control group (n=22)	2.0 (0.9)	5.9 (1.3)

Values are mean (±SD) on 1-10 scale.

dynamometry of the left lower extremity showed that isometric plantar- and dorsiflexion torques were significantly lower (48% and 38%, respectively) in the children with JIA than in the controls. The JIA group also produced lower shortening in the plantarflexion, whereas the lengthening plantarflexor torques did not differ significantly between the two groups. All children were four to five times stronger in plantarflexion than in dorsiflexion. Hedengren *et al*. (10) reported that the plantarflexor strengths in the children with JIA and in healthy controls were approximately 30% to 35% greater than that of the dorsiflexors. They used isometric measurements of the plantar- and dorsiflexors with a HHD and only the right lower extremity was tested. In keeping with those results we noticed that knee extensors and ankle plantar flexors were relatively stronger compared to their antagonists both in patients with JIA and healthy controls.

Muscle strength is also dependent on the child's motivation and co-operation. During or after the measurement none of the children reported any pain or discomfort. Isometric strength measurement could be theoretically more reliable than isokinetic measurement for patients with arthritis because in the former there is no or only slight motion of the joint during examination, and it is therefore less dependent on joint pain or stiffness. Lehtonen *et al*. (16) showed that with the same measurement system in the children with CP, the reliability was high to excellent. However, when strength is tested in a supported sitting position with the hips flexed, as was done in this study, children can lean against the back of the chair and use compensatory supportive movements. This could be overcome by changing the testing position, taking away the back support or changing the knee angle in ankle measurement. Although a good fixation was used, ankle plantarflexion was still difficult to control and the plantarflexion was difficult for the children to perform without lifting the heel. For clinical use, because of the size of the dynamometer chair, a separate testing room in close proximity to the clinic would be desirable.

Many factors may reduce muscle strength in children with JIA, *e.g*., inactivation of muscles due to reflex inhibition near an inflamed joint. Reduced physical activity may increase muscle weakness. In clinical practice, effective anti-rheumatic drugs can be used to suppress inflammation, which allow children with JIA to regain their normal physical activity and keep up a good muscle condition. In this study the children with JIA had near to normal or normal lower extremity isometric strength. Regardless of the finding that controls were two times more physically active compared to the patients with JIA, muscle strength between these two groups did not differ appreciably. We submit that this is a reflexion of good general health and low or no inflammation in our patient population even with relatively lower physical activity levels in comparison with healthy peers. Children had no active arthritis in the lower extremities at the time of testing, because we felt that heavy muscular exertion during an active arthritis would not necessarily provide reliable results. Besides, recommendations for long-term muscle training, if needed, should usually be based on a more stable situation.

In conclusion, muscle strength in children with JIA can be near to normal when the disease is not active. Compared to a method that evaluates one joint only bilateral, isometric multilevel (knee and ankle) muscle strength testing using a dynamometer chair provides more comprehensive information of muscle strength in children with JIA. Because the sensitivity to change over time of this method is currently not known, the usefulness of the method in early recognition of functional limitations and for planning and follow-up of training programs should be studied prospectively.

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