

# Assessment of Exercise-Induced Minor Muscle Lesions: The Accuracy of Cyriax's Diagnosis by Selective Tension Paradigm

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Cyriax has proposed a selective tension assessment paradigm for the diagnosis of soft tissue lesions (2). Other manual therapy authors have utilized a similar assessment scheme (6,7). The selective tension paradigm is based on the application of tension by different methods to different tissues and then asking the patient to report the result. A series of joint movements are systematically tested, and importance is placed on the movements that are painful and the movements that are limited. In the clinic, when a physical therapist is evaluating a patient who has pain complaints, the selective tension paradigm is often used to determine the cause of pain.

Cyriax's assessment system serves to differentiate the origin of pain that arises from inert structures from pain that arises from contractile structures. Cyriax states that this diagnostic system is used to determine the origin of pain but not always the pathological diagnosis of the lesion (2). Cyriax further suggests that often adjunct diagnostic tests are required to adequately diagnose disorders (2).

In Cyriax's selective tension assessment, four different components

The Cyriax selective tension assessment paradigm is commonly used by clinicians for the diagnosis of soft tissue lesions; however, studies have not demonstrated that it is a valid method. The purpose of this study was to examine the construct validity of the active motion, passive motion, resisted movement, and palpation components of the Cyriax selective tension diagnosis paradigm in subjects with an exercise-induced minor hamstring muscle lesion. Nine female subjects with a mean age of 23.6 years ( $SD = 4.7$ ) and a mass of 57.3 kg ( $SD = 10.7$ ) performed two sets of 20 maximal eccentric isokinetic knee flexor contractions designed to induce a minor muscle lesion of the hamstrings. Active range of motion, passive range of motion, knee extension end-feel pain relative to resistance sequence, knee flexor isometric strength, pain perception during knee flexor resisted movement testing, and palpation pain of the hamstrings were assessed at 0, .5, 2, 12, 24, 48, and 72 hours postexercise and compared with Cyriax's hypothesized selective tension paradigm results. Consistent with Cyriax's paradigm, passive range of motion remained unchanged, and perceived pain of the hamstrings increased with resistance testing at 12, 24, 48, and 72 hours postexercise when compared with baseline. In addition, palpation pain of the hamstrings was significantly elevated at 48 and 72 hours after exercise ( $p < 0.05$ ). In contrast to Cyriax's paradigm, active range of motion was significantly reduced over time ( $p < 0.05$ ), with the least amount of motion compared to baseline (85%) occurring at 48 hours postexercise. Further, resisted movement testing found significant knee flexor isometric strength reductions over time ( $p < 0.05$ ), with the greatest reductions (33%) occurring at 48 hours postexercise. According to Cyriax, when a minor muscle lesion is tested, it should be strong and painful; however, none of the postexercise time frames exhibited results that were strong and painful. This study suggests that the validity of using Cyriax's selective tension testing for the diagnosis of exercise-induced minor muscle lesions is questionable.

**Key Words:** Cyriax, muscle lesion, diagnosis

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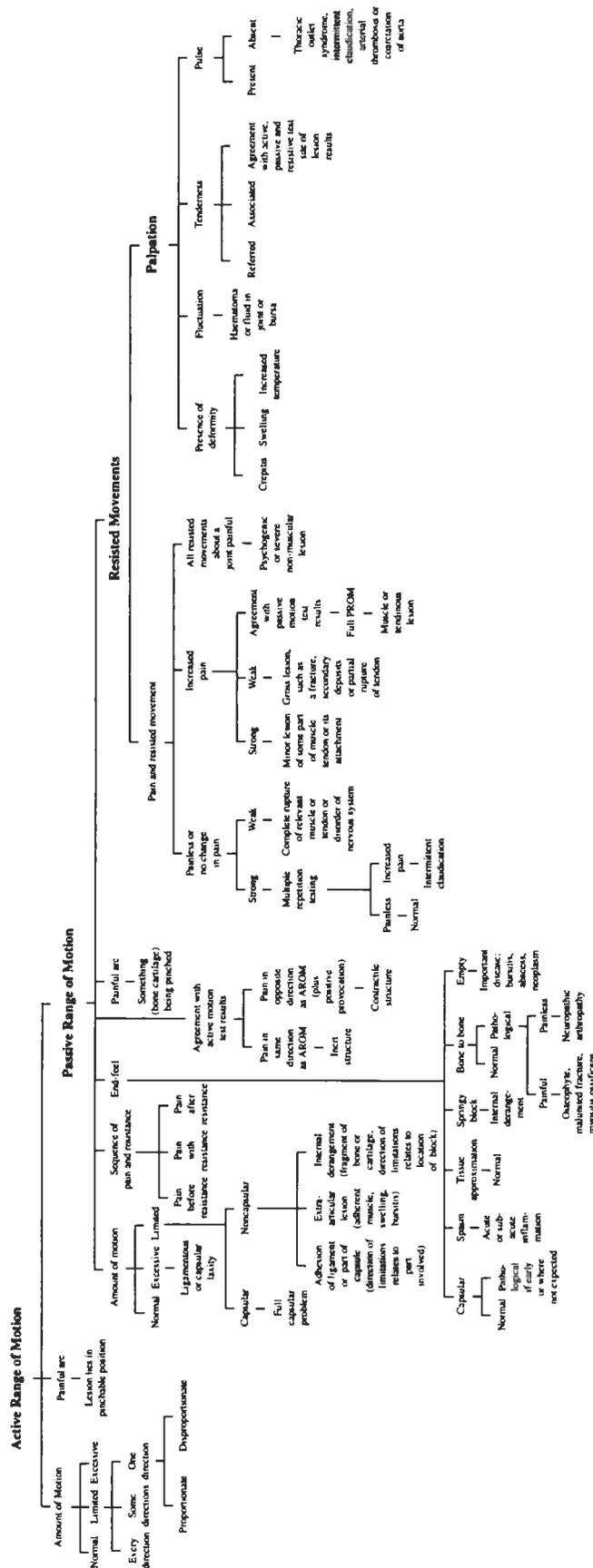


FIGURE 1. Added diagram of the Hayes et al (4) selective tension diagram schematic proposed by Cyriax (2). AROM = Active range of motion. PROM = Passive range of motion. (Adapted from Hayes et al (4), reprinted from Physical Therapy with the permission of the American Physical Therapy Association).

***Increased pain with resistance testing began to occur at 12 hours postexercise and peaked at 100% at 48 and 72 hours postexercise.***

are tested in the following order: active motion, passive motion, resisted movement, and palpation. A full narrative description of the entire selective tension diagnosis system is described in Cyriax's book (2). A diagrammatic representation of the Cyriax selective tension system is depicted in Figure 1.

According to Cyriax (2), active movements demonstrate the patients' ability and willingness to perform the movements, the range and direction of movement available, and whether there is a painful arc. Passive range of motion testing involves assessing the amount and direction of motion available, the end of range of motion end-feel, and end-feel sequence of pain reported by the patient. End-feel testing involves describing how the end of range of motion feels to the examiner. End-feel can be described as capsular, spasm, tissue approximation, springy block, bone to bone, and empty. End-feel sequence of pain describes at what point in the end-range the patient experiences pain relative to the resistance that is felt by the examiner. Active movement results are then compared and contrasted with passive range of motion results. Resisted movements provide information on the state of each muscle group surrounding a joint. The patient is required to perform a maximal midrange isometric contraction against the examiner. Muscular strength and amount of change in pain perception are assessed. Lastly,

palpation is performed to help determine and describe the location of the lesion. Cyriax suggests, however, that palpation can be misleading and often unnecessary (2).

This study addresses all four components of the selective tension paradigm. These components were chosen because of their importance, according to the Cyriax paradigm, in the diagnosis of a minor muscle lesion.

Cyriax suggests that with active range of motion testing, the amount and direction of active range of motion should be compared with passive range of motion and resisted movement measurements. He hypothesizes that if the passive movement is full in all directions at a joint and the active range of motion is impaired in one or both directions, a muscular problem such as a cut tendon, myopathy, or nervous system lesion is occurring (2) (Figure 1).

According to Cyriax (2), passive range of motion testing determines whether there is a capsular or non-capsular problem when range of motion limitations are present. He further suggests that pain relative to resistance testing at the end-range of passive range of motion indicates the state of chronicity of inflammation. Cyriax hypothesizes that pain before end-range resistance represents a lesion with active inflammation; pain at the same time as resistance is felt indicates less active inflammation; and pain after resistance is a lesion with no inflammation (2).

Cyriax suggests that resisted movement testing determines whether there is involvement of the muscles or tendons that perform the movement. The examiner notes the strength of the muscular contraction and whether there is a change in pain with a resisted maximal isometric contraction. Cyriax states that these results are then compared with passive range of motion results to determine whether an inert or contractile structure is involved. He suggests that if pain increases with re-

sisted movements and there is full passive range of motion, then a contractile structure is involved. Cyriax further suggests that the resisted movement testing determines whether the musculo-tendinous lesion is minor, partial, or complete (Figure 1). According to Cyriax, the muscle strength should be strong in a muscle with a minor lesion, and the patient should have increased pain with the resistive movement testing of the involved muscle (2).

A review of the theoretical and clinical bases for manually applied examination procedures has been provided by Riddle (12). While the Cyriax selective tension paradigm has been widely used clinically, studies have not demonstrated that it is a valid and reliable method. Hayes et al (4) examined the construct validity and test-retest reliability of the passive motion component of Cyriax's selective tension paradigm in patients having osteoarthritis of the knee. Hayes et al (4) found that the validity of the pain/resistance sequence as representing chronicity and the reliability of the end-feel and pain/resistance sequence was questionable. In contrast, Patla and Paris (11) found end-feel identification for elbow flexion and extension using the Paris identification system had fair to good reliability.

The purpose of this study was to further examine the construct validity of the Cyriax selective tension diagnosis system. Construct validity has been defined by Rothstein (14) as "a logical argument that supports the idea that a measurement reflects what we want it to measure." We compared the expected results for active knee range of motion, passive knee range of motion, knee extension end-feel pain relative to resistance sequence, resisted movement knee flexor strength and pain perception, and hamstring palpation pain to the actual assessments of subjects with an exercise-induced acute minor muscle lesion of the hamstrings.

## METHODS

### Subjects

The subjects included nine volunteer, healthy, female physical therapy students. Mean age was 23.6 years (SD = 4.7) and their mass was 57.3 kg (SD = 10.7). All subjects were instructed to refrain from any strenuous exercise for 4 days prior to and 3 days following the commencement of the study. All participants had no known history of cardiac dysfunction, neuromuscular disease, or knee problems. Each subject signed a Human Subjects Review Board approved consent document after being informed of the study's risks and benefits.

### Procedure

#### I. Exercise Protocol Designed to Induce Muscle Damage and Inflammation

Each subject participated in one exercise session consisting of two sets of 20 maximal eccentric isokinetic contractions of the left knee flexors at 120°/sec on a Biodex isokinetic dynamometer (Biodex Corporation, Shirley, NY). The hips were placed in 60° of flexion and a neutral internal and external rotation position. The range of motion of knee flexion during the eccentric exercise was 10–90°, for a total of 80°. Each contraction was separated by approximately 5 seconds of rest, and there were 2 minutes of rest between sets.

Webster's Dictionary defines minor as that which is "not serious" (18). An injury that causes muscular disruptions but does not produce necrosis or permanent damage and has muscular strength levels of involved tissues return to normal 7–10 days postexercise should be considered minor. Eccentric exercise has been shown to elicit immediate and delayed ultrastructural damage in muscle (1,5,9). Jones et al (5) examined muscle biopsies following eccen-

***Cyriax suggests that if pain increases with resisted movements and there is full passive range of motion, then a contractile structure is involved.***

tric exercise and found evidence of muscle damage immediately after and up to 7 days postexercise. Friden et al (3) found no evidence of fiber necrosis following a 30-minute eccentric cycle ergometer regimen that produced marked muscle soreness and swelling that peaked 48 hours postexercise. Z-band disorganization was noted in 18, 20, and 1% of all muscle biopsy micrographs that were examined 1 hour, 3 days, and 6 days postexercise. Friden et al (3) also found isometric knee extension strength was significantly decreased compared with baseline levels 20 minutes and 3 days postexercise but returned to baseline levels 6 days postexercise.

#### II. Measurement of Muscle Damage and Inflammation Indicators

Activity of serum creatine kinase, an indirect indicator of muscle damage, and upper thigh swelling were measured prior to and .5, 2, 12, 24, 48, and 72 hours postexercise.

Activity of serum creatine kinase was analyzed by Roche Biomedical Laboratories, Burlington, NC, using a kinetic spectrophotometric assay at 340 nm (13).

Upper thigh circumference measurements using a cloth tape measure were done to assess swelling. During the baseline measurement, the tape measure was placed circumferentially

at the most proximal position of the medial thigh, and the skin was permanently marked to assist with subsequent measurement positioning. Three measurements were taken during each testing session by a senior physical therapy student, and a mean value was calculated.

#### III. Selective Tension Assessments

The following selective tension assessments were performed and listed in the order that was recommended by Cyriax (2). Each selective tension assessment was done prior to, .5, 2, 12, 24, 48, and 72 hours postexercise.

*A. Active range of motion and passive range of motion* Active range of motion and then passive range of motion of the knee were measured by a 12.5-inch universal goniometer in the prone position with the hip in a neutral position according to the method of Norkin and White (10). Full extension was considered to be zero and full flexion approximately 150°. Three measurements were taken during each passive and active range of motion testing session by a senior physical therapy student, and a mean value was calculated. Goniometric measurements of the knee have been shown to be highly reliable (15,17).

The pain/resistance sequence was assessed at the end of knee extension passive range of motion and graded on a four-point scale: 1 = no pain; 2 = pain after resistance is felt; 3 = pain at same time as resistance is felt; and 4 = pain before resistance is felt.

*B. Resisted movement (strength and pain) testing* Resisted movement testing involved the assessment of each subject's maximal midrange isometric knee flexor strength. A Biodex isokinetic dynamometer was used to measure the maximal voluntary isometric knee flexion torque (60° of knee flexion) of the subjects. The machine was calibrated each morning prior to the testing sessions. One

maximal isometric knee flexion contraction was performed by the subjects just prior to testing. Three maximal isometric knee flexion contraction torque measurements were taken during each testing session by a physical therapy faculty member, and a mean was calculated. Just after the subjects performed the maximal isometric knee flexion contraction, they were asked to describe whether they had had hamstring muscle pain during the contraction using a two-point scale: 1 = no pain or no change in pain and 2 = increase in pain.

**C. Palpation testing** Perceived soreness ratings for five different hamstring sites were measured in the prone position. The muscle soreness at each hamstring site was assessed by a senior physical therapy student examiner exerting 4 kg of force perpendicular to the skin site with a manometer (Spark Instruments and Academics, Inc., Coralville, IA) that had a modified 2.0-cm diameter tip. The five hamstring sites included:

- 1) a distal medial site, which was 2.5 cm above the knee joint line over the semimembranosus tendon;
- 2) a distal lateral site, which was 2.5 cm above the knee joint line over the biceps femoris tendon;
- 3) a middle medial site, which was halfway between the knee joint line and the ischial tuberosity and over the semimembranosus muscle belly;
- 4) a middle lateral site, which was halfway between the knee joint line and the ischial tuberosity and over the biceps femoris muscle belly;
- and 5) over the ischial tuberosity.

Perceived soreness ratings were assessed at each hamstring site on a zero to 10-point scale. Subjects were asked to circle the number that corresponded to the level of muscle soreness they experienced in their respective hamstring site while they were receiving the 4 kg of pressure: 0 = none; 2 = minimal; 4 = mild; 6 = moderate; 8 = severe; and 10 = extreme.

## Data Analysis

Descriptive statistics were calculated. Creatine kinase measurements were converted to logarithmic values because of their exponential pattern of elevation. Four analyses of variance (ANOVA) with repeated measures were calculated for log creatine kinase, knee passive range of motion, thigh circumference, and maximum voluntary isometric contraction values.

Due to unequal variances between the knee active range of motion group means over time, nonparametric statistics were used for analysis. Nonparametric ANOVAs with repeated measures were calculated for perceived soreness of the five hamstring sites and ranked knee active range of motion values to determine whether significant differences occurred over time following the single eccentric exercise session.

The Tukey studentized range test was performed to test pair-wise comparisons between pre- and postexercise means for ranked knee active range of motion, log creatine kinase, knee passive range of motion, thigh circumference, perceived soreness of the five hamstring sites, and maximum voluntary isometric contraction torque.

Two chi-square statistics were calculated to compare the frequency of occurrence of subjects between the four passive range of motion pain/resistance categories during each pre- and postexercise time frame and between the two resisted movement resistance and pain categories during each pre- and postexercise time frame.

To assess reliability, intraclass correlation coefficients were calculated for the average of the three trials that were measured for each testing session for knee passive range of motion, knee active range of motion, maximum voluntary isometric contraction torque, and upper thigh circumference using the Spearman-Brown prophecy formula (8).

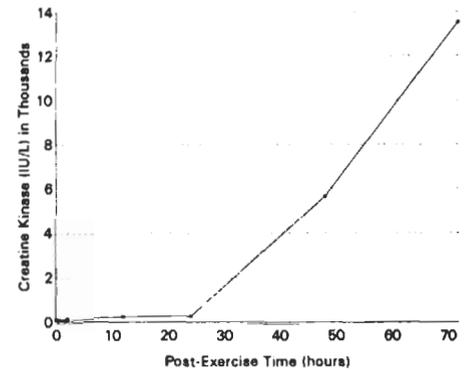


FIGURE 2. Creatine kinase means (IU/L) before and after eccentric exercise.

## RESULTS

### Indicators of Muscle Damage and Inflammation

**Creatine kinase** The mean creatine kinase levels were 81 IU/L (SE = 8) and 13,538 IU/L (SE = 5,881) at baseline and 72 hours postexercise, respectively (Figure 2). Creatine kinase, a muscle damage indicator, was found to be significantly elevated over time following the single eccentric exercise session ( $F = 3.49$ ,  $p < .01$ ). Post hoc testing revealed significant differences between the baseline log creatine kinase group levels and the 48- and 72-hour log creatine kinase group levels.

**Upper thigh circumference** The mean upper thigh circumference increased from a baseline value of 61.7 cm (SD = 7.3) to 64.8 cm (SD = 7.3) at 72 hours postexercise (Figure 3). Upper thigh circumference, an

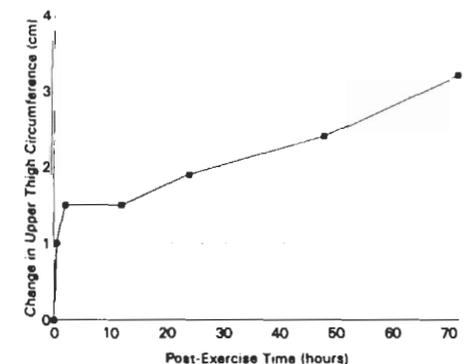


FIGURE 3. Left upper thigh changes in circumference (cm) following eccentric exercise.

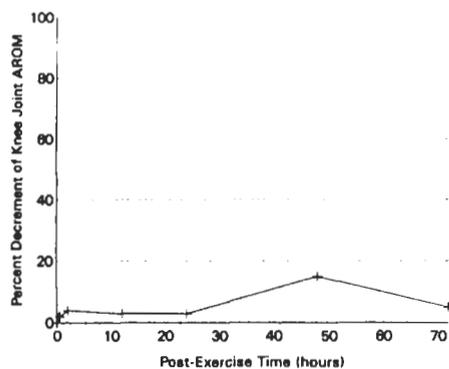


FIGURE 4. Percent decrement of knee joint flexion active range of motion (AROM) following eccentric exercise.

indicator of swelling, was found to be significantly elevated over time following the single eccentric knee flexor exercise session ( $F = 9.42$ ,  $p < .01$ ). Post hoc testing revealed significant differences between the baseline circumference levels and 2, 12, 24, 48, and 72 hours postexercise circumference levels (Figure 3).

### Selective Tension Assessments

**Knee active range of motion** The mean active range of motion values of knee flexion decreased from baseline levels of  $132.0^\circ$  ( $SD = 6.13$ ) to  $111.8^\circ$  ( $SD = 40.8$ ) at 48 hours postexercise for a reduction in total knee flexion active range of motion of 15% (Figure 4). Ranked knee flexion active range of motion was found to be significantly reduced over time following a single knee flexion eccentric exercise session ( $F = 8.29$ ,  $p < .01$ ). Post hoc testing revealed differences between ranked knee flexion active range of motion baseline levels and 2, 12, and 48 hours postexercise-ranked knee flexion active range of motion levels ( $p < .05$ ).

**Knee passive range of motion** No significant differences in passive range of motion of the knee occurred over time following the single eccentric knee flexor exercise session. All subjects experienced no pain at the end-range of knee extension passive range of motion for all pre- and postexercise time frames.

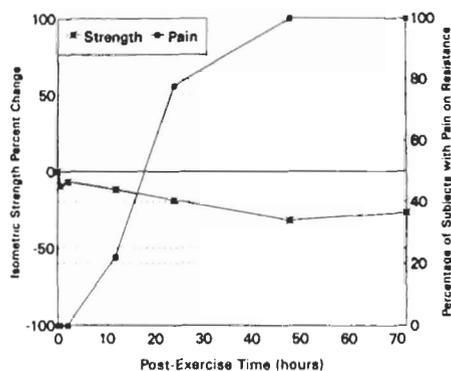


FIGURE 5. Isometric knee flexor strength percent change and percentage of subjects reporting an increase in pain with resistance of the hamstrings following eccentric exercise.

**Knee flexor strength** Maximum voluntary isometric contraction torque (MVIC) of the knee flexors decreased from a baseline level of 55.1 ft-lbs ( $SD = 9.6$ ) to 37.3 ft-lbs ( $SD = 12.1$ ), 48 hours postexercise, for a reduction in isometric strength of 33% (Figure 5). Maximum voluntary isometric contraction torque of the knee flexors was found to be significantly reduced over time following a single knee flexion eccentric exercise session ( $F = 36.1$ ,  $p < .01$ ). Post hoc testing revealed differences between MVIC baseline levels and .5, 12, 24, 48, and 72 hours postexercise MVIC levels ( $p < .05$ ).

**Resistance and pain** The frequency of subjects experiencing increased pain with resistance testing increased from a mean of 0% at baseline to 100% at 48 and 72 hours postexercise (Figure 5). Chi-square testing revealed that significant differences occurred over time between the two categories, including: 1) no pain with resistance or painful but no change in pain with resistance and 2) an increase in pain with resistance ( $\chi^2 = 50.3$ ,  $p < .01$ ).

**Palpation of hamstring muscle soreness** Of the five hamstring sites, only middle lateral and distal medial sites demonstrated significant soreness over time after a single session of knee flexor eccentric exercise (Table). Post hoc testing revealed that for both of these sites, 48- and 72-

hour soreness levels were significantly elevated from baseline levels.

**Reliability estimates** Intraclass correlation coefficients for the average of three trials were .86 for knee passive range of motion, .94 for knee active range of motion, .94 for maximum voluntary isometric contraction torque, and .99 for upper thigh circumference.

## DISCUSSION

### Active and Passive Range of Motion Results as Indicators of a Minor Muscle Lesion

Cyriax states "in tendinous lesions, a full passive range of movement always exists at the relevant joint, and even a lesion in a muscle belly can limit only that passive movement which stretches the healing breach" (2). The results of this study found that no change in passive range of motion of the knee occurred with an exercise-induced minor lesion in the hamstrings. However, the hamstrings cross both the hip and knee joints and if the hip had been placed in  $90^\circ$  of flexion, these passive range of motion results may have changed. We chose to measure knee range of motion using the method described by Norkin and White (10) because it is commonly used in clinical settings. Passive range of motion restrictions have been demonstrated in a previous biceps brachii muscle lesion study (1).

Cyriax also stated that if a patient has full passive range of motion but is unable to perform one or more movements actively, this shows that one or more muscles have an intrinsic defect, such as a cut tendon or myopathy or that there is interference with nervous paths which could be from peripheral neuritis, anterior poliomyelitis, cerebrovascular accident, or psychogenic disorder (2). The results of this study demonstrated that at the knee there was full passive range of motion and limita-

Hamstring Site	Postexercise Time (hours)							F	p
	0	.5	2	12	24	48	72		
Middle medial									
$\bar{X}$	.22	.44	.33	.22	.22	1.33	.89	1.72	NS
SD	.44	.53	.50	.67	.67	1.00	1.05		
Middle lateral									
$\bar{X}$	.33	.78	.89	.67	.78	1.56*	1.33*	4.39	<.01
SD	.71	.83	.60	.71	.83	1.51	.71		
Distal medial									
$\bar{X}$	.33	.89	.89	.78	.56	2.33*	1.56*	6.04	<.01
SD	.50	.78	.78	.83	.73	1.58	1.88		
Distal lateral									
$\bar{X}$	.11	.22	.33	.22	.22	1.11	1.0	2.0	NS
SD	.33	.44	.50	.44	.44	1.96	1.32		
Proximal									
$\bar{X}$	.11	.22	.22	.11	.11	.11	.22	1.0	NS
SD	.33	.44	.44	.33	.33	.33	.44		

\* Significantly different from baseline mean ( $p < .05$ ).

NS = Nonsignificant.

**TABLE.** Mean ( $\bar{X}$ ), standard deviation (SD), and results of analysis of variance with repeated measures and post hoc testing for hamstring muscle soreness (pain scale units) of five hamstring sites before and after eccentric exercise.

tions of flexion active range of motion at 2, 12, and 48 hours postexercise. At 48 hours, there was a 15% reduction in knee flexion active range of motion. Because there were limitations in active range of movement, our results were not in agreement with Cyriax's selective tissue paradigm. However, when Cyriax wrote the statement "inability to perform movements actively" (2), it was unclear whether he meant complete or partial inability to perform active range of motion.

### Resisted Movement Results as Indicators of a Minor Muscle Lesion

Cyriax states that with a minor muscle lesion of some part of a mus-

***Cyriax states that with a minor muscle lesion, the muscle should still be strong; however, we found a 33% force decrement 48 hours postexercise.***

cle or tendon, the damage is not gross enough to cause weakness, but a strong contraction hurts, thus indicating that the structural integrity of the muscle tendon complex is impaired (2).

These results demonstrated that with an exercise-induced minor muscle lesion of the hamstring, knee flexor force was significantly lower than baseline levels at .5, 12, 24, 48, and 72 hours postexercise, with the highest decrement (33%) occurring at 48 hours postexercise. Increased pain with resistance testing began to occur at 12 hours postexercise and peaked at 100% at 48 and 72 hours postexercise. These results are not in agreement with Cyriax's proposed selective tension paradigm. In the first 2 hours postexercise, force decrements were present and no pain was experienced with resistance testing. Studies have indicated that with eccentric exercise, there is histological evidence of muscle damage during the first few hours postexercise (3,5). Cyriax states that with a minor muscle lesion, the muscle should still be strong; however, we found a 33% force decrement 48 hours postexercise. This suggests that weakness or reluctance to contract due to pain is occurring, but according to the selec-

tive tension paradigm, a weak and painful muscle is indicative of a gross lesion, such as a fracture, secondary deposits, or a partial rupture of the tendon.

Our subjects never experienced pain at the end of knee passive range of motion. Pain may have occurred if we had done the passive range of motion testing at the knee with the hip flexed to 90°.

### Palpation Results as Indicators of a Minor Muscle Lesion

Cyriax states that of the four selective tension components, palpation is the least important and is often misinterpreted. In this study, when the hamstrings were palpated, they became significantly painful 48 and 72 hours postexercise. These results were in partial agreement with the Cyriax selective tension paradigm. Muscle ultrastructural studies have demonstrated muscle damage immediately following high tension eccentric exercise (3,5); however, pain was not significantly elevated in our study until 48 hours postexercise. Authors have hypothesized that the immune response to muscle damage is delayed and that the substances that are

released that produce pain are associated with the immune response (16).

While Hayes et al (4) examined the construct validity and test-retest reliability of only the passive motion component of the Cyriax selective tissue paradigm, they found capsular pattern, end-feels, and pain resistance sequence were not valid indicators of osteoarthritis. The results of this study found the validity of using Cyriax's selective tension testing for the diagnosis of exercise-induced minor muscle lesions questionable as well. Further studies need to examine whether the Cyriax paradigm is valid for other types of minor muscle lesions, such as strains or contusions, and for exercise-induced minor muscle lesions in men and older or younger-aged populations.

## CONCLUSION

This study examined the validity of the active motion, passive motion, and resisted movement components of Cyriax's selective tension paradigm for the diagnosis of minor muscle lesions. The results suggested that the usage of Cyriax's selective tension paradigm as a diagnostic system for minor muscle lesions needs to be re-examined.

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