University Of Alberta

The Relationship Between Knee Strength and Lower Limb Function in Females with Juvenile Arthritis

by

Jean Shun-Wai Fan

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

Department of Physical Therapy

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled *The Relationship Between Knee Strength and Lower Limb Function in Females with Juvenile Arthritis* by *Jean Shun-Wai Fan* in partial fulfillment of the requirements for the degree of Master of Science.

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Janet Ellsworth, MD

September 27, 1996

DEDICATION

- To David -
for being my '24 hour help desk',
and especially for his loving support at all times

- To my parents, Louis and Esther -
for instilling in me a continuous desire to learn

ABSTRACT

The purpose of this study was to describe the relationship between isokinetic quadriceps strength and function in females with juvenile arthritis (JA).

Twenty girls with JA aged 6 to 16 years participated in the study. Function and strength were measured on one occasion. Isokinetic concentric and eccentric quadriceps torque was measured on the Kin-Com. Function was measured on the Childhood Health Assessment Questionnaire and a 50 metre (m) run. Pain and joint count were taken as measures of disease activity. Correlations between function, strength, pain and joint count were determined. Multiple regression analyses with function as the predicted variable were performed.

Correlations between torque and CHAQ scores were moderate. Correlations between torque and run scores were also moderate. Pain and total joint count were the best predictors of CHAQ score while concentric torque was the best predictor of running ability. Quadriceps strength and lower extremity function are moderately related in girls with JA.

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Chapter 1

INTRODUCTION

Juvenile arthritis (JA) is the most common paediatric rheumatic disease and is an important cause of childhood disability in the United States [1]. The prevalence of JA is estimated at 113.4 cases per 100,000 U.S. Children [2].

Muscle weakness and functional disability are known consequences of JA [3-5]. Giannini and Protas [4] found that children with JA had significantly decreased isometric knee extensor strength when compared to controls matched for age, sex and body surface area. Muscle weakness is thought to be secondary to a multitude of factors including joint pain, stiffness, disuse, synovitis, joint deformities, isolation and enforced limitations of physical activity by parents and school personnel [4]. Gare and Fasth [6] report that 60% of all children with juvenile chronic arthritis (JCA) (includes juvenile rheumatoid arthritis, juvenile ankylosing spondylitis, juvenile psoriatic arthritis, and inflammatory bowel disease) experience some functional difficulties even when many mild cases are included.

A primary focus of physical therapy intervention in this population is to improve and maintain muscle strength [7-10]. The goal is for each child to reach his/her maximum potential in order to minimize functional difficulties [7-10]. Strength measurements are often the only method used to evaluate effectiveness of strengthening programs. If the ultimate goal of strengthening programs is the restoration of maximal function, the measurement of function should also be used to evaluate these programs

[11]. It has been suggested that the most important inference that can be made from the evaluation of strength is whether strength measurements can be used to predict function [12, 13].

Strengthening programs with the goal of improving functional performance are widely accepted as necessary approaches to the rehabilitation of a child with a diagnosis of JA [5, 7-10]. However, no studies have related muscle strength to function in children with JA. The purpose of this study was to determine the relationship between muscle strength and functional performance in children with JA.

1.1 Objectives

The primary objective of this study was to determine the relationship between isokinetic knee extension torque and performance on the Childhood Health Assessment Questionnaire (CHAQ) and a 50 metre (m) run in children with JA. The hypothesis tested was that peak knee extension torque would be negatively correlated to performance on the functional measures.

The secondary objective was to determine which type of muscle contraction, concentric versus eccentric, was more highly correlated to function. With the functional assessments used in this study, the hypothesis was that concentric muscle torque would be more strongly related to functional performance than eccentric muscle torque as most of the items on the functional assessments required concentric muscle action.

1.2 Definitions

- Juvenile arthritis
  A syndrome of closely related host responses characterized primarily by idiopathic peripheral arthritis for at least 6 weeks [9, 14].

- Systemic JA
  Arthritis onset marked by fever for at least 2 weeks and an erythematous rash [14].

- Polyarthritic JA
  Arthritis affecting 5 or more joints during the first 6 months of the disease [14]. Two groups of polyarthritis exist: a) Rheumatoid Factor Negative and b) Rheumatoid Factor Positive.

- Oligoarthritic JA
  Arthritis affecting one to four joints during the first 6 months of the disease [14].

- Extended oligoarthritic JA
  Arthritis affecting one to four joints during the first 6 months of the disease, and a cumulative total of 5 joints or more after the first 6 months of the disease [14].

- Enthesitis related arthritis
  Arthritis and enthesitis (tenderness at the point of insertion of tendon, ligament, joint capsule or fascia into bone) [14].

- Psoriatic arthritis
  Arthritis and psoriasis (diagnosed by a dermatologist) [14].

- Isokinetic
  Movement of a limb segment at a constant angular speed [15].

- Torque
  Force times the perpendicular distance from the axis of rotation [15].

1.3 Limitations

- Results will only indicate a relationship between strength and function, they will not determine if function can be altered by a change in strength.
- Reliability and validity of isokinetic torque measurement has not been specifically determined in children with juvenile arthritis, although isokinetic torque measurement has been found to be reliable and valid in healthy children and in adults with rheumatoid arthritis.
- Measurements were performed on one day only. The assumption is that this is representative of the child's strength and function.

1.4 Delimitations

- Results will be applicable only to females with juvenile arthritis aged 6 to 16 years.
- Results will most likely reflect functional abilities and strength measurements of girls with juvenile arthritis who are followed by tertiary care facilities.
- Results will only indicate how functional abilities are related to one muscle group, the quadriceps.

Chapter 2

LITERATURE REVIEW

2.1 Juvenile arthritis

Juvenile arthritis is a rheumatic disease occurring in childhood. It is characterized by idiopathic peripheral joint inflammation [9]. Etiology remains unknown, but a variety of possible causes have been identified, including infection, autoimmunity, trauma, stress, and genetic disposition [1]. Specific criteria have been established for the diagnosis of JA, including criteria set by the American College of Rheumatology (ACR) [9], the European League Against Rheumatism (EULAR) [3], and more recently, the International League of Associations for Rheumatology (ILAR) [14]. Although some differences in criteria exist between the definitions, several classes of JA have been identified, including systemic arthritis, polyarthritis, oligoarthritis, psoriatic arthritis, and enthesitis related arthritis. These have been defined in Chapter 1.

Arthritis can occur in any joint, but is most commonly seen in the larger joints [1]. Inflammation in the joint results in swelling, erythema, heat, pain and loss of function for children with JA [1]. Swelling in JA is usually due to intra-articular effusion or hypertrophy of the synovial membrane, although periarticular soft tissue swelling may also occur [1]. Pain usually occurs with movement at the extremes of the range of movement [1]. This can result in the avoidance of movement of involved joints.

Muscle weakness can occur secondary to pain and disuse [1]. Shortening of flexion tendons and non-specific myositis may also contribute to muscle weakness [1].

Stiffness in the joint, deformities and protein-energy malnutrition have also been noted to contribute to strength loss in children with JA [4].

Loss of function is well documented in children with JA. On a functional assessment developed by Howe et al. [16], children with JA showed significantly higher disability than healthy children. Singh et al. [17] found similar results when using the Childhood Health Assessment Questionnaire.

Although muscle weakness and functional disability have both been documented in children with JA, it has not been determined whether muscle weakness leads to functional disability, or vice versa.

2.2 Relationship between strength and function in children

Although no evaluations of the relationship between strength and function in children with JA have been performed, studies have shown relationships between lower extremity strength and gross motor function and mobility in children and adolescents with cerebral palsy (CP) [18] and meningomyelocele [19]. McDonald et al. [19] found that specific muscle strength accounted for 86 per cent of the observed variance in mobility in children with meningomyelocele. Kramer and MacPhail [18] found that walking efficiency and gross motor ability was modestly related to peak knee extension torque in adolescents with CP ($r=0.49-0.68$, $p<0.01-0.05$). The authors concluded that this relationship between strength and function suggests that inadequate knee extensor strength may be one of the factors limiting functional abilities in adolescents with CP.

Two recent studies examining the effects of resistive strengthening exercises on children with CP found some improvement in function after quadriceps and hamstrings strengthening programs [20, 21]. MacPhail & Kramer [20] reported that gross motor function as measured on the Gross Motor Function Measure (GMFM) improved in 9 of 17 subjects after an eight week isokinetic muscle strengthening program. Damiano et al. [21] also reported improvements in gait including less crouch at initial contact and increased stride length in children who participated in a six week isotonic strengthening program. Results from these studies further support the hypothesis that quadriceps muscle strength is related to function.

2.3 Relationship between strength and function in rheumatoid arthritis

Little has been written regarding the relationship between strength and functional performance in adults with rheumatoid arthritis (RA). One study revealed that the peak isokinetic torques of knee extension at 30°, 60°, and 120°/s were correlated to both walking speed ($r=0.50-0.51$, $p<0.01$) and a climbing test ($r=0.64$, $p<0.01-0.05$) [22]. Peak isokinetic plantar flexion torque was also correlated with both walking speed ($r=0.57$, $p<0.01$) and the climbing test ($r=0.69-0.74$, $p<0.001$). In a study determining the safety and effectiveness of isokinetic concentric knee extension training in adults with RA, Lyngberg et al. [23] found that patients experienced functional improvements after the training. The improvements in function were measured by patient self-report on whether function had improved in four areas. No standardized functional assessment was used in either of the studies. Functional disability as determined by two self-report questionnaires was found to be correlated to various measures of impairment in RA including the erosive state of the joint disease and grip strength [24]. No lower extremity strength correlations were examined in this study even though both self-report questionnaires included activities of daily living which were primarily lower extremity activities, for example, walking.

2.4 Measuring function in children with JA

The importance of measuring functional performance in children with JA has been recognized. Several tools have been developed to meet this need [16, 17, 25-30]. However, studies thus far have not endeavoured to demonstrate a relationship between lower extremity strength and functional performance. During the development of the tools, function was related to measures including number of joints involved, disease activity, Steinbrocker functional class, pain, disease duration and morning stiffness [16, 17, 27, 31]. Function has been found to be related to the above measures of disease except disease duration.

Although functional disability has been noted through the use of measures developed specifically for JA, many children with JA experience only minimal disability as measured on the functional scales [16, 17, 31]. With a possible total score of 46 on the Juvenile Arthritis Functional Assessment Report (JAFAR) [16] indicating highest level of disability, fifty per cent of children with JA had scores of less than or equal to 2, indicating minimal disability. The mean score on the JAFAR was 4.4 for children with JA. Similarly, children with JA had a mean score of 0.84 (highest disability score =3.0) on the Childhood Health Assessment Questionnaire (CHAQ) [17] and a mean of 0.33 on a Swedish version of the CHAQ [31].

Present functional measures are sensitive enough to classify children according to disease severity [16, 17, 31], but their ability to determine disability in mildly affected children may be limited. Gare & Fasth [6] reported that children with JCA had difficulty participating in physical education even when they did not report any other problems with activities of daily living. Because many recreational activities of childhood involve skills required for physical education, children with mild disability may experience limitations not related to the functional skills assessed on tools traditionally used for the assessment of function in children with JA.

2.4.1 Childhood Health Assessment Questionnaire (CHAQ)

The CHAQ is an adaptation of the Stanford HAQ, a tool developed for the assessment of function in adults with RA [17]. The CHAQ includes the Disability and Discomfort scales of the HAQ. New questions were developed for each functional area to make the questionnaire more applicable to children of all ages (Appendix A). It was developed on 72 children with JA aged 1 to 19 years with a control group of 22 healthy children aged 1 to 17. The controls all scored 0 (no disability) on both the Disability and Discomfort Indexes. Internal reliability as measured by Cronbach's alpha was 0.94. Convergent validity of the Disability Index was demonstrated by strong positive correlations to the Steinbrocker functional class, number of involved joints, physician's assessment of disease activity, and morning stiffness. Test-retest scores were strongly correlated (Spearman's r=0.79, p<0.002).

2.4.2 *Pain assessment*

The visual analog scale (VAS) is a valid and reliable measure of pain intensity in children both as a self- and parent-report measure [32]. It has been widely used with children with JA [16, 17, 27, 33-36]. Children above the age of five have been able to complete the VAS without difficulty [33, 34]. Scott et al. [34] found the failure rate was only 11% when children with JA aged 2 - 17 years were asked to complete a VAS. Most of the children who were unable to complete the VAS were under the age of 5.

Parent and child reports of pain using a VAS have been found to be significantly related and not significantly different. Parent report of pain was significantly related to pain reported by children (r=0.35, p=0.01) [33]. Howe et al. [16] reported no significant difference between parent and child reports of pain intensity (Z=0.69, p=0.49).

Most studies report that pain intensity is relatively low in children with JA [33, 34, Vandvik, 1990 #55]. However, one study found that older children (≥ 12 years) reported a significantly higher pain intensity than younger children [37].

2.4.3 *Fifty metre (m) run*

The 50 m run is a test of strength, power, and agility on the Canada Fitness Award program [38]. Norms for each age group and sex were determined by testing 10,000 randomly selected Canadian students. The participants were ranked according to the level of achievement: 1=excellence, 2=gold, 3=silver, 4=bronze. No reliability data was available for the run, but reliability coefficients for a 50 yard dash were 0.83-0.90 [39]. Test-retest reliability was performed on the first 15 participants in this study, with excellent reliability (intraclass correlation (ICC)=0.99 (Appendix B)) [40].

2.5 Measurement of strength

The Kin-Com has been found to be reliable and valid for the measurement of force produced by known weights and by human subjects. Mayhew et al. [41] reported that the Kin-Com is a highly reliable and valid instrument for the measurement of force produced by known weights. Agreement between force measurements of known weights repeated on the same day and over two days was excellent (ICC=0.99). The Kin-Com has been used to measure peak isometric torque in children with JA [4], and Wessel and Galbraith [42] reported that the Kin-Com was reliable for the measurement of isokinetic knee extension torque in women with RA. The Kin-Com has been shown to be reliable for the measurement of peak isokinetic knee extension torque in pre-adolescent males aged 10-12 years [13]. There is no information available on the reliability of the Kin-Com in children less than 10 years of age. However, isokinetic measurement of knee extension strength on the Cybex II and the Lido Active has been found to be reliable in children aged 7 - 15 years [43] and 6 - 8 years [44].

2.6 Concentric and eccentric muscle strength

Both concentric, or muscle shortening actions, and eccentric, or muscle lengthening actions, can be evaluated isokinetically. It has been reported consistently that eccentric knee extension muscle strength is greater than concentric muscle strength [13, 18, 45, 46].

In evaluating the relationship between the two types of muscle action and functional performance, Kramer and MacPhail [18] found that concentric knee extension torque was more highly related to gross motor ability in adolescents with CP than eccentric knee extension torque. They suggest that concentric capability may be the limiting factor in many functional activities.

2.7 Summary

In conclusion, it is clear that little is known regarding the relationship between lower extremity strength and functional performance in children with JA. Studies in this area suggest that a relationship exists between strength and function in children with meningomyelocele and CP and adults with RA. Because strengthening regimens are commonly recommended for children with JA in hopes of improving functional abilities, it is important to determine whether a relationship exists between strength and function.

Chapter 3

METHODS

3.1 Study participants

Females aged 6 to 17 with a diagnosis of JA according to the International League of Associations for Rheumatology (ILAR) criteria [14] were included in the study (Appendix C), excluding those with enthesitis-related and psoriatic arthritis. Children who had arthritis in any lower extremity joint were included in the study. Exclusion criteria included children who had:

1. active systemic disease, determined by the presence of fever >38.5°C for two days in the past week,
2. a knee flexion contracture of greater than or equal to 20° in either leg,
3. severe knee pain during manual muscle strength testing,
4. been receiving corticosteroid medication, or
5. those who had received an intra-articular knee injection in the past 6 months.

All children followed through the Glenrose Rehabilitation Hospital (GRH) or the British Columbia's Children's Hospital (BCCH) and who met the inclusion criteria were contacted regarding the study. Ethical approval from both institutions was received prior to subject recruitment.

3.2 Study design

This was a cross-sectional study. Strength and function were measured during the same appointment. Written consent from the child and her parent was obtained before any testing was initiated (Appendix D & E). Examination of active joints was performed while the child's parent filled out the CHAQ. The child indicated the amount of pain she experienced during the past week and the amount of pain she was experiencing on the day of testing using two visual analog scales (VAS). The child was then timed on the 50 m run prior to strength testing. Functional assessment and joint assessment was performed by one therapist and strength testing by another.

3.3 Variables measured

Demographic information including age, height, weight, disease type, frequency of regular physical therapy treatment, and current medications was collected.

The independent variables were average isokinetic concentric and eccentric knee extension torque. Knee extension concentric and eccentric torque was the average torque in Newton metres (Nm) from four maximal efforts for the two legs. Average torque was standardized by dividing it by the child's weight [18, 44]. Knee extension torque was chosen because the knee is the most commonly affected joint in JA [7]. Knee inflammation results in weakness of the knee extensors. Giannini and Protas [4] suggest that knee extension weakness may also result from inactivity and disuse when other lower extremity joints are inflamed.

The dependent variable was functional performance as determined by the CHAQ and the 50 metre run.

Possible intervening variables measured included joint count and pain. These were considered measures of disease severity. Disease duration was not included because it has not been found to be highly related to function in these children. The joint count was the total number of active joints. A joint with swelling alone, or with limitation of motion as well as pain and tenderness was determined as active [14]. Both the total body joint count and the total lower extremity joint count were presented. Pain intensity was assessed using self- and parent-report on visual analog scales.

3.4 Strength assessment protocol

The Kin-Com was calibrated according to manufacturer's specifications prior to use. Angle, speed and force calibrations were performed. Subjects were positioned in prone over a small roll on the Kin-Com (Figure 3.1). The child's thigh and buttocks were strapped for stabilization. The anatomical axis of rotation for the knee joint (lateral epicondyle) was aligned with the rotational axis of the dynamometer. A pen was placed into a hole at the mechanical axis of the lever arm in orc ovide an easy reference with which to align the lateral epicondyle of the subject. The resistance pad was placed just above the malleoli on the anterior aspect of the lower leg while still allowing full ankle dorsiflexion. Velocity was set at 60°/s. The minimal forward force (force required to start the concentric portion of the test) was set at 20 Newtons (N) and the minimal backward force (force required to start the eccentric portion of the test) was set at 40 N

(Appendix F). Only two girls were unable to produce the necessary forces to start the test. The minimal forces were adjusted for them. Gravity correction was employed, with the limb weight measured with the knee flexed 20°. A level was used to ensure that the lever arm was correctly placed at horizontal prior to gravity correction procedures.

The subjects performed a concentric contraction from 110° knee flexion to 20° knee flexion followed by a 5 second rest before performing an eccentric contraction through the same range, starting at 20° knee flexion. The child was given two submaximal practices and two maximal effort practices in order to familiarize themselves with the Kin-Com. A safety switch was given to the subjects. Each child was given verbal encouragement during the testing. No visual feedback was given during the testing. Four trials were performed on each lower extremity. The testing sequence of the extremities was randomized.

Figure 3.1: Subject position on the Kin-Com

3.5 Childhood Health Assessment Questionnaire

Functional performance and pain was measured on the CHAQ [17]. Parents were asked to rate the child's ability to perform activities in 8 categories: Dressing and Grooming, Arising, Eating, Walking, Hygiene, Reach, Grip, and Activities. The total score, or Disability Index, was the average of the scores for each of the 8 functional areas. Possible scores ranged from 0 to 3, with 3 representing the most disability. A lower extremity CHAQ score was also determined by averaging the scores for four areas: rising, walking, hygiene and activities. This was of interest as quadriceps strength would presumably be more highly correlated to activities involving the lower extremities. This CHAQ score was interpreted with caution as the test was not developed to be used in this manner.

3.6 Pain assessment

Pain was assessed on a visual analog scale (VAS) by parents and subjects. Parents reported pain intensity on the Discomfort portion of the CHAQ (Appendix G). This portion consists of a 15 cm doubly anchored horizontal VAS with "no pain" and "very severe pain" as the anchors. The parents were asked to mark a line to indicate their child's pain level in the past week. The children were asked to indicate their pain level on two separate visual analog scales, one indicating the amount of pain experienced in the past week, and the other indicating the amount of pain experienced on the day of testing (Appendix H). These visual analog scales were identical to the scale used by the parents. The distance between the left anchor and the mark was measured in centimetres and multiplied by 0.2, as described by the CHAQ developers, giving a Discomfort Index value between 0-3.

3.7 Canada fitness award: 50 metre run

The 50 m run was chosen as an additional measure of function because many children who are mildly affected by JA express difficulties with participation in physical education [6]. Ability to run as fast as their peers may be one of the limiting factors to their participation.

Participants were asked to run as fast as they could for 50 m. They were timed with a stopwatch to the nearest tenth of a second. The girls were ranked according to the Canada fitness award guidelines (Appendix I). The rankings included: 1 = excellence, 2 = gold, 3 = silver, 4 = bronze. A fifth rank (5 = below bronze) was added for the present study as most of the girls did not run fast enough for a ranking of 4.

3.8 Analyses

Descriptive analyses were performed on all measures. Because the number of children who chose not to participate was high, the participants and non-participants were compared on age and disease type. A t-test was used to determine if the two groups differed in age [47]. A Chi-square [47] was calculated in order to determine whether the two groups differed in disease onset type. Alpha was set at 0.05.

Pearson correlations were calculated to describe the relationships between concentric knee extension torque, eccentric knee extension torque, pain, joint count, the

50 m run rank, and the CHAQ Disability Index score.

Stepwise multiple regression analyses with the scores on each functional measure as the dependent variable were performed to determine the best predictors of function. The probability of F for entry of variables was set at 0.05 and the probability of F for the removal of variables was set at 0.10. Concentric torque, eccentric torque, joint counts, and pain scores were the independent variables.

Chapter 4

RESULTS

A total of 63 girls met the inclusion criteria and were contacted regarding the study. Twenty girls volunteered to participate in the study. Descriptive statistics regarding the subjects are presented in Tables 4.1, 4.2, 4.3 and 4.4 and Figure 4.1. Average age of girls who did not participate in the study was 12.1 years. This was not significantly different from the average age of participants (t=0.99, p=0.33). Chi-square (X^2) analysis showed a significant difference in disease onset type between participants and non-participants (X^2 Pearson=6.39, p=0.04).

Results from the strength testing are presented in Table 4.5.

Table 4.1: Average age, weight and height of subjects

	Mean	Standard deviation
Age (years)	11.30	3.13
Weight (kilograms)	42.32	16.54
Height (centimetres)	148.08	14.96

Table 4.2: Frequency of participants and non-participants with different types of JA

Disease Type	Participants frequency (%)	Non-Participants frequency (%)
systemic	2 (10)	5 (11.6)
polyarthritis, Rh-	7 (35)	10 (23.3)
polyarthritis, Rh+	3 (15)	
extended oligoarthritis	1 (5)	
oligoarthritis	7 (35)	28 (65.1)
TOTAL	20 (100)	43 (100)

* non-participants were classified only as systemic, polyarthritis, or oligoarthritis

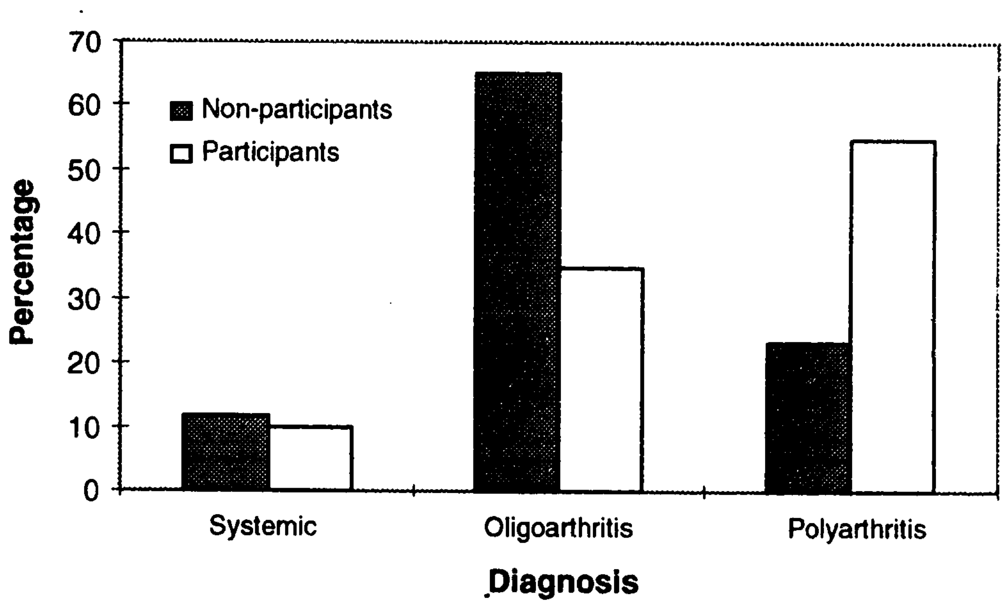

Figure 4.1: Diagnostic distribution of participants and non-participants

Table 4.3: Medications taken by subjects at the time of study

Medication	Frequency	Percentage
none	8	40
anti-inflammatories	7	35
anti-inflammatory + methotrexate	4	20
salazopyrine	1	5
TOTAL	20	100

Table 4.4: Frequency of physical therapy treatment received by subjects

Frequency of Physical Therapy	Number of Subjects (%)
none	5 (25)
every 6 months	6 (30)
every 3-5 months	3 (15)
every 1-2 months	1 (5)
more than monthly	5 (25)
TOTAL	20 (100)

Table 4.5: Mean concentric and eccentric quadriceps torque of all subjects

	Mean	Standard deviation
average concentric torque (Nm)	34.73	18.40
average eccentric torque (Nm)	58.97	30.83
standardized concentric torque (Nm/kg)	0.79	0.29
standardized eccentric torque (Nm/kg)	1.36	0.52

Most girls experienced only minimal functional disability according to the CHAQ scores (Table 4.6). Total active joints ranged from 0 - 19 (x=5.35).

Pain was minimal, as described on the VAS by parents and participants (Table 4.6). No significant difference was found between parent and child reports of pain in the past week (t=1.48, p=0.15), therefore only parent reports were used for the correlations. A significant difference was found between the two child VAS scores, indicating less pain experienced on the day of testing than in the past week (t=3.07, p=0.006). Because of this, the child's VAS for the pain experienced on the day of testing was also included in the correlations.

Table 4.6: Scores on the CHAQ and VAS

Measures *	mean	standard deviation	range
CHAQ score	0.51	0.64	0 - 2.00
Lower extremity CHAQ score	0.43	0.64	0 - 2.00
Parent VAS	0.59	0.74	0 - 2.34
Child VAS (pain in past week)	0.77	0.64	0 - 2.38
Child VAS (pain on day of testing)	0.35	0.47	0 - 1.61

* maximum score was 3 on ALL measures, indicating most impairment

Most girls scored quite low on the 50 m run test. The mean time on the run was 11.51 seconds (s.d.=2.11 seconds). No girls scored excellent or gold and only one girl scored a silver level (5%). Four girls (20%) received a bronze rating and 15 girls (75%) were classified as below bronze. For the girls who scored below bronze, the average difference between their actual running time and the time required to attain a bro...

rating was 1.64 seconds (range=0.15-5.35s).

Correlations between standardized torque and functional measures were moderate (Table 4.7). Scatterplots of the relationships between torque and function are presented in Appendix J. Standardized concentric torque was more highly correlated to both 50 m run and CHAQ scores than eccentric torque (Table 4.7). CHAQ scores were moderately correlated to the total number of active joints and highly correlated to parent VAS scores (Table 4.7).

Table 4.7: Correlations between function and torque, pain, and joint counts

	CHAQ	Lower extremity CHAQ	50 m run rank
standardized concentric torque	-0.48 *	-0.50 *	-0.48 *
standardized eccentric torque	-0.43	-0.45 *	-0.31
Pain in past week - Parent report	0.86 ***	0.77 ***	0.33
Pain on day of testing - Child report	0.34	0.25	0.31
Total joint count	0.64 **	0.45 *	0.22
Lower extremity joint count	0.59 *	0.50 *	0.36

* p<0.05
** p<0.01
*** p<0.001

Results of multiple regression analyses are presented in Tables 4.8, 4.9, 4.10, 4.11, 4.12 and 4.13. Refer to Appendix K for correlations between all independent variables. The inter-relationships between independent variables are important to consider when interpreting the multiple regression analyses. Stepwise multiple

Regression analysis with the total CHAQ score as the dependent variable indicated that parent report of pain and total joint count was the best combination of predictors of function with an explained variance of 80.4 %. When standardized eccentric and concentric torques were forced into the regression analysis, the explained variance was 82.7%.

For the lower extremity CHAQ score the best predictor was parent report of pain, with no other variable contributing significantly to the prediction (r^2=0.59). When standardized concentric and eccentric torque was forced into the regression analysis, the explained variance was 64%.

With the 50 m run, the best predictor was the average concentric torque, with an explained variance of 23.3%. No other variable contributed significantly to the prediction of run time. When eccentric torque was forced into the regression, explained variance was 34%.

Table 4.8: Multiple regression analysis with CHAQ as the predicted variable

Variable	multiple r	r^2
parent report of pain	0.86	0.74
total joint count	0.90	0.80

Table 4.9: Multiple regression analysis with CHAQ as the predicted variable and standardized torques forced into the regression

Variable	multiple r	r^2
parent report of pain	0.86	0.74
total joint count	0.90	0.80
standardized concentric torque	0.90	0.82
standardized eccentric torque	0.91	0.83

Table 4.10: Multiple regression analysis with lower extremity CHAQ as the predicted variable

Variable	multiple r	r^2
parent report of pain	0.77	0.59

Table 4.11: Multiple regression analysis with lower extremity CHAQ as the predicted variable and standardized torques forced into the regression

Variable	multiple r	r^2
parent report of pain	0.77	0.59
standardized concentric torque	0.80	0.64
standardized eccentric torque	0.80	0.64

Table 4.12: Multiple regression analysis with 50 m run rank as the predicted variable

Variable	multiple r	r^2
standardized concentric quadriceps torque	0.48	0.23

Table 4.13: Multiple regression analysis with 50 m run rank as the predicted variable and eccentric torque forced into the regression

Variable	multiple r	r^2
standardized concentric quadriceps torque	0.48	0.23
standardized eccentric quadriceps torque	0.58	0.34

4.1 Additional results

Table 4.14: Fifty metre run time classification of subjects who scored '0' on the CHAQ

Run classification	frequency (%)
Excellence	0 (0)
Gold	0 (0)
Silver	1 (12.5)
Bronze	2 (25.0)
below bronze	5 (62.5)
TOTAL	8 (100)

Table 4.15: Correlations between strength and age, height, and weight of subjects

	age	height	weight
average concentric torque	0.83 ***	0.87 ***	0.72 ***
average eccentric torque	0.76 ***	0.79 **	0.65 **

** $p<0.01$
*** $p<0.001$

Chapter 5

DISCUSSION

5.1 Generalizability of results

The disease type distribution of subjects is similar to the distribution as described by Cassidy & Petty [1] except that children with polyarthritis were slightly over-represented while children with oligoarthritis were slightly under-represented. Cassidy and Petty [1] report that 10% of all children with JA have systemic onset of disease, 40% have polyarthritis and 50% have oligoarthritis. Because the present study only included girls with JA and Cassidy and Petty [1] describe only the distribution of disease types in all children with JA, a slight discrepancy between the values may be expected.

The difference in distribution of disease type could possibly be due to the fact that the Glenrose Rehabilitation Hospital (GRH), from which 15 of the subjects were recruited, is a tertiary care centre, serving only those children with severe arthritis requiring interdisciplinary treatment. Children with oligoarthritis and especially those with monoarthritis are not usually served through the GRH. The high proportion of girls with oligoarthritis choosing not to participate in the study (Figure 4.1) may indicate that the study did not appeal to those children with mild arthritis who may not experience any restrictions as a result of their condition.

The age range of girls recruited for the study may have also biased the disease type representation to girls with polyarticular arthritis. The peak age of onset of oligoarthritis is between age 1 and 3, while onset of polyarthritis has two peaks, one occurring between age 1 and 3 and the second at age 9 [1].

The subjects in the present study may not be representative of all girls with JA. However, the sample is of clinical interest because it is representative of girls with JA receiving regular interdisciplinary treatment for arthritis.

5.2 Quadriceps torque

It is difficult to compare quadriceps torque in this study to other studies because of the variability in testing instrument, protocols used and measures attained. The most notable difference between this protocol and others described in the literature is that the subjects were tested in the prone position, where most other protocols used sitting as the test position. The prone position was chosen primarily to prevent the inability to perform muscle strength testing secondary to hamstring muscle tightness. The prone position may also place the quadriceps in a more functional position than the sitting position. One study reported lower average peak torque values for the quadriceps when assessed in supine compared to sitting [48] while another study reported no difference in quadriceps torque between sitting and semi-reclined positions [49].

The other important difference is that average torque was used to describe strength, not average peak torque. Average torque values will be lower than peak torque values, therefore direct comparisons will not be possible. However, average and peak torque values are highly related, making comparisons of relationships between torque values and function possible.

Only one study has described quadriceps strength in children with JA [4], but only isometric torque was measured. Isometric torque would be expected to be higher than isokinetic torque. Giannini and Protas [4] measured isometric torque in 25 girls and 3 boys with JA between age 7 and 17 years. Peak isometric torque was measured on the Kin-Com with the knee in 60° of flexion, the range at which the knee extensors are the most efficient for isometric force measurement. Average isometric peak torque was 123 Nm, which is much higher than the average torque values found in this study.

Mohtadi et al. [13] found peak quadriceps torque measured on the Kin-Com at 60°/s to be 81 Nm (concentric) and 91.75 Nm (eccentric) in healthy pre-adolescent boys in the non-dominant leg. The girls in the present study exhibited much lower values when compared to Mohtadi's results. However, Mohtadi et al. [13] presented peak torque results, tested the boys in sitting, and included only boys aged 10 to 12, therefore any comparisons made must be viewed with caution.

Two studies have described the standardization of peak torque in children by dividing the torque value by weight [18, 44]. Standardized concentric quadriceps peak torque values were 1.60 Nm/kg for adolescents with cerebral palsy [18] and 1.48 Nm/kg in healthy boys aged 6-8 years [44]. Average standardized concentric torque values from the present study were lower in comparison to the two studies, which suggests that girls with JA are weaker than adolescents with CP [18] and healthy boys aged 6-8 years [44]. However, once again, these comparisons may be misleading because of the difference in testing protocol, and the difference in testing machine, as Merlini et al. [44] evaluated torque using the Lido Active. No evaluation has been performed to determine whether torque values obtained using the Kin-Com are significantly different than torque values obtained with the Lido Active. However, evaluations between other instruments including the Cybex, Lido, Merac and Biodex have shown significant differences between actual peak torque values on different instruments [50-55].

Although other studies have concluded that children with JA are weaker when compared to healthy children their age [4, 56], the protocol variability makes it extremely difficult to compare the results from the present study with any published reports of quadriceps strength in other children. However, in light of all the comparisons made above, it may be reasonable to conclude that the girls in the present study are probably weaker than healthy girls.

5.3 Functional performance

Girls in the present study scored very low on the CHAQ, indicating minimal functional disability ($\bar{x}$=0.51). This finding supports other studies that have concluded that children with JA, on average, experience minimal functional disability [6, 16, 17, 31]. Singh et al. [17] reported a mean score of 0.84 on the CHAQ in 72 children with JA. With a Swedish version of the CHAQ, Gare et al. [31] found a mean score of 0.33 in children with JCA.

In contrast to this, the girls in the present study performed very poorly on the 50 m run. Over sixty per cent of the girls who scored '0' on the CHAQ, indicating no disability, also scored a '5=below bronze' on the 50 m run (Table 4.14). This seems to indicate that the girls may not have difficulty with activities of daily living, but may have limitations with recreational activities. Because many childhood activities involve running, this would presumably limit them from many of their regular peer activities. It is clear that the 50 m run is not a sensitive instrument for the assessment of functional ability in girls with arthritis as 75% of the girls in the present study scored 'below bronze' on the run. However, this highlights a need for the development of a functional assessment for girls with mild arthritis who may experience functional disabilities unrelated to the activities necessary for daily living.

5.4 Relationship between torque and CHAQ scores

This was the first study to relate quadriceps torque to function in children with JA. Two measures of function were chosen, one specifically designed for children with arthritis (CHAQ), and one chosen for its possible relevance to a child's participation in physical activities (50 m run).

The correlations between quadriceps torque and CHAQ scores were moderate ($r=0.48$ for concentric and $r=0.43$ for eccentric torque). These correlations are slightly lower than correlations found between strength and function in adolescents with CP and adults with RA [18, 22]. Kramer and MacPhail [18] found that standardized concentric ($r=0.68$, $p<0.01$) and eccentric ($r=0.58$, $p<0.01$) peak torques were moderately related to gross motor ability. Danneskiold-Samsoe and Grimby [22] found correlations of 0.50-0.69 between isokinetic quadriceps torque and walking speed and step climbing ability in adults with RA being treated with corticosteroids. Lower correlations in the present study may be a result of the functional assessment chosen. Both Kramer and MacPhail [18] and Danneskiold-Samsoe and Grimby [22] chose lower extremity functional measures, while the CHAQ includes both upper and lower extremity activities.

Concentric torque was more highly correlated with function than eccentric torque. These results support Kramer & MacPhail's [18] suggestion that concentric quadriceps torque is more related to function than eccentric torque.

It was surprising that the correlations between the lower extremity CHAQ score and torque were not very much greater than the correlations between the total CHAQ score and torque (Table 4.7). This may be due to the fact that the items chosen from the CHAQ to represent lower extremity items may not be dependent only on lower extremity strength. Items under the 'activities' section were quite variable in muscles required; for example, the child was assessed on her ability to run errands and shop, get in and out of a car or toy car, ride a bike or tricycle, do household chores, or run and play. With the scoring on the CHAQ, the child's highest score on any one item under the section was the child's score for that section. These activities are quite variable and may not truly reflect only lower extremity function.

5.5 Relationship between CHAQ and measures of disease activity

CHAQ scores were much more highly correlated to parent reports of pain and active joint counts than quadriceps torque. This was expected because the CHAQ was specifically designed to measure functional limitations secondary to JA [17]. Singh et al.

[17] reported a correlation of 0.67 between CHAQ score and number of active joints. This is similar to the correlation found in the present study (r=0.64). Lovell et al. [27] and Howe et al. [16] also found that function was related to joint count (r=0.40 & r=0.49). Howe et al. [16] reported a moderate correlation between function as assessed on the JAFAR-P and pain assessed on a VAS by parents (r=0.61). This is lower than the correlation found between CHAQ scores and parent pain assessments in the present study (r=0.86). Results from the present study support the use of the CHAQ as a tool to measure functional restriction secondary to joint activity as determined by an active joint count and parent report of pain.

Results from the multiple regression analyses further support the use of the CHAQ as a tool to measure functional restriction secondary to disease activity. For both the CHAQ and the lower extremity CHAQ scores, the measures of disease activity were the best predictors of function. This is important to realize as changes in joint activity may translate into changes in function as measured on the CHAQ. However, cause-effect relationships can not be determined by the present cross-sectional study. Because the CHAQ score is best predicted by the parent report of pain and total joint count, changes occurring as a result of a strengthening program may only contribute minimally to a change in function as measured on the CHAQ. The results from this study seem to suggest that the CHAQ may not be an appropriate tool for measuring changes in function which may occur as a result of improved strength in the quadriceps.

CHAQ scores were not very highly correlated to the child's reported pain level on the day of testing. This could be due to the fact that the CHAQ is based on function in the past week. The fact that both the child's and her parent's reported pain levels for the week ($r=0.55$, $p=0.01$ & $r=0.86$, $p<0.0001$) were more highly correlated to the CHAQ than the child's reported pain level for the day of testing ($r=0.31$, $p=0.19$) further supports this suggestion. Because the CHAQ scores were only determined by parent report, a higher correlation between CHAQ scores and the parent's reported pain level for the week would be expected in comparison to the correlation between CHAQ scores and the child's reported pain level for the week [16].

5.6 Relationship between torque and 50 m run

Concentric torque was more highly correlated to the 50 m run than eccentric torque (Table 4.7). Lack of variability in the 50 m run rankings may have limited the correlations between torque and 50 m run rankings. No girls were able to run fast enough to achieve a rank of 'Excellence' or 'Gold', and only one girl achieved a rank of 'Silver'. A majority of the girls did not run fast enough to achieve 'Bronze'. This suggests that the 50 m run is not sensitive enough to discriminate between girls with JA who have different functional abilities. Girls who ranked less than bronze on the 50 m run varied significantly in CHAQ score, with scores ranging from 0 - 2.

Studies have found strength to be correlated to sprinting speed in elite sprinters [57, 58]. Alexander [57] found that concentric knee extension, eccentric knee extension and eccentric knee flexion torque were the best combination of predictors of speed in elite adult female sprinters. Young et al. [58] found very high correlations between various measures of lower extremity strength and a 50 m run time in athletes aged 16 -

18 years. Correlations between running speed and some strength measures were as high as r=0.86. This correlation between strength and sprinting speed may be higher than the correlation found in the present study because the strength measures used by Young et al. [58] were much more specific to actions required for sprinting. They measured strength through a variety of resisted vertical jumps in positions closely related to sprinting postures. The vertical jumps were also a measure of strength in more than one muscle group. Co-ordination would be a more important factor in the vertical jump tests than the isokinetic testing used in the present study. All of these factors may have contributed to the lower correlations found between strength and running speed in the present study. It is also important to note that the subjects tested by Young et al. (1995) were adolescent athletes.

Running performance on the 50 m run was best predicted by average concentric torque, but the explained variance was very low. This seems to indicate that strength is related to running ability in children with JA, but many other factors are also involved. Measures related to severity of disease, including joint count and pain, were not significant contributors to the prediction of running performance.

5.7 Running performance

The participants in the present study performed very poorly on the 50 m run. In comparison to the standard running times recorded with the Canada Fitness Award program, most of the girls finished the run well above the slowest standards. On average, they were more than 1.5 seconds slower than the time required for a bronze rating. Even though one second does not seem to be a long time, the difference between a ranking of excellence and gold was only about 0.2 seconds. The difference between a ranking of gold and silver was only about 0.5 seconds. The difference between a silver and a bronze rating was greatest, at about 1 second.

These results are in agreement with findings that children with arthritis scored lower on a physical fitness test than healthy children their age [59]. Klepper et al. [59] found that children with polyarticular JA had low fitness levels, and fitness levels were not significantly related to joint count and/or disease severity scores. Results from the present study also found that disease activity, as indicated by an active joint count and pain, was not significantly related to running speed (Table 4.7). Klepper et al. [59] suggest that low physical fitness levels may be a result of physical inactivity, lack of experience with the test items, or muscle weakness. Results from this study support the suggestion that muscle strength, specifically concentric quadriceps strength, may be related to speed of running.

Poor sprinting performance may be due to a variety of other factors in addition to quadriceps strength. Strength in other muscles, range of motion, and co-ordination have all been found to be related to sprinting speed in athletes [57, 58, 60]. Mann & Hagy [60] described the importance of the intrinsic and extrinsic foot muscles in running, with the gastrocnemius, anterior lower leg compartment muscles, flexor hallicus longus and flexor digitorum longus functioning more during running than during walking. Because children with JA are frequently discouraged from running while their weight bearing joints are active, they may lack the practice required to gain the necessary coordination for running.

Alexander [57] found that running speed was highly related to stride length, upper arm displacement, touchdown distance, and lower leg displacement. These measures are all related to the amount of motion available in a joint. Children with arthritis may have restricted range of motion, which may affect stride length and arm and leg displacement. Again, lack of practice may also affect these variables.

Strength in hip and ankle musculature has been related to running speed in young athletes and elite adult sprinters [57, 58]. Because children with arthritis are known to be weaker than their peers [4, 56], poor general strength may lead to poor running performance.

In the present study, the testing environment may have led to less than optimal running performance. All girls were tested individually, while the Canada Fitness Award program was designed to be used in a classroom environment. This may have decreased the amount of motivation and excitement in the girls being tested, leading to a decrease in speed. The testing was also performed indoors in a hallway, not in a gymnasium or on an outdoor track, as would probably be the case in a school environment. A few of the girls did not have runners and ran bare-footed. This may have affected their running speed.

5.8 Limitations

The primary limitation in this study was the small numbers of subjects and the lack of a homogenous group. Because of limited numbers of children with JA, the sample included a large age range of girls. An attempt was made to limit this variability by standardizing torque by the subject's weight, as described in previous studies [18, 44]. However, in analyzing correlations between torque and age, height and weight (Table 4.15), height was the most highly correlated to torque in this sample. In order to be able to compare the results with other studies, weight was chosen as the standardizing variable. Future studies with a more limited age group would assist in further defining the relationship between strength and function in children with JA.

The small sample size did not allow for the comparison of strength and function between girls with knee involvement and those with other lower extremity joints involved. It would be interesting to determine whether quadriceps weakness is more severe in girls with knee joint involvement than girls with only ankle involvement, for example.

Generalizability is limited to girls with juvenile arthritis. Also, the sample is more likely representative of girls with more severe arthritis as the recruitment was through two centres which serve children who require intensive rehabilitation. Girls with monoarticular arthritis and oligoarthritis may have been under-represented in this sample.

Only one muscle group was evaluated in this study. Because functional activities require many muscles, perhaps the evaluation of strength in more than one muscle may be valuable. In addition, functional activities are not dependent only on muscle strength. Other measures such as joint range of motion, motivation, co-ordination, balance, and environmental factors may also play a role in functional abilities.

Isokinetic assessment of quadriceps torque has not been well studied in children with JA. Results from studies with healthy children and adults with RA seem to indicate that isokinetic assessment would be reliable in children with JA, but no studies have evaluated the reliability of isokinetic muscle testing in these children. Greater reliability in the measurement of strength would enhance the relationships found between strength and function.

5.9 Clinical implications

This was the first study to assess quadriceps strength in children with JA using an isokinetic technique, even though isokinetic testing has been described in adults with RA [42, 46, 61]. Isokinetic concentric and eccentric testing of the quadriceps as described in this study had no adverse affects on the subjects during or immediately after the testing. No subjects complained of pain during the testing and only one subject reported muscle soreness for two days post testing. When this subject was assessed two days post testing, no inflammation was found in the knees. Further research is required to ensure that evaluation of isokinetic muscle torque is reliable and safe in children with JA. Clinically, the Kin-Com may not be easily accessible, but its proven validity and reliability cause it to be a valuable tool in research. In addition, the Kin-Com may be an additional option for strengthening children with JA.

Moderate relationships between strength and function suggest that treatment aimed at improving strength may improve function, however, further research is required to show a cause-effect relationship.

Poor performance on the 50 m run, even in girls who showed no disability on the CHAQ, suggests that children with JA may continue to have difficulties in physical education and organized sports even when their disease is not in an active state. In a population based study of subjects with JCA born between 1968 and 1972, Gare & Fasth [6] found that only 5% of the individuals with JCA reported severe functional limitations. However, 20% did not participate in physical education at all, and the physical education item on the Swedish CHAQ was perceived as a difficult or very difficult task for respondents who did not report any other functional problems. Even though most physical therapy intervention is aimed towards the rehabilitation of children with severe arthritis, it may be important for physical therapists to become involved in the education and support of those who have mild arthritis in order to encourage optimal functioning in all areas, including physical education and recreation. As studies are indicating that children with arthritis are less physically active and less physically fit than their peers [59, 62-64], it is important that physical therapists encourage appropriate physical activity in children with JA in order to prevent possible long-term health implications due to poor physical fitness.

Results from this study further support the use of the CHAQ as a measure of functional limitations secondary to joint activity in children with JA. The results, however, question the use of the CHAQ as a measure of functional limitation secondary to impairments which result from continued joint activity such as decreased muscle strength.

5.10 Future considerations

Further research is required to determine a cause-effect relationship between strength and function. This would be important to consider due to the major emphasis on strengthening in children with JA. Other factors related to function should also be explored, especially those which may possibly be altered with physical therapy intervention. This information would assist physical therapists in treatment planning towards functional goals.

Continued research in the area of evaluation of function in children with mild JA may assist physical therapists in determining the functional limitations of these children. Children with mild JA who do not have any functional limitations when assessed with an arthritis specific tool may still experience difficulties in activities which are important such as sports and recreation.

Future studies are required to determine the reliability and safety of isokinetic muscle testing in children with JA.

Chapter 6

SUMMARY AND CONCLUSIONS

6.1 Summary

The present study was performed in order to determine the relationship between isokinetic quadriceps torque and function in girls with JA. Twenty girls with JA between the ages of 6 and 16 years volunteered for the study. Function was measured on the CHAQ and a 50 m run. Average isokinetic quadriceps torque was measured on the Kin-Com.

The girls in this study experienced minimal functional disability as determined on the CHAQ. However, they performed very poorly on the 50 m run. Quadriceps torque was moderately related to function as determined on both the CHAQ and the run. Multiple regression analyses found that measures of disease activity were better predictors of function on the CHAQ than quadriceps torque. However, quadriceps torque was the best predictor of function on the 50 m run.

6.2 Conclusions

1. Quadriceps torque is moderately correlated to function in girls with JA as assessed on the CHAQ and a 50 m run.
2. Concentric isokinetic torque is more highly related to function than eccentric isokinetic torque.

3. Results from the present study support the use of the CHAQ as a measure of functional disability secondary to joint activity in children with JA.
4. Girls with JA scored poorly on the 50 m run, even when they had no functional disability as assessed on the CHAQ.

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APPENDIX A:

CHILDHOOD HEALTH ASSESSMENT QUESTIONNAIRE

CHILDHOOD HEALTH ASSESSMENT QUESTIONNAIRE

In this section, we are interested in learning how your child's illness affects her ability to function in daily life. Please feel free to add any comments on the back of this page. In the following questions, please check the one response which bet describes your child's usual activities (average over an entire day) **OVER THE PAST WEEK. ONLY NOTE THOSE DIFFICULTIES OR LIMITATIONS WHICH ARE DUE TO ILLNESS.** If most children at your child's age are not expected to do a certain activity, please mark it as "Not Applicable". For example, if your child has difficulty in doing a certain activity or is unable to do it because she is too young but NOT because she is RESTRICTED BY ILLNESS, please mark it as "Not Applicable".

	Without ANY Difficulty	With SOME Difficulty	With MUCH Difficulty	UNABLE To Do	Not Applicable
DRESSING AND GROOMING					
Is your child able to:					
- Dress, including tying shoelaces and doing buttons?	______	______	______	______	______
- Shampoo her hair?	______	______	______	______	______
- Remove socks?	______	______	______	______	______
- Cut fingernails?	______	______	______	______	______
ARISING					
Is your child able to:					
- Stand up from a low chair or floor	______	______	______	______	______
- Get in and out of bed or stand up in crib?	______	______	______	______	______
EATING					
Is your child able to:					
- Cut her own meat?	______	______	______	______	______
- Lift a cup or glass to mouth?	______	______	______	______	______
- Open a new cereal box?	______	______	______	______	______
WALKING					
Is your child able to:					
- Walk outdoors on flat ground?	______	______	______	______	______
- Climb up ive steps?	______	______	______	______	______

* Please check any AIDS or DEVICES that your child usually uses for any of the above activities:

_____ Cane _____ Devices used for dressing (button hook, zipper pull, long-handled shoe horn, etc.)
_____ Walker _____ Built up pencil or special utensils
_____ Crutches _____ Special or Built up chair
_____ Wheelchair _____ Other (Specify:_____________________________)

*Please check any categories for which your child usually needs help from another person **BECAUSE OF ILLNESS**:

_____ Dressing and Grooming _____ Eating _____ Arising _____ Walking

	Without ANY Difficulty	With SOME Difficulty	With MUCH Difficulty	UNABLE To Do	Not Applicable
HYGIENE					
Is your child able to:					
- Wash and dry entire body?	______	______	______	______	______
- Take a tub bath (get in & out of tub)?	______	______	______	______	______
- Get on and off the toilet or potty chair?	______	______	______	______	______
- Brush teeth?	______	______	______	______	______
- Comb/Brush hair?	______	______	______	______	______
REACH					
Is your child able to:					
- Reach and get down a heavy objects such as a large game or books from just above her head?	______	______	______	______	______
- Bend down to pick up clothing or a piece of paper from the floor?	______	______	______	______	______
- Pull on a sweater over her head?	______	______	______	______	______
- Turn neck to look back over shoulder?	______	______	______	______	______
GRIP					
Is your child able to:					
- Write or scribble with pen or pencil?	______	______	______	______	______
- Open car doors?	______	______	______	______	______
- Open jars which have been previously opened?	______	______	______	______	______
- Turn faucets on and off?	______	______	______	______	______
- Push open a door when she has to turn a door knob?	______	______	______	______	______

	Without ANY Difficulty	With SOME Difficulty	With MUCH Difficulty	UNABLE To Do	Not Applicable
ACTIVITIES					
Is your child able to:					
- Run errands and shop?	____	____	____	____	____
- Get in and out of car or toy car or school bus?	____	____	____	____	____
- Ride bike or tricycle?	____	____	____	____	____
- Do household chores (eg. wash dishes, take out trash, vacuuming, yardwork, make bed, clean room)?	____	____	____	____	____
- Run and play?	____	____	____	____	____

*** Please check any AIDS or DEVICES** that your child usually uses for any of these activities:

_____ Raised Toilet Seat _____ Bathtub bar _____ Bathtub Seat
_____ Long-handled Appliances for Reach _____ Jar opener (for jars previously opened)
_____ Long-handled Appliances in Bathroom

***Please check any categories for which your child usually needs help from another person BECAUSE OF ILLNESS:**

_____ Hygiene _____ Gripping and Opening things
_____ Reach _____ Errands and Chores

APPENDIX B:

RELIABILITY ANALYSIS FOR THE 50 METRE RUN

CALCULATION OF INTRACLASS CORRELATION (ICC)

RELIABILITY ANALYSIS FOR THE 50 METRE RUN

CALCULATION OF INTRACLASS CORRELATION (ICC)

The ICC(1,1) was calculated from the mean square (MS) values derived from an analysis of variance. The following formula was used:

$$ICC = \frac{\text{MS between - MS within}}{\text{MS between + (k-1) MS within}}$$

where k = number of repeated measures

From the analysis of variance, the following MS values were obtained:

Source of Variation	Mean square
Between People	11.12
Within People	0.07

$$ICC = \frac{11.12 - 0.07}{11.12 + (2-1)(0.07)} = 0.99$$

APPENDIX C:

INTERNATIONAL LEAGUE OF ASSOCIATIONS FOR RHEUMATOLOGY (ILAR)

CLASSIFICATION CRITERIA FOR IDIOPATHIC ARTHRITIDES OF CHILDHOOD

INTERNATIONAL LEAGUE OF ASSOCIATIONS FOR RHEUMATOLOGY (ILAR)

CLASSIFICATION CRITERIA FOR IDIOPATHIC ARTHRITIDES OF CHILDHOOD [13]

SYSTEMIC ARTHRITIS

Definite
Documented quotidian fever for at least 2 weeks
Evanescent, nonfixed, erythematous rash
Arthritis
Probable

1. In the absence of arthritis, the presence of criteria 1 and 2 above, together with any 2 of the following:
2. Generalized lymph node enlargement
3. Hepatomegaly or splenomegaly
4. Serositis

Descriptors

1. Age at onset
2. Pattern of arthritis: (I) oligoarthritis, (ii) polyarthritis, (iii) no persisting arthritis
3. Disease course (this may be obscured by therapy): (I) single episode in remission for at least 2 years; (ii) persistent arthritis, no systemic features for more than 6 months; (iii) persistent arthritis, persistent systemic features for more than 6 months; (iv) relapsing disease in childhood (before the 16th birthday); (v) relapsing disease in adulthood (after the 16th birthday); (vi) others (specify)
4. Antinuclear antibodies (ANA)
5. Rheumatoid factor

Specific Exclusions, e.g.,

1. Neonatal onset multisystem inflammatory diseases, hyper-IgD, FAPA (fever, aphthous ulceration, pharyngitis, adenopathy), and other periodic syndromes including familial Mediterranean fever
2. Drug hypersensitivity

POLYARTHRITIS: RHEUMATOID FACTOR NEGATIVE

Arthritis affecting 5 or more joints during the first 6 months of the disease.
Descriptors

1. Age at onset
2. Pattern of arthritis: (I) symmetrical, (ii) asymmetrical
3. ANA
4. Uveitis

Specific Exclusions

1. Positive rheumatoid factor

POLYARTHRITIS: RHEUMATOID FACTOR POSITIVE

Arthritis affecting 5 or more joints during the first 6 months of the disease, associated with positive rheumatoid factor tests on at least 2 occasions 3 months apart.
Descriptors

1. Age at onset
2. Pattern of arthritis: (I) symmetric, (ii) asymmetric
3. ANA

Specific Exclusions

1. Family history of psoriasis

OLIGOARTHRITIS

Arthritis affecting one to 4 joints during the first 6 months of the disease.
Descriptors

1. Age at onset
2. Pattern of arthritis: (i) large joints only; (ii) small joints only; (iii) large and small joints, upper limb predominant; (iv) large and small joints, lower limb predominant
3. ANA
4. Uveitis

Specific Exclusions

1. Positive family history of psoriasis
2. Positive family history of spondyloarthropathy
3. Positive rheumatoid factor

EXTENDED OLIGOARTHRITIS

Arthritis affecting one to 4 joints during the first 6 months of the disease, and a cumulative total of 5 joints or more after the first 6 months of the disease.

Descriptors

1. Age at onset
2. Pattern of arthritis: (I) large joints only; (ii) small joints only; (iii) large and small joints, upper limb predominant; (iv) large and small joints, lower limb predominant; (v) large and small joints, no predominance
3. Symmetry of arthritis
4. ANA
5. Uveitis

Specific Exclusions

1. Positive family history of psoriasis
2. Positive rheumatoid factor

CRITERIA DEFINITIONS

Arthritis: Swelling within a joint, or limitation in range of joint movement with joint pain or tenderness, which is not due to primary mechanical disorders (also see exclusion list in ARA Criteria for Arthritis).

Quotidian fever: Documented daily recurrent fever for at least 2 weeks to above 39°, returning to or below 37° between fever spikes

Rash: Evanescent, nonfixed, erythematous rash

Positive rheumatoid factor: At least 2 positive results (as routinely defined in the laboratory you use) 3 months apart, during the first 6 months of observation, indicate technique used

Positive antinuclear antibody: At least 2 positive results (as routinely defined in the laboratory you use) 3 months apart, during the first 6 months of observation, indicate technique used

APPENDIX D:

PARENT CONSENT FORM

PARENT CONSENT FORM

Title: The Relationship between Knee Strength and Lower Limb Function in Females with Juvenile Arthritis

Principal Investigators:

Jean Fan, M. Sc. P.T. student, U of A, phone #: (403) 430-9569
Jean Wessel, PhD, Associate Professor, U of A,
phone #: (403) 492-2812

Purpose: Muscle weakness is a major problem in children with juvenile arthritis (JA). We do not know how muscle strength is related to a child's every day activities, such as walking and climbing up stairs. The purpose of this study is to find out whether knee muscle strength is related to your daughter's ability to do these activities.

Procedure:

1. A physical therapist will determine the amount of swelling in your daughter's knees. If there is a lot of swelling, your daughter will not be asked to do any of the other tests. Your daughter's ability to do a muscle test without pain will be tested by a physical therapist. If your daughter feels any pain with the strength testing, she will not be asked to do any of the other tests.
2. You and your child will be asked to tell us how much pain your daughter is feeling. You will do this by answering a question on a piece of paper. You will also be asked to fill out a questionnaire about your daughter's ability to do every day activities. The questionnaire will take about 10 minutes to complete.
3. Your daughter will be asked to run as fast as she can for 50 metres. She will be timed during the run.
4. If your daughter is able to do the muscle testing without pain, her muscle strength will be measured on a computer-controlled exercise machine called the Kin-Com.

The total time required will be about 90 minutes.

Risks & Benefits: It is possible that your daughter may feel minor pain during muscle testing. Your daughter can easily stop the test by pressing a button if she feels any discomfort. The pain will likely go away once the test is stopped. Your daughter will be asked to try the test only one more time if this happens. The investigator will emphasize that your daughter does not have to try the test again unless she wants to.

One benefit from being in the study is that you and your daughter will receive information on her strength and ability to do every day activities. You will also receive a brief report of the results of the study.

Parking fees will be paid for you.

I, ____________________________(please print your name), give permission for my daughter, ______________________ (please print your daughter's name), to take part in this project. The study has been completely described to me. I understand that my daughter's participation is voluntary. I may withdraw my daughter from the study at any time. This will NOT affect the treatment that my daughter receives in any way. I understand that all information will be kept confidential. Any paper written about the study will not identify my daughter by name.

All questions I had about the project have been answered. I understand that I may call Jean Fan at (403) 430-9569 or Jean Wessel at (403) 492-2812 at any time if I have any more questions. I can call collect to talk to these people about the study. I have been given a copy of this consent form.

I have read and understood the information above. I sign this consent willingly.

______________________________	____________________
Signature of Parent	Date
______________________________	____________________
Signature of Witness	Date
______________________________	____________________
Signature of Investigator	Date

APPENDIX E:

PARTICIPANT'S CONSENT FORM

PARTICIPANT'S CONSENT FORM

Title: The Relationship between Knee Strength and Lower Limb Function in Females with Juvenile Arthritis

Principal Investigators:

Jean Fan, M. Sc. P.T. student, U of A, phone #: (403) 430-9569
Jean Wessel, PhD, Associate Professor, U of A,
phone #: (403) 492-2812

Purpose: Muscle weakness is a problem in children with juvenile arthritis (JA). We do not know how muscle strength is related to every day activities, such as walking and climbing up stairs. This study will find out if knee muscle strength is related to your ability to do these activities.

Procedure:
A physical therapist will make sure that you are able to be in this study. She will check to see if you have a lot of swelling in your knees. Then she will check your knee strength. If your knee has a lot of swelling or if you have pain with the strength test, you will not be asked to do the rest of the tests.

You will be asked to do 3 things.

1. Tell us how much pain you feel by answering a question on a piece of paper.
2. Run as fast as you can for 50 metres, and
3. Push as hard as you can with your leg on a special machine.

Your mom or dad will be asked to fill out a questionnaire about how well you can do every day activities. They will also be asked to answer a question about how much pain you feel.

Risks & Benefits: You may feel a little pain while your muscles are being tested. You can easily stop the test by pressing a button. The pain will likely go away once the test is stopped. You will be asked to try the test only one more time if this happens. You DO NOT have to try the test again unless you want to.

I, ___________________________________ (please print your name), want to be in this study. The study has been completely described to me. I know that my participation is voluntary. I may withdraw from the study at any time. This will NOT affect the treatment that I receive in any way. I understand that all information will be kept confidential. Any paper written about the study will not identify me by name.

All questions I had about the project have been answered. I know that I may call Jean Fan at (403)-430-9569 or Jean Wessel at (403)-492-2812 at any time if I have any more questions. I may call collect to talk to these people. I have been given a copy of this consent form.

I have read and understood the information above. I sign this consent willingly.

______________________________   ______________
Signature of participant   Date

______________________________   ______________
Signature of Witness   Date

______________________________   ______________
Signature of Investigator   Date

APPENDIX F:

KIN-COM SPECIFICATIONS

KIN-COM SPECIFICATIONS

SPEED OF EXERCISE

Speed Forward	60 °/s
Speed Backward	60 °/s
Type of Contraction	Con/Ecc

FORCE SETTINGS

Start Forward Force	20 Newtons
Start Backward Force	40 Newtons
Minimum Force	40 Newtons
Maximum Force	2002 Newtons

TURNING POINTS

Forward	Low
Backward	Low
Constant	Speed
Repetitions per set	4
Number of sets	1

FEEDBACK SETTINGS

Type	Overlay
Target	Off
Trace Line	Thin

APPENDIX G:

CHAQ: DISCOMFORT INDEX

PARENT REPORT

CHAQ: DISCOMFORT INDEX

PARENT REPORT

We are also interested in learning whether or not your child has been affected by pain because of her illness.

How much pain do you think your child has had because of his or her illness IN THE PAST WEEK?

Place a straight line through the line below to indicate the severity of the pain.

No Pain — Very Severe Pain

0 — 100

APPENDIX H:

CHAQ: DISCOMFORT INDEX

SELF-REPORT

CHILDHOOD HEALTH ASSESSMENT QUESTIONNAIRE

SELF-REPORT DISCOMFORT INDEX

We want to know how much pain you have because of your arthritis. Please draw a straight line through the line below to tell us how much pain you have **TODAY**.

No Pain   Very Severe Pain

0   100

CHILDHOOD HEALTH ASSESSMENT QUESTIONNAIRE

SELF-REPORT DISCOMFORT INDEX

We want to know how much pain you have because of your arthritis. Please draw a straight line through the line below to tell us how much pain you had **IN THE PAST WEEK.**

No Pain — Very Severe Pain

0 — 100

APPENDIX I:

CANADA FITNESS AWARD

50 METRE RUN

FEMALE STANDARDS

CANADA FITNESS AWARD

50 METRE RUN

FEMALE STANDARDS

(time in seconds)

rank \ age	6	7	8	9	10	11	12	13	14	15	16	17
1 = excellence	10.7	10.0	9.5	9.1	9.0	8.6	8.4	8.0	7.9	8.0	7.9	7.9
2 = Gold	11.0	10.3	9.7	9.4	9.3	8.9	8.6	8.2	8.1	8.2	8.1	8.1
3 = Silver	11.7	11.0	10.2	9.9	9.8	9.4	9.2	8.7	8.6	8.7	8.5	8.5
4 = Bronze	12.9	12.2	11.4	10.8	10.9	10.4	10.2	9.5	9.4	9.4	9.3	9.2
5 = Below Bronze	>12.9	>12.2	>11.4	>10.8	>10.9	>10.4	>10.2	>9.5	>9.4	>9.4	>9.3	>9.2

APPENDIX J:

SCATTERPLOTS OF CORRELATIONS BETWEEN STRENGTH AND FUNCTION

SCATTERPLOTS OF CORRELATIONS BETWEEN STRENGTH AND FUNCTION

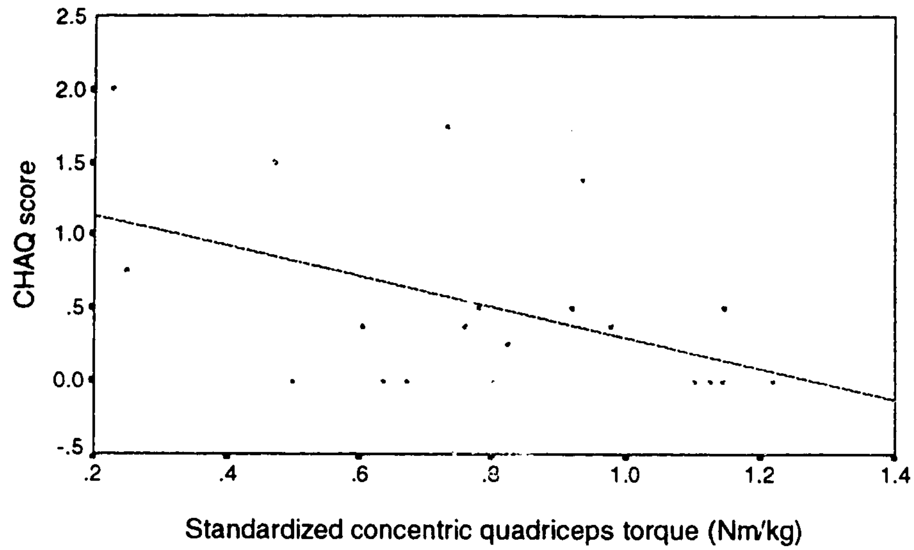

Figure J.1 Relationship between CHAQ score and concentric knee extensor torque (r^2=0.23)

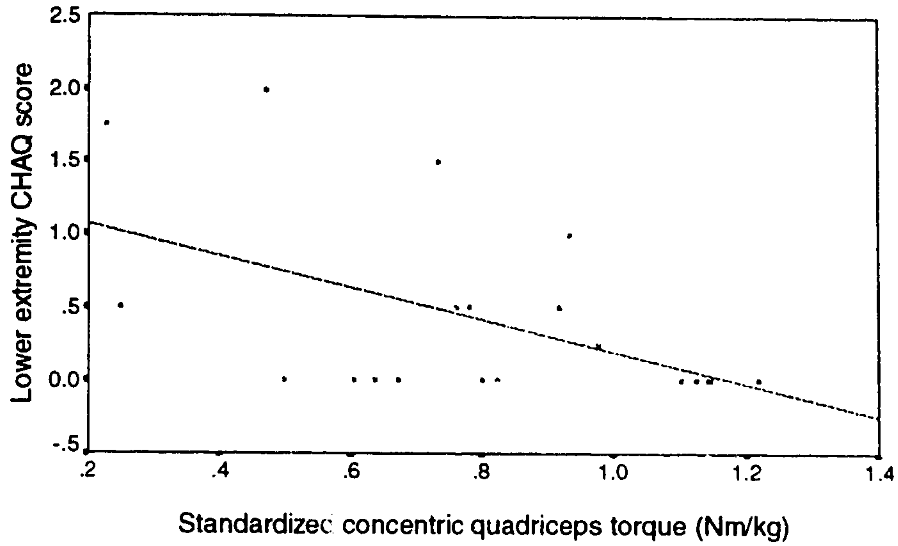

Figure J.2 Relationship between lower extremity CHAQ and concentric knee extensor torque (r^2=0.25)

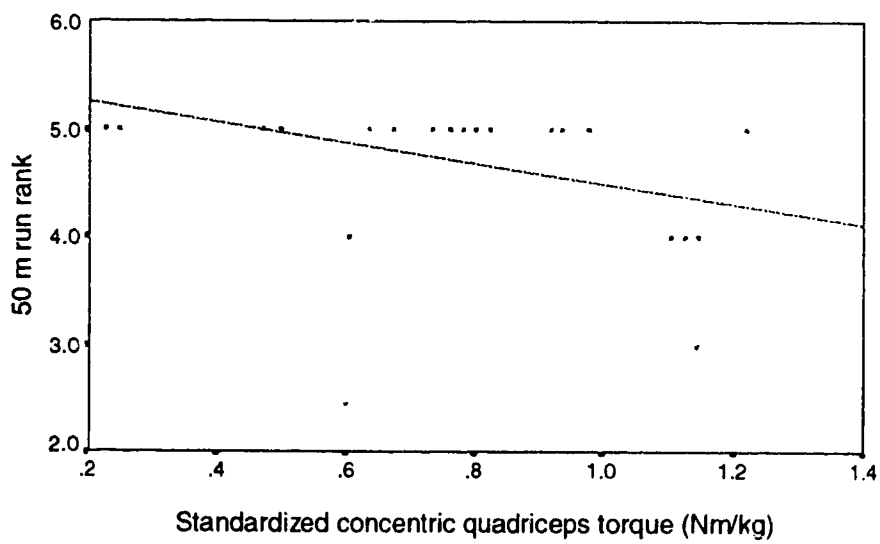

Figure J.3 Relationship between 50 m run and concentric knee extensor torque (r^2=0.23)

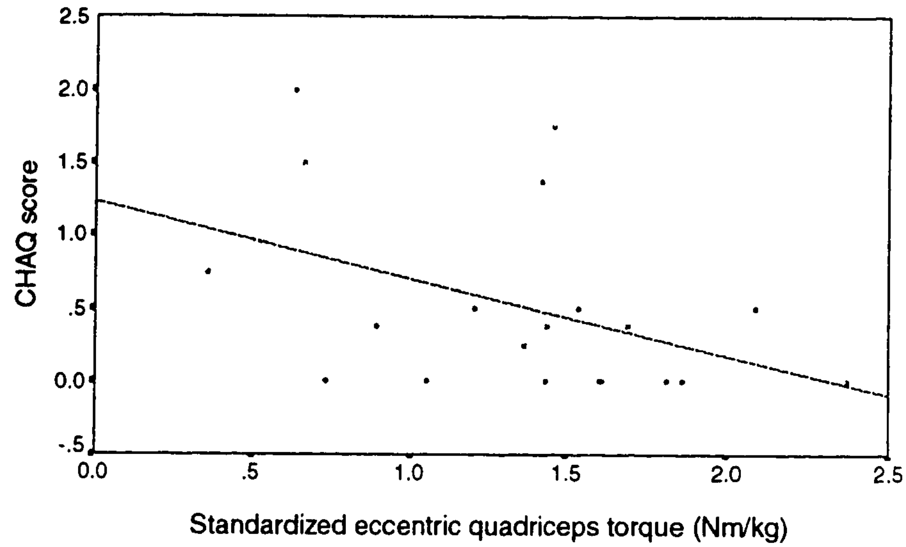

Figure J.4 Relationship between CHAQ and eccentric knee extensor torque (r^2=0.18)

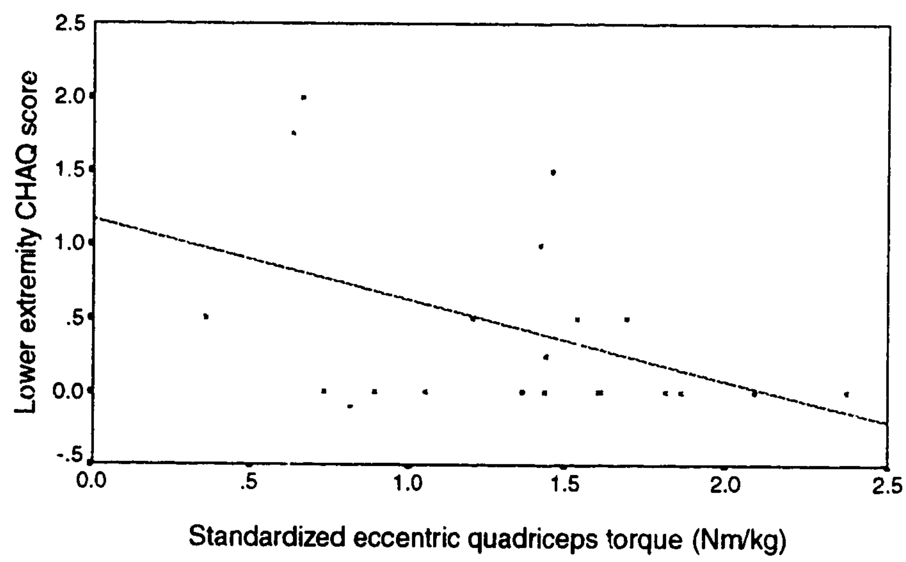

Figure J.5 Relationship between lower extremity CHAQ and eccentric knee extensor torque (r^2=0.20)

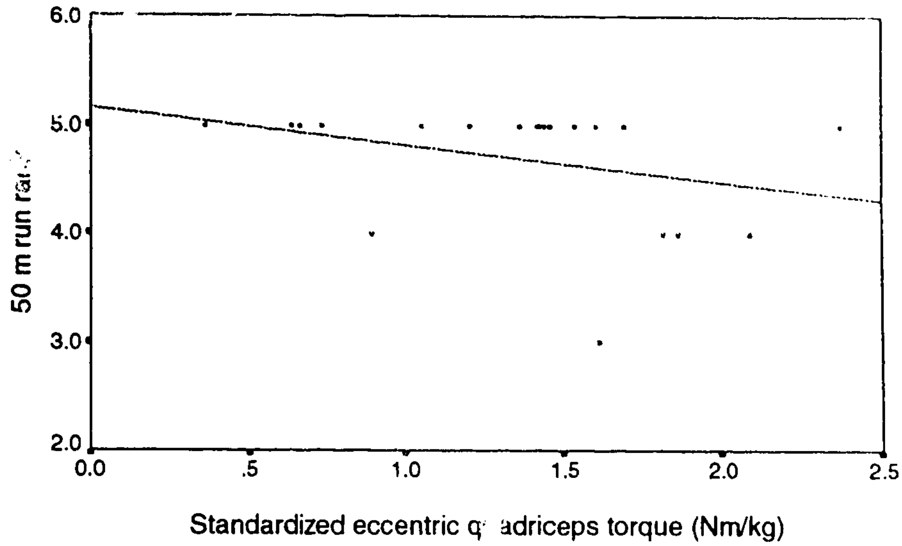

Figure J.6 Relationship between 50 m run and eccentric knee extensor torque (r^2=0.10)

APPENDIX K:

CORRELATION MATRIX OF INDEPENDENT VARIABLES

Table K.1 Correlation matrix of independent variables

	standardized eccentric torque	total joint count	lower extremity joint count	parent VAS	child VAS - pain today
standardized concentric torque	0.91 p=0.000	-0.32 p=0.171	-0.55 p=0.012	-0.39 p=0.087	-0.37 p=0.112
standardized eccentric torque		-0.30 p=0.193	-0.55 p=0.013	-0.40 p=0.082	-0.32 p=0.162
total joint count			0.73 p=0.000	0.49 p=0.029	0.61 p=0.004
lower extremity joint count				0.44 p=0.050	0.75 p=0.000
parent VAS					0.36 p=0.118