4) Knee Osteoarthritis

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REFERENCES
Osteoarthritis (OA) is a pathologic process of multi-factorial origin leading to cartilaginous degeneration with associated clinical symptoms. Although this pathologic process is closely related to aging, it is different from the effect of aging itself. Chronological aging and OA are two separate and distinct processes.11

Osteoarthritis can be either primary or secondary. Typically, an injury to the joint cartilage can lead to secondary OA. Because of the limited healing capability of cartilage, even minor damage of the cartilage matrix can often lead to the progressive degeneration of cartilage and the eventual loss of joint function.19

Hyaline cartilage that makes up the articular surface of major joints is a hypocellular substance made up of 5% cells by volume and 75-80% water in an aggregated proteoglycan complex. It essentially acts as a water-filled sponge with daily activity, especially in weight-bearing joints. The water, by means of external motion of the body and impact loading, is pushed out of the spongy parenchyma, thus it serves as a rapid exchanger of water and solutes essential for supplying nutrients to the joint surface for repair and daily function.11

Although the etiology of osteoarthritis remains controversial, the pathological changes seem to be a combination of qualitative changes and mechanical fatigue of the joint cartilage. It is well known that one of the significant changes that occurs with cartilage degeneration is an increase of water content and a loss of glycosaminoglycans (GAGs). This is usually initiated by damage to the collagen network. Once the collagen network is destroyed, the GAGs that are incorporated in the collagen network escape from the collagen scaffold, resulting in decreased tolerance to compressive force. These mechanical changes to the supporting matrix lead to further destruction of the collagen network. This vicious cycle contribute primarily to the degenerative changes of articular cartilage following traumatic injury.

Another factor that may lead to micro-fractures in the articular surface, is repetitive impact loading, this can eventually lead to destruction of deep subchondral bone resulting in subchondral hypertrophy. On a cellular level, the pathophysiology is summarized as follows: increased joint stress stimulates a decrease in mucopolysaccharide, and its state of aggregation, there is then an increase in water within the articular cartilaginous matrix. Chondrocytes attempt to repair the joint, if damage is minimal with no continued insult, this increase in activity may be enough to arrest the process and begin repair. However, cellular pathophysiology usually continues and the articular surface becomes fibrillated, thus resulting in decreased mechanical integrity and lubrication causing increased friction. The increase in frictional forces predispose the cartilaginous matrix to thinning and further destruction. Do to the aforementioned hypertrophy of the joint there may be an accompanied functional instability which can lead to further cystic changes of the trabecular bone.11

Prior injury that affects gait, joint alignment, or ligamentous stability, is a potential risk factor for the development of OA.11

The major goal of any OA program is to shift the process from one of degradation and catabolism to synthesis and anabolic activity.11

**JOINT ALIGNMENT**

There is now general agreement that the principal etiology of degenerative arthropathy is mechanical, not inflammatory. Direct clinical evidence of a cause-and-effect relationship between malalignment and arthrosis has not been possible, but substantial evidence from the orthopedic literature supports this hypothesis.20

The total load on the joint, as well as how that load is distributed over the articular surface contact area, determines the magnitude of stress sustained by articular cartilage. Any intense stress concentration in the contact area will play a primary role in tissue degeneration. High contact pressures between the articular surfaces reduce the probability of fluid film lubrication. Subsequent actual surface-to-surface contact of aspirates causes microscopic stress concentrations that are responsible for further damage.12
The load on a joint is a function of the alignment of the bones relative to that joint. Significant changes in the axial alignment of the femur or tibia may influence the load distribution in the knee joint. Malalignment causes asymmetric transmission of weight-bearing forces across the knee. Research has shown that fluctuations in the pattern and magnitude of compressive loads experienced by the chondrocyte affects its biomechanical environment, and thus its synthesis of matrix macromolecules.

Although some studies have shown a relationship between forces observed at the knee and limb alignment, others have not, and therefore, their relationship remains ambiguous. Our study demonstrates a significant, direct relationship between the alignment of the lower limb as measured by the mechanical axis and the peak adduction moment (an indicator of knee medial compartment loading) during early stance phase in normal subjects. Subjects who have a varus alignment tend to have a high knee adduction moment and those who have a neutral or valgus alignment tend to have a low adduction moment.

There are several combinations of muscle forces, adduction moments, and lateral soft tissue forces that can lead to higher medial joint forces. The adduction moment is likely the single most important extrinsic load factor leading to higher medial compartment loads.

The dynamics of malalignment are based on the combination of the static limb alignment and the dynamics of loading at the knee during walking and other activities of daily living. The loads that are generated during these dynamic activities are substantially greater than the loads that can be generated during static postures. Therefore, limb alignment based on static radiographic measurements provides one component to the complete analysis of the factors influencing loading at the knee joint.

This study provides reliable and reproducible data that suggest that lower limb alignment and foot position affect coronal knee moments. Perhaps in the future, non-surgical methods to alter gait mechanisms, such as foot orthosis, knee bracing, or gait retraining, may be an effective means of addressing particular arthritic and pain problems of the lower extremity.

**ALIGNMENT BRACING**

Using gait analysis techniques, it has been shown that individuals with severe unicompartmental gonarthrosis can benefit from using valgus knee bracing to alter the biomechanics of knee function to more normal levels. Both kinetic and kinematic gait laboratory data support this finding. Abnormal adduction moments about the knee can also be significantly reduced, with medial tibiofemoral load reaching normal ranges. These changes appear to be the foundation for significant decreases in pain and increases in functional scores. Findings also demonstrate that valgus knee bracing is a mechanically valid method of treatment of medial compartment gonarthrosis.

Therefore, treatment of angular deformities of the tibiofemoral joint using orthosis reduce the malalignment, in turn reducing the joint forces to a greater extent than with a non-corrective brace. Furthermore, valgus orthosis are shown to share a significant proportion of load bearing (33%) during the majority of stance phase.

Adjusting the location of the center of gravity can effectively alter load transmission across the knee. This dynamic compensation involves either an external support or gait modification. Shifting the upper body center of mass to a position directly over the involved limb can decrease the medial compartment force by 50%, compared with its value, when the center of gravity is positioned in the midline.

**EXERCISE**

Often, patients are told not to exercise for fear of increasing their symptoms. Studies have shown that patients with osteoarthritis are able to tolerate weight-bearing exercises, especially walking. Hyaline-fibrocartilaginous healing is dependent on motion and hydrostatic pressure changes. The motion and pressure changes must be induced by weight-bearing exercise, which increases intra-articular diffusion of nutrients.

Dynamic loading of articular cartilage can promote the circulation of interstitial fluid. The forced circulation of interstitial fluid during cyclic compression might benefit cartilage metabolism by promoting the transport of various macromolecules necessary for cartilage metabolism. Intermittent negative hydrostatic pressure, within the extracellular matrix during cyclic dynamic loading, may promote healing by stimulating the metabolic activity of chondrocytes.
It has been well documented that mechanical forces can regulate the metabolic response of articular cartilage. For example, immobi-
lization or reduced loading of a joint results in a decrease in proteoglycan synthesis, whereas moderate exercise leads to an
increase in proteoglycan synthesis and thickening of the cartilage matrix. However, severe mechanical loading can cause a thinning
of cartilage matrix and leads to degenerative changes. 19

Aerobic training involving major muscle groups may help decrease active inflammatory disease, including osteoarthritis. This may
be done as a result of decreasing obesity, increasing bone density, or increasing muscle strength and tone. 19

Since obesity is a definite risk factor for osteoarthritis of the knee aerobic exercise such as cycling is recommended. However, keep
in mind that acute inflammation or joint swelling should be an absolute contraindication to initiate such exercise. 19 Cryotherapy fol-
lowing exercise remains an important measure in controlling post-exercise induced inflammation. 19

**QUADRICEPS FUNCTION**

In some cases, osteoarthritis may be due to deficiencies in the biomechanical mechanisms that minimize joint peak forces, e.g., the
active processes of joint flexion and muscle lengthening of the quadriceps. 12

Normally, the quadricep muscles contribute significantly to knee extension [concentric contraction] as well as controlled knee flex-
ion (eccentric contraction). Knee hyperextension with weak quadriceps muscles reduces knee stability during weight bearing, as
they are unable to restrain hyperextension. Since the quadriceps muscles become relatively inactive in the stance phase, additional
weakness further compounds the patient’s subjective descriptions of knee instability and giving way. 13

It is well established that pain-free joint effusions, whether induced experimentally or secondary to acute or chronic joint pathology,
prevent full volitional activation of muscles across the effused joint. This phenomenon has been called arthrogenous muscle inhibi-
tion (AMI). AMI has been shown to be present in pain-free joints clear of clinical effusion following traumatic and degenerative joint
pathologies. AMI is more than likely elicited by abnormal afferent information from the damaged joint, thus resulting in decreased
motor function to muscle groups that cross that joint. 7

AMI may undermine effective rehabilitation by preventing increases in strength of the affected muscle groups. Therefore, until inflam-
mation and joint effusion is decreased strength losses may be partly irreversible, exposing the joint to further structural damage. 7

**GAIT**

Although static malalignment is readily documented on long standing radiographs, it has not been a reliable means of predicting out-
come following corrective osteotomy. The clinical situation is far more complex, as simple activities of daily living can create dynamic
loading conditions that reflect additional considerations, including joint instability, quality of muscle contractions, and individual idiosyn-
crasies of gait. Gait analysis is being used more frequently to assess the dynamic aspects of malalignment, but this technology has not
been widely available. Unfortunately, most of the literature to date is representative of static assessments of malalignment. 20

Knee flexion is necessary to absorb shock during the load acceptance phase of gait. Therefore, any limitation of normal knee flexion
is intrinsically pathologic to OA. A limb that is hyperextended during this phase transfers body weight directly from the femur to the
tibia without the muscles absorbing energy and cushioning necessary to protect the joint (i.e., abnormal high compressive forces).
Long term patterns of knee hypertension frequently cause pain in the medial tibiofemoral joint and posterolateral ligamentous
structures. 13

Our over-all finding related to the major gait variables was that strength of the quadriceps femoris muscle was positively and signifi-
cantly correlated with flexion and extension excursions of the knee during the stance phase of gait. We believe that the observed
alterations in the gait of the patients in the present study represent an adaptation related to weakness of the quadriceps femoris.
This weakness closely predicts functional outcome. 14
Thrusting hyperextension motion at the knee is associated with an abnormally high adduction moment, which tends to increase medial compartment compression forces and lateral distraction forces. A knee brace limiting knee hyperextension may be useful initially; however, the patient needs to accomplish dynamic gait restraining and not push backward into the brace, using it as a passive limit to hyperextension.  

Subconscious control of limb position, such as foot placement, active muscle contraction, passive soft tissue stability, as well as the speed of walking, can influence dynamic loading at the knee.  

PROPRIOCEPTION

The multi-factorial etiology of osteoarthritis predominately involves molecular, biological, and mechanical changes as well as traumatic, genetic, and hormonal factors. The decline in proprioception also forms an important part of this pathogenetic process. The common finding of altered gait, which often cannot be attributed solely to pain, is an early sign of impaired proprioception. Proprioception has clearly been shown to decline with age. The age-related decline in proprioception appears to be present even in a clinically and radiologically normal joint; the degenerative process exacerbates this impairment.  

Changes in the gait of elderly subjects are partly explained by the decline in proprioception, even where no evidence of osteoarthritis exists. Patients with osteoarthritic joints have clearly been shown to have worse proprioception than control patients of corresponding age.  

In animal studies, deafferentation of structurally intact, stable joints does not accelerate joint degeneration. However, in unstable joints, deafferentation greatly accelerates joint degeneration.  

Muscular atrophy, very marked in some cases, was observed in almost all the investigated knee joints, and the deterioration in proprioception is thus partly due to muscular factors.  

A reduction of AMI following rehabilitation, allied with marked subjective and objective improvements, may reflect an improvement in muscle proprioception. Thus, rehabilitation incorporating proprioceptive retraining may be effective in retarding or reversing disease progression.  

ELECTRICAL STIMULATION

Application of a pulsing direct current to rabbit joints, in which an osteochondral defect was surgically created, resulted in an apparent improved quality of repair of the articular cartilage. The evaluation of the efficacy of the electrical signal used in this study was based on the presence of a superior repair tissue, i.e., fibrocartilage and hyaline cartilage vs. fibrous tissue in treated or untreated defects, respectively. Our data does not provide definitive evidence of possible mechanisms of action whereby electrical signals enhance the quality of the cartilage repair response. A reasonable postulate is that such treatment stimulates differentiation of mesenchymal cells derived from marrow elements into chondrocytes and induces proliferation of existing chondrocytes located at the wound margins.  

Our results demonstrated that intermittent pulsed electrical stimulation, delivered at night for 4 weeks, provided significant short-term improvement in knee pain, function, knee flexion, and duration of morning stiffness for patients with osteoarthritis of the knee.  

The use of neuromuscular electrical stimulation to activate muscle could short-circuit the effects of reflex inhibition of the quadriceps. External activation of the motor units most easily activated by electrical stimulation may have an effect on subsequent voluntary utilization of these same motor units. Volitional muscle strengthening may be unable to overcome the effects of this reflex inhibition during volitional exercise, regardless of the level of rehabilitative training.  

Perhaps irreversible muscle atrophy or an alteration in muscle cells occurs. Possibly patients are not encouraged to contract the muscles vigorously enough during exercise. We, as well as others, have demonstrated that neuromuscular electrical stimulation after reconstruction (of the anterior cruciate ligament) increases the strength of the quadriceps more than a similar regimen of volitional exercise. Perhaps the neuromuscular electrical stimulation overcomes the patient’s tendency not to contract the quadriceps fully.
INTRODUCTION

This manual contains information that is presented by Biodex Medical Systems as part of our commitment to provide continuing service to medical professionals and to the community at large.

IMPORTANT READ BEFORE PROCEEDING

Suggested courses of rehabilitation for any specific conditions are meant as references and generalized program models, and are not intended as precise prescriptions for individual treatment. The data is a compilation of information, based on the work of acknowledged experts, which has been published in respected medical journals.

We believe it is representative of current trends in scientifically derived and clinically proven principles and methods of rehabilitative medicine. Much of the published information that we review, however, is based on research and case studies involving very specific patient or test subject populations. Many research subjects, for instance, are highly trained and well-conditioned athletes prior to treatment, or are chosen because they have no known medical problems other than the condition involved in the study. It should therefore be noted that the application of any published methods should be done with extreme care, and should be based on limitations, and overall medical condition. In the presence of any doubt or question, regarding the efficacy of initiating a procedure, seek advice from appropriate sources and/or consult with the patient’s physician.

NOTE: This protocol is intended as a guide for rehabilitation associated with knee osteoarthritis. Consider appropriate program modifications if additional tissue pathology or damage is present, associated repairs or treatments are undertaken. This protocol was not intended to rehabilitate the patient post surgically. Consult the patient’s physician prior to incorporating any of the rehabilitation principles listed below.

Please send any comments or concerns to:

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A special thanks goes to Terry McLaughlin, MS, ATC, Steven Jacoby, ATC and Morgan Boyle III, MEd, ATC, for their assistance in the organization of this protocol.

REHABILITATION GOAL

The objective of rehabilitation for the knee osteoarthritis patient is to quickly and efficiently return the patient to the highest level of pre-injury activity as is reasonably possible with minimized risk of increased signs and symptoms, other related complications, or predisposing them to re-injury.
DEFINITIONS:

<table>
<thead>
<tr>
<th></th>
<th>Continuous WB</th>
<th>Intermittent WB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-duration</td>
<td>10-30 minutes</td>
<td>1/2-2 hours</td>
</tr>
<tr>
<td>Sustained</td>
<td>1/2-2 hours</td>
<td>2-4 hours</td>
</tr>
<tr>
<td>Prolonged</td>
<td>2-4 hours</td>
<td>4-8 hours</td>
</tr>
<tr>
<td>Extended</td>
<td>4-8 hours</td>
<td>&gt; 8 hours</td>
</tr>
</tbody>
</table>

ACTIVITY CLASSIFICATIONS:

Low-stress: Walking on level ground, swimming, aquatic exercise, cycling
Moderate-stress: Walking on uneven ground, climbing/descending stairs, lifting/carrying 10-25% BW, golf
High-stress: Running, jumping, climbing/descending ladders, lifting/carrying > 25% BW, softball, tennis or basketball
*0-100 score determined by the sum of rating values for each of the following 10 parameters

**SUBJECTIVE PATIENT RATING: VISUAL ANALOG SCALE**

1) Pain:
   - 10 = no pain
   - 0 = constant and severe pain

2) Overall ADL Function:
   - 10 = no impairment
   - 0 = incapable of walking without assistance

**CLINICAL EXAMINATION: STATUS RATED BY CLINICIAN**

3) Synovial Thickening/Effusion:
   - 10 = normal appearance
   - 8 = mild watery effusion
   - 6 = moderate to marked watery effusion, loss of normal concave surface contours
   - 4 = marked spongy effusion/synovial hypertrophy, tight joint distension
   - 2 = marked synovial hypertrophy, firm tissue consistency
   - 0 = gross joint enlargement, hard tissue consistency

4) Joint Stability:
   - 10 = stable joint
   - 8 = hypermobility with firm end points
   - 6 = mild pathologic laxity
   - 4 = moderate pathologic laxity, lack of firm end points
   - 2 = marked pathologic laxity, primarily confined to one plane of motion
   - 0 = gross multidirectional instability (complete ACL or PCL deficiency combined with marked varus or valgus laxity)

5) Maximum Passive Flexion (in degrees):
   - 10 = >120
   - 9 = 114 - 120
   - 8 = 107 - 113
   - 7 = 100 - 106
   - 6 = 93 - 99
   - 5 = 86 - 92
   - 4 = 79 - 85
   - 3 = 72 - 78
   - 2 = 66 - 71
   - 1 = 60 - 65
   - 0 = < 60

6) Maximum Active Extension (in degrees):
   - *Full extension = 0 degrees*
   - 10 = 0 - 2
   - 9 = 2 - 4
   - 8 = 5 - 6
   - 7 = 7 - 8
   - 6 = 9 - 10
   - 5 = 11 - 12
   - 4 = 13 - 14
   - 3 = 15 - 16
   - 2 = 17 - 18
   - 1 = 19 - 20
   - 0 = > 20

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7) Gait:
   10 = optimal, unlimited walking distance @ >3.0 mph pace
   8 = capable of >20 min. walking @ >10% elevation and >2.5 mph pace with optimal gait
   6 = capable of >10 min. walking @ >2.5 mph pace, no limping or gait asymmetry
   4 = capable of >5 min. walking @ >2.0 mph pace, mild limping/gait asymmetry evident
   2 = incapable of >5 min. walking without assistive device, moderate degree of limping
   0 = incapable of ambulation without assistive device

RADIOGRAPHIC PRESENTATION (STANDING A-P VIEW): STATUS RATED BY CLINICIAN

8) Joint Space/Articular Surface:
   10 = 100% joint space, surface normal
   8 = 50-100% joint space, surface normal
   6 = 50-100% joint space, surface mildly irregular
   4 = <50% joint space, surface mildly irregular
   2 = <50% joint space, surface moderately irregular
   0 = joint space obliterated, severe surface degeneration

9) Varus/Valgus Malalignment: Measured in degrees
   10 = 0 6 = 4 - 5 2 = 12 - 13
   9 = 1 5 = 6 - 7 1 = 14 - 15
   8 = 2 4 = 8 - 9 0 = >15
   7 = 3 3 = 10 - 11

PERFORMANCE TESTING: DYNAMOMETER

10) Quadricep Peak Torque to Body Weight: Isometric or isokinetic value.
    Isometric @ 60° angle       Isokinetic @ 300 deg/sec
    10 = >100 10 = >50
    9 = 95-100 9 = 48-50
    8 = 89-94 8 = 45-47
    7 = 83-88 7 = 42-44
    6 = 77-82 6 = 39-41
    5 = 71-76 5 = 36-38
    4 = 65-70 4 = 33-35
    3 = 60-64 3 = 30-32
    2 = 55-59 2 = 27-29
    1 = 50-54 1 = 25-26
    0 = <50 0 = <25
PHASE I

FUNCTIONAL STATUS:

- Sustained weight-bearing activity and ability to perform certain ADLs severely limited by weakness, pain, and/or swelling
  - Level 0: Incapable of ambulation without assistive device.
  - Level 1: Crutches required for ambulation, but capable of pain-free walk-through crutch gait with 50-75% WB
  - Level 2: Capable of ambulating 100% WB short distances, but with some pain and/or apprehension and obvious limping

GOALS AND CRITERIA FOR ADVANCEMENT:

- Educate/mentally prepare patient for rehabilitation
- Identify specific needs relative to performance of ADLs
- Identify potential problems (exercise contraindications)
- Reduce pain and swelling
- Maintain hip and ankle strength and function
- Normalize gait deviations and correct biomechanical faults
- Identify contributory factors
- Increase tolerance for sustained weight-bearing activity
- PROM < 30% deficit
- Proprioception < 40% deficit
- Isometric Strength QUAD/HAM < 40% deficit bilaterally

CLINICAL EVALUATION (INITIAL):

- General history and observation (previous knee injury/surgery)
- Patient assessment of pain and function: Visual Analog Scale
- Determine OA index
- Knee appearance: Swelling and/or synovial thickening, QUAD tone
- Pain: Location, quality, relationship to weight-bearing activities (Walking, stair climbing/descending), duration, severity
- Evidence of knee degeneration (using radiographs, MRI, and/or surgical report) such as changes in articular surface, joint space height, tibiofemoral alignment and/or the existence of osteophytes
- Palpation: Localized tenderness, crepitus and character of swollen/thickened tissue
- Range of motion: Extension/flexion (passive and active)
CLINICAL EVALUATION (INITIAL) (cont.):


  TEST: Bilateral isometric 2 position evaluation
  - **Device:** Biodex Multi-Joint System
  - **Motion:** knee EXT/FLEX
  - **Pad Placement:** normal [distal]
  - **Setup:** 30º/60º
  - **Mode:** Isometric
  - **Reps and Time:** 5 @ 5 sec

  TEST: Bilateral Open Kinetic Chain (OKC) Proprioception
  - **Device:** Biodex Multi-Joint System
  - **Motion:** knee EXT/FLEX
  - **Report:** Active and passive position sense
  - **Setup:** full active range of motion
  - **Percent Range:** as tolerated
  - **Mode:** Isokinetic and Passive
  - **Reps and Speed:** 5 @ 30 deg/sec; 5 @ 60 deg/sec

  TEST: Balance with bilateral and unilateral stance
  - **Device:** Biodex Balance System
  - **Report:** Stability Index
  - **Stance:** Bilateral and Unilateral
  - **Duration:** 5 bouts of 30 sec each stance
  - **Stability Level:** 8

  TEST: Gait evaluation (footnote)
  - **Device:** Biodex Gait Trainer
  - **Speed:** Very slow, comfortable for patient
  - **Elevation:** 0%
  - **Recommendations:** Gradually increase speed and duration of walking with proper gait, emphasis on proper foot progression angle and gait symmetry

CLINICAL TREATMENT OPTIONS:

- Rehab process education
- Psychological preparation:
  - Compliance
  - Expectations
  - Cautions
- Reduce edema and manage pain:
  - **PR.R.C.E.:** Cryotherapy and compressive garment (neoprene or elastic) for reduction of pain and swelling
  - Electrical Stimulation (6-10 hr/day) to decrease pain, stiffness and swelling
- Electrical stimulation of QUAD for maximal activation if unable to perform SLR or reflex inhibition interferes with optimal voluntary contraction
- Application of brace and/or foot orthotics [lateral wedge] if medial joint space narrowing and/or varus tibiofemoral malalignment of >5 degrees is evident
- Ambulation Training with emphasis on “normal” gain
- Instruct on use of crutches (as needed)
- Passive (PROM), Active (AROM) and Active Assisted Range of Motion (AAROM) exercises

PHASE I: REDUCTION OF ACUTE SYMPTOMS
CLINICAL TREATMENT OPTIONS (cont):

- Passive Range of Motion (PROM):
  Device: Biodex Multi-Joint System
  Pattern: Knee EXT/FLEX
  Setup: ROM Limits set to treatment goals
  Percent Range: initial settings well within current PROM
  Mode: Passive Speed: 2 deg/sec initial setting
  Duration: 5-15 min as tolerated
  Recommendations: Instruct patient to produce no force. Determine pain-free ROM by gradual adjustment of "percent range". Can be done concurrently with ice/heat and electric.

- Non-weight-bearing Proprioception:
  Device: Biodex Multi-Joint System
  Passive and Active position sense
  Pattern: Knee EXT/FLEX
  Mode: Passive and Isokinetic
  Sets and Reps: 3 x 5 each target angle
  Target angles: 90º/60º/30º
  Recommendations: There should be no incidence of pain or inhibition with movement.

- Weight-bearing Proprioception:
  Device: Biodex Balance System
  Stance: Bilateral (Both feet)
  Setup: Dynamic Balance
  Stability level: 8 (most stable) progressing to 6 (less stable)
  Duration: 5 bouts of 30 sec (progressing to 10 bouts)
  Exercises: Balancing, controlled circumduction of platform, controlled forward-backward and side-to-side platform tilting
  Recommendation: Initially determine WB capability. If unable to fully WB, use Unweighing System to unweigh up to 40% BW initially with bilateral stance, or train from a non-weight bearing position unilaterally. Gradually increase amount of WB as tolerated.

- QUAD/HAM strengthening:
  Device: Biodex Multi-Joint System
  Mode: Isometric
  Angles: 30º/60º
  Sets and Reps: 3 x 10
  Contract/Relax: 3 seconds/5 seconds
  Recommendations: Provide visual performance feedback and verbal encouragement for maximal effort

- Isotonic strengthening:
  Hip flexion, quad sets, abduction and adduction SLRs, progressively increasing repetitions and ankle cuff weight resistance.

- Low-speed treadmill walking with Unweighing System:
  Gradually increase speed and duration of walking with proper gait:
  Device: Biodex Gait Trainer
  Speed: Very slow, comfortable for patient
  Elevation: 0%
  Duration: Progress to 15 min, as tolerated
  Recommendations: Unweighing up to 40% of BW and increase WB as tolerated - emphasis on proper foot progression angle
SUPERVISED PROGRAM:

- Control edema and manage pain
- Stretching for preservation/restoration of extensibility in posterior capsule/HAM (hip flexion and knee extension) and anterior capsule/QUAD (knee flexion and hip extension)
- Cardiovascular training: Biodex UBC > 20 min. at 60%-80% MHR
- Stationary cycling initiated when knee flexion is > 90 degrees flexion:
  - **Device**: Biodex BioStep® Semi-Recumbent Elliptical
  - **Mode**: Isokinetic
  - **Speed**: Gradual increase to 60 RPM as capable
  - **Duration**: 5-15 min
  - **Recommendation**: Increase seat height to accommodate limited knee flexion ROM
- Gait Training:
  - **Device**: Biodex Gait Trainer
  - Low-speed treadmill walking with Biodex Unweighing System
  - Gradually increase speed and duration of walking with proper gait:
    - **Speed**: Very slow, comfortable for patient
    - **Elevation**: 0%
    - **Duration**: Progress to 15 min, as tolerated
  - **Recommendations**: Unweighing up to 40% of BW and increase WB as tolerated - emphasis on proper foot progression angle and step symmetry

HOME PROGRAM:

- Reduce edema and manage pain:
  - **PR.I.C.E.**: Cryotherapy and compressive garment (neoprene or elastic) for reduction of pain and swelling
  - **Electrical Stimulation**: (6-10 hr/day) to decrease pain, stiffness and swelling
- Passive and active ROM exercises
- QUAD and HAM strengthening: SLRs (four planes), quad sets and standing leg curls

REPORTS:

- Pain Scale
- Functional status
- Biodex Bilateral OKC Proprioception test
- Biodex Stability Index (as indicated by weight-bearing status)
- Biodex Isometric Bilateral comparison QUAD/HAM @ 30 and 60 degrees
- Knee OA Index: score on 100-point scale
PHASE II  range of motion & initial strengthening

**FUNCTIONAL STATUS:**
- Prolonged weight-bearing activity and/or ability to perform moderate-stress ADLs primarily limited by gross muscle weakness and/or rapid muscle fatigue.
- Pain and/or swelling does not preclude initiation of isotonic and isokinetic strengthening program and progressive closed-chain unidirectional exercises.
  - Level 3: Capable of unassisted walking for at least 5 min without pain/apprehension or gross gait abnormality
  - Level 4: Capable of maintaining unilateral postural stability for at least 5 seconds with knee flexed at 40 degrees (unilateral mini-squat or stop down from platform)
  - Level 5: Capable of upslope Power walking on treadmill (> 2.5 mph, > 10% elevation) for at least 10 min, with symmetrical gait and without pain

**GOALS AND CRITERIA FOR ADVANCEMENT:**
- Decrease pain and inflammation
- Pain-free performance of PREs
- Minimal post-exercise joint swelling and/or discomfort
- Identify specific needs relative to performance of moderate-stress ADLs
- Identify potential problems (exercise contraindications)
- Increase strength and endurance of hip abductors and adductors
- Eliminate any dependence on assistive device for ambulation
- Increase walking Speed and distance with optimal gait
- Increase tolerance for prolonged weight-bearing activity
- Increase Balance Index: Two-foot stance (when indicated by WB status)
- Increase knee EXT/FLEX ROM to < 20% deficit
- Proprioception < 30% deficit
- Isometric strength QUAD/HAM < 20% deficit
- Isokinetic strength QUAD/HAM < 40% deficit at 300 deg/sec
**CLINICAL EVALUATION:**

- Functional Status Level
- Verify home program compliance
- Determine OA index
- Knee appearance: Increase vs. decrease in swelling and/or synovial thickening since last evaluation
- Pain: Any change in location, quality, duration or severity since last evaluation - note relationship to weight-bearing activities
- Palpation: Any change in localization of tenderness, crepitus and character of swollen or thickened tissue since last evaluation
- Range of motion: Active and passive EXT/FLEX

**TEST: Gait evaluation**

- **Device:** Biodex Gait Trainer
- **Report:** Exercise Summary
  - Speed: Very slow, comfortable for patient
  - Elevation: 0%
  - Recommendations: Gradually increase speed and duration of walking with proper gait - emphasis on proper foot progression angle and gait symmetry

**TEST: Bilateral stability**

- **Device:** Biodex Balance System
- **Report:** Stability Index
  - Stance: Bilateral (Both feet)
  - Setup: Dynamic Balance
  - Stability level: 8
  - Duration: 5 bouts of 30 sec (progressing to 10 bouts)

**TEST: Bilateral isometric QUAD/HAM evaluation**

- **Device:** Biodex Multi-Joint System
- **Motion:** knee EXT/FLEX
- **Report:** Isometric Evaluation
  - Setup: 30 and 60º
  - Mode: Isometric
  - Reps and Time: 5 @ 5 sec
  - Recommendation: Instruct patient to generate as much force as they feel capable.

**TEST: OKC Proprioception**

- **Device:** Biodex Multi-Joint System
  - Active (muscle mechanoreceptor)
  - Passive (joint capsule mechanoreceptor)

**TEST: Bilateral isokinetic QUAD/HAM evaluation**

- **Device:** Biodex Multi-Joint System
- **Motion:** knee EXT/FLEX
- **Report:** Isokinetic Evaluation
  - ROM: Full
  - Setup: 300 deg/sec
  - Sets and Reps: 1 x 10
  - Recommendation: Perform test as tolerated by patient
**CLINICAL TREATMENT OPTIONS:**

- Electrical stimulation of QUAD during isometric strength training (if reflex inhibition prevents strength gains)

- Hip flexion SLRs with eccentric knee flexion: 45° hip flexion maintained in supine position while knee is slowly flexed from 0- 45° with ankle cuff weight

- Hip abduction and hip adduction SLRs, progressively increasing repetitions and ankle cuff weight resistance

- Short-arc isotonic QUAD and HAM strengthening within pain-free ROM, progressively increasing arc of motion from 90°+ to full extension (unless contraindicated) and progressively increasing reps and resistance

- **Active-assisted Range of Motion (AAROM):**
  
  **Device:** Biodex BioStep® Semi-Recumbent Elliptical  
  **Mode:** Isokinetic  
  **Speed:** 60 RPM  
  **Duration:** 15-30 min  
  **Recommendation:** Have patient perform greater power output/increased duration for each session.

- **Gait training:**
  
  **Device:** Biodex Gait Trainer  
  **Speed:** Slow initially, progressively increasing  
  **Elevation:** 0% initially, progressively increasing  
  **Duration:** Progressively increase to 20 min  
  **Recommendations:** Defer increases in speed, elevation, or duration with any deterioration in gait pattern or discomfort. Decrease Unweighing system support to < 20%

- **Strengthening:**
  
  **Device:** Biodex Multi-Joint System  
  **Pattern:** Knee flexion/extension  
  **Mode:** Isometric  
  **Setup:** 90°/60°/30°  
  **Sets and Reps:** 3 x 10  
  **Contract/Relax:** 3 seconds/5 seconds  
  **Recommendations:** Provide visual performance feedback and verbal encouragement for maximal effort.

  **Device:** Biodex Multi-Joint System  
  **Pattern:** Knee flexion/extension  
  **Mode:** Isokinetic  
  **Setup:** No ROM restriction, unless necessary for comfort.  
  **Speed:** 300 deg/sec  
  **Recommendations:** Defer isokinetic testing if patient is incapable of wide-arc (100°) EXT/FLEX. Perform isometric contractions if isokinetic contractions induce pain.

  **Device:** Biodex Multi-Joint System  
  **Exercise:** High-speed resistive QUAD/HAM training  
  **Mode:** Isokinetic  
  **Setup:** No ROM restriction, unless necessary for comfort  
  **Speed:** 300 deg/sec  
  **Recommendations:** First set determines maximum total work for 30-second set; second set goal is to achieve first set's total work in minimum time. Perform third set at second set's total work goal achieved in < 45 seconds.
  
  Isotonic terminal knee extension Sets and Reps: 3 x 10 with 3-second hold  
  **Pattern:** Unilateral short-arc eccentric lowering (30-40 degrees, pain-free range), bilateral concentric lift back to full extension, progressively increasing repetitions and resistance -isotonic wide-arc knee flexion (0-90 degrees) - isotonic standing hip abduction and adduction.
CLINICAL TREATMENT OPTIONS (cont):

- Non-weight-bearing Proprioception:
  
  **Device:** Biodex Multi-Joint System
  
  Passive and Active position sense
  
  **Pattern:** Knee EXT/FLEX
  
  **Mode:** Passive and Isokinetic
  
  **Sets and Reps:** 3 x 5 each target angle
  
  **Hold:** 10 seconds
  
  **Target angles:** 90º/60º/30º/0º
  
  **Recommendations:** There should be no incidence of pain or inhibition with movement.

- Weight-bearing Proprioception:
  
  **Device:** Biodex Balance System
  
  **Stance:** Bilateral (Both feet)
  
  **Setup:** Dynamic Balance
  
  **Stability level:** 8 (most stable) progressing to 6 (less stable)
  
  **Duration:** 5 bouts of 30 sec (progressing to 10 bouts)
  
  **Exercises:** Balancing, controlled circumduction of platform, controlled forward-backward and side-to-side platform tilting.
  
  **Recommendation:** Initially determine WB capability. If unable to fully WB, use Unweighing System to unweigh up to 40% BW initially with bilateral stance, or train from a non-weight bearing position unilaterally. Gradually increase amount of WB as tolerated.

SUPERVISED PROGRAM:

- Control edema and manage pain

- **P.R.I.C.E.**

- Stretching for preservation/restoration of extensibility in posterior capsule/HAM (hip flexion + knee extension) and anterior capsule/QUAD (knee flexion + hip extension)

- Electrical Stimulation as needed for pain and edema control

- Hip isotonics, calf raises and knee OKC and CKC exercises

- Cardiovascular Training: Biodex UBC, LBC or Treadmill
HOME PROGRAM:

- Control pain and swelling using P.R.I.C.E.
- Passive and active ROM exercises
- Strengthening: Hip isotonics, calf raises and NWB knee exercises
- Cardiovascular Training: cycling, walking (as tolerated) or swimming for > 20 min at 60-80% MHR

REPORTS:

- Pain scale
- Functional status
- Biodex Stability Index (as indicated by weight-bearing status)
- Biodex Gait Trainer exercise summary
- Knee OA Index: score on 100-point scale
- OKC Proprioception evaluation
- Isokinetic evaluation: QUAD/HAM @ 180 and 300 deg/sec
PHASE III

FUNCTIONAL STATUS:
- Extended weight-bearing activity and/or ability to perform some moderate-stress ADLs. Primarily limited by muscle weakness, inadequate fatigue resistance, and/or lack of multi-segmental neuromuscular coordination.
- Pain and/or swelling does not preclude initiation of complex, closed chain, multi-segmental/multi-directional movement patterns.
  Level 6: QUAD and HAM isokinetic performance deficit for involved extremity:
  < 40% @180 deg/sec < 30% @ 300 deg/sec
  Level 7: Limited* return to normal vocational activities with specific work restrictions

GOALS:
- Pain-free performance of multi-segmental and multidirectional CKC exercises
- No post-exercise joint swelling or discomfort
- Identify specific deficiencies contributing to inability to perform complex functional activities
- Identify potential problems [work activity restrictions]
- Increase walking speed and distance with maintenance of optimal gait
- Increase tolerance for extended weight-bearing activity
- Increase Balance Index: Two-foot stance and single-foot stance [when indicated by weight-bearing status]
- Range of Motion (ROM) < 10% deficit
- Open Kinetic Chain (OKC) Proprioception < 10% deficit
- Isometric strength QUAD/HAM < 10% deficit
- Isokinetic strength QUAD/HAM < 40% deficit @ 180 deg/sec < 30% deficit @ 300 deg/sec
- Cardiovascular conditioning > 30 min @ 60-80% MHR
CLINICAL EVALUATION:

- Verify home program compliance
- Functional Status Level
- Knee appearance: Increase vs. decrease in swelling and/or synovial thickening since last evaluation
- Pain: Any change in location, quality, duration or severity since last evaluation. Note relationship to weight-bearing activities
- Palpation: Any change in localization of tenderness, crepitus, character of swollen or thickened tissue since last evaluation
- Range of motion: active and passive EXT/FLEX

TEST: Gait evaluation
  **Device:** Biodex Gait Trainer
  **Report:** Exercise Summary
  **Speed:** Very slow, comfortable for patient
  **Elevation:** 0%
  **Recommendations:** Gradually increase speed and duration of walking with proper gait - emphasis on proper foot progression angle and gait symmetry

TEST: Stability Index
  **Device:** Biodex Balance System
  **Report:** Stability Index
  **Stance:** Bilateral (two-foot stance) and Unilateral (single foot stance) when indicated by WB status.
  **Eyes:** Open
  **Trials and Duration:** 3 x 30 sec

TEST: OKC Proprioception
  **Device:** Biodex Multi-Joint System
  **Active (muscle mechanoreceptor)**
  **Passive (joint capsule mechanoreceptor)**

TEST: Bilateral isometric QUAD/HAM evaluation
  **Device:** Biodex Multi-Joint System
  **Motion:** knee EXT/FLEX
  **Report:** Isometric Evaluation
  **Setup:** 30º/60º/90º
  **Mode:** Isometric
  **Reps and Time:** 5 @ 5 sec
  **Recommendation:** Instruct patient to generate as much force as they feel capable.

TEST: Bilateral isokinetic QUAD/HAM evaluation
  **Device:** Biodex Multi-Joint System
  **Motion:** knee EXT/FLEX
  **Report:** Isokinetic Evaluation
  **ROM:** Full
  **Setup:** 180 and 300 deg/sec
  **Sets and Reps:** 1 x 10 each
  **Recommendation:** Perform test as tolerated by patient

4-20 PHASE III: INITIAL WEIGHT-BEARING & INTERMEDIATE STRENGTHENING
CLINICAL TREATMENT OPTIONS:

- Isokinetic knee extension/flexion test:
  
  **Device:** Biodex Multi-Joint System
  
  **Mode:** Isokinetic
  
  **Setup:** No ROM restriction
  
  **Speeds:** 60, 180 and 300 deg/sec
  
  **Recommendations:** Defer testing at 60 deg/sec if pain is experienced during warm-up trials
  
- 4-way standing straight leg kicks (flexion, extension, abduction, and adduction), standing on involved extremity, non-involved extremity motions resisted by elastic band
  
- Weight-bearing Proprioception:
  
  **Device:** Biodex Balance System
  
  **Stance:** Bilateral (Both feet)
  
  **Setup:** Dynamic Balance
  
  **Stability level:** 6 (most stable) progressing to 4 (less stable)
  
  **Duration:** 5 bouts of 30 sec (progressing to 10 bouts)
  
  **Exercises:** Balancing, controlled circumduction of platform, controlled forward-backward and side-to-side platform tilting.
  
  **Recommendation:** Initially determine WB capability. If unable to fully WB, use Unweighing System to unweigh up to 40% BW initially with bilateral stance, or train from a non-weight bearing position unilaterally. Gradually increase amount of WB as tolerated
  
- Upslope treadmill walking, forward and backward.
  
  **Device:** Biodex Rehabilitation Treadmill
  
  **Speed:** Progressively increasing to maximum capability
  
  **Elevation:** Progressively increasing to maximum capability
  
  **Duration:** 20 min or more
  
  **Recommendations:** Do not increase walking speed, elevation, or duration beyond levels that permit maintenance of proper gait
  
- Cardiovascular training:
  
  60-80% max heart rate sustained for >30 min (stair-stepper, treadmill, stationary cycle, rowing, x-country skiing, upper body cycle, etc)
  
  Lower extremity exercises as tolerated by patient
  
- Analysis of critical functional demands of job (work site visit, if possible)

SUPERVISED PROGRAM:

- Control edema and manage pain using P.R.I.C.E.
  
- Stretching for preservation/restoration of extensibility in posterior capsule/HAM (hip flexion and knee extension) and anterior capsule/QUAD (knee flexion and hip extension)
  
- Electrical Stimulation as needed for pain and edema control
  
- Supervised performance of work-specific functional tasks (pushing, pulling, lifting, carrying, climbing, etc)
  
- Hip isotonics, calf raises and knee OKC and CKC exercises
  
- Cardiovascular Training: Biodex UBC, LBC or Treadmill
**HOME PROGRAM:**

- Control pain and swelling using P.R.I.C.E.
- Passive and active ROM exercises
- Unilateral postural balance exercises
- Strengthening: Hip isotonics, calf raises and knee OKC exercises for QUAD and HAM
- Cardiovascular Training: cycling, walking [as tolerated] or swimming for > 30 min at 60-80% MHR

**REPORTS:**

- Pain Scale
- Functional status
- Knee OA index: score on 100-point scale
- Cardiovascular status
- Biodex Gait Trainer exercise summary
- Biodex Stability Index: Bilateral and unilateral evaluation
- Biodex Isokinetic Bilateral comparison QUAD/HAM @ 60, 180 and 300 deg/sec
  
  Test @ 60 deg/sec only if patient has full ROM and is pain-free with activity
PHASE IV

FUNCTIONAL STATUS:

- Ability to perform high-stress work-related activities and/or participate in high-stress sports and/or recreational activities primarily limited by lack of sufficient strength and/or lack of multi-segmental neuromuscular coordination
- Status of articular surfaces and level of knee instability do not preclude initiation of dynamic impact absorption exercises (Knee OA Index score > 80)
  - Level 8: Unrestricted work/sports participation, periodic functional limitation or performance decrement due to discomfort and/or activity-induced joint inflammation
  - Level 9: Unrestricted work/sports participation, completely asymptomatic during all functional activities, minor work/sports performance decrement and/or periodic post-activity discomfort
  - Level 10: Optimal knee function, completely asymptomatic

GOALS AND CRITERIA FOR ADVANCEMENT:

- Pain-free performance of eccentric strengthening and plyometric impact absorption exercises
- No post-exercise joint swelling or discomfort
- Identify specific deficiencies contributing to inability to effectively dampen impact loading of knee joint surface
- Identify potential problems (high-stress activities associated with patient’s lifestyle and/or vocation)
- Continue emphasis on increasing strength and endurance of QUAD and HAM
- Increase running speeds and distance with maintenance of optimal gait
- Continue to enhance postural stability and neuromuscular control of lower extremity joints
- Increase tolerance for high-stress weight-bearing activity
- Stability Index within normal range for age
- OKC Proprioception equal bilaterally
- Optimal QUAD strength: QUAD PT/BW > .90 @ 60 deg/sec and > .45 @ 300 deg/sec
- Optimal HAM strength: HAM PT/BW > .50 @ 60 deg/sec and > .35 @ 300 deg/sec
CLINICAL EVALUATION:

- Verify home program compliance
- Functional Status Level
- Knee appearance: Increase vs. decrease in swelling since last evaluation
- Pain: Any change in location, quality, duration or severity since last evaluation - note relationship to weight-bearing activities
- Palpation: Any localized tenderness, crepitus, or swelling
- Range of Motion: Ext/Flex, PROM/AROM

TEST: Gait evaluation
  Device: Biodex Gait Trainer
  Report: Exercise Summary
  Speed: Very slow, comfortable for patient
  Elevation: 0%
  Recommendations: Gradually increase speed and duration of walking with proper gait. Emphasis on proper foot progression angle and gait symmetry. Assessment of running speed and endurance, and quantification of gait parameters

TEST: Stability Index
  Device: Biodex Balance System
  Report: Stability Index
  Stance: Bilateral (two-foot stance) and Unilateral (single foot stance) when indicated by WB status
  Eyes: Open
  Trials and Duration: 3 x 30 sec

TEST: OKC Proprioception
  Device: Biodex Multi-Joint System
  Active (muscle mechanoreceptor)
  Passive (joint capsule mechanoreceptor)

TEST: Bilateral isokinetic QUAD/HAM evaluation
  Device: Biodex Multi-Joint System
  Motion: knee EXT/FLEX
  Report: Isokinetic Evaluation
  Pad Placement: proximal
  ROM: Full
  Setup: 60 and 300 deg/sec
  Sets and Reps: 1 x 10 each
  Recommendation: Perform test as tolerated by patient
CLINICAL TREATMENT OPTIONS:

- Isokinetic knee extension/flexion:
  - **Device**: Biodex Multi-Joint System
  - **Mode**: Isokinetic
  - **Setup**: No ROM restriction.
  - **Speeds**: 180 and 300 deg/sec
  - **Recommendations**: Increase number of repetitions to 15-20 to increase muscular endurance

- Isokinetic knee extension/flexion:
  - **Device**: Biodex Multi-Joint System
  - **Mode**: Isokinetic
  - **Setup**: No ROM restriction
  - **Speeds**: 60 deg/sec
  - **Recommendations**: Defer testing if pain exists

- 4-way standing straight leg kicks (flexion, extension, abduction, and adduction), standing on involved extremity, non-involved extremity motions resisted by elastic band

- Stair-stepper machine, progressively increasing work intensity and duration to >30 min

- Aerobic training, 60-80% max heart rate sustained for >30 min (stair-stepper, treadmill, stationary cycle, rowing, x-country skiing, upper body cycle, etc)

- Weight-bearing Proprioception:
  - **Device**: Biodex Balance System
  - **Stance**: Bilateral (Both feet)
  - **Setup**: Dynamic Balance
  - **Stability level**: 4 (most stable) progressing to 2 (less stable)
  - **Duration**: 5 bouts of 30 sec (progressing to 10 bouts)
  - **Exercises**: Balancing, controlled circumduction of platform, controlled forward-backward and side-to-side platform tilting
  - **Recommendation**: Initially determine WB capability. If unable to fully WB, use Unweighing System to unweigh up to 40% BW initially with bilateral stance, or train from a non-weight bearing position unilaterally. Gradually increase amount of WB as tolerated.

- Upslope treadmill walking, forward and backward
  - **Device**: Biodex Rehabilitation Treadmill
  - **Speed**: Progressively increasing to maximum capability
  - **Elevation**: Progressively increasing to maximum capability
  - **Duration**: 20 min or more
  - **Recommendations**: Do not increase walking speed, elevation, or duration beyond levels that permit maintenance of proper gait.

- Analysis of critical functional demands of job (work site visit, if possible)

- Review of home program exercises for post-release maintenance
SUPERVISED PROGRAM:

- Control edema and manage pain using P.R.I.C.E.
- Stretching for preservation/restoration of extensibility in posterior capsule/HAM (hip flexion and knee extension) and anterior capsule/QUAD (knee flexion and hip extension)
- Electrical Stimulation as needed for pain and edema control
- Supervised performance of work-specific functional tasks (pushing, pulling, lifting, carrying, climbing, etc)
- Hip isotonics - calf raises and knee OKC and CKC exercises
- Cardiovascular Training: Biodex UBC, LBC or Treadmill

HOME PROGRAM:

- Control pain and swelling using P.R.I.C.E.
- PROM and AROM exercises
- Unilateral postural balance exercises
- Strengthening: Hip isotonics, calf raises and knee OKC exercises for QUAD and HAM
- Flexibility training: post-exercise
- Cardiovascular Training: cycling, walking (as tolerated) or swimming for > 30 min at 60% to 80% MHR

REPORTS:

- Pain Scale
- Functional status
- Knee OA index: score on 100-point scale
- Cardiovascular status
- Biodex Gait Trainer evaluation
- Biodex Stability Index: Bilateral and unilateral evaluation
- Isokinetic evaluation: QUAD/HAM @ 60, 180 and 300 deg/sec
**NORMATIVE VALUES:**

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<tr>
<th>Age (yrs)</th>
<th>Stability Index</th>
<th>Standard Deviation (+/-)</th>
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<tbody>
<tr>
<td>17-35</td>
<td>1.54</td>
<td>0.72</td>
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<tr>
<td>36-53</td>
<td>2.13</td>
<td>0.90</td>
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<tr>
<td>54-71</td>
<td>2.57</td>
<td>0.78</td>
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<tr>
<td>72-89</td>
<td>2.70</td>
<td>0.80</td>
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Females are more stable than males:

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<tr>
<th>All ages</th>
<th>Stability Index</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>1.94</td>
<td>0.80</td>
</tr>
<tr>
<td>Males</td>
<td>2.70</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Values were collected by J.A. Finn, et al, Stability Performance Assessment among Subjects of Disparate Balancing Abilities. Southern Connecticut State University.


# EVIDENCE BASED CLINICAL PROTOCOL FOR THE MANAGEMENT OF: knee osteoarthritis

## Phase I:
### Reduction of Acute Symptoms
- Decrease pain and edema (s/p exercise)
- Pain-free performance of P.T.
- Identify potential problems or contraindications of exercise, A.D.L.'s
- Maintain ankle and hip ROM and strength
- Elimination of ambulation assistive devices
- Increased walking speed and distance
- Increased tolerance for prolonged WB activity
- PROM < 20% deficit
- OKC Proprioception < 30% deficit
- Isometric strength QUAD/HAM < 20% deficit
- Isometric strength QUAD/HAM < 40% deficit @ 300 deg/sec
- Increased Balance Index: 2 foot stance

## Phase II:
### Range of Motion and Initial Strengthening
- Functional Status Level, pain assessment
- General patient history and observation (previous injury/surgery)
- Knee OA Index
- ROM (active/passive)
- Joint stability (varus/volus, A/P)
- Neurological assessment: myotomes, dermatomes, and reflexes
- Palpation: Localized tenderness, crepitus, character of swollen tissue
- Functional status: WB and A.D.L's
- TEST: Biodyex bilateral isometric QUAD @ 60; HAM @ 30 degrees
- TEST: Biodyex bilateral isokinetic QUAD/HAM @ 300 deg/sec
- TEST: Biodyex Gait Trainer Evaluation
- TEST: Biodyex Balance System (bi/unilateral)

## Goals:
- Mentally prepare patient for rehabilitation
- Education of Pt to understand the problems of osteoarthritis
- Identify specific needs of patient and potential problems
- Decrease pain and edema
- Maintain ankle and hip ROM, strength, function
- Normalize gait deviations and correct biomechanical faults
- Identify contributory factors
- PROM < 30% deficit
- OKC Proprioception < 40% deficit
- Isometric strength QUAD/HAM < 40% deficit bilaterally
- Increase tolerance for sustained WB activity

## Clinical Evaluations:
- Functional Status Level, pain assessment
- General patient history and observation (previous injury/surgery)
- Knee OA Index
- ROM (active/passive)
- Joint stability (varus/volus, A/P)
- Neurological assessment: myotomes, dermatomes and reflexes
- Palpation: Localized tenderness, crepitus, character of swollen tissue
- Functional status: WB and A.D.L's
- TEST: Biodyex bilateral isometric QUAD @ 60; HAM @ 30 degrees
- TEST: Biodyex bilateral isokinetic QUAD/HAM @ 300 deg/sec
- TEST: Biodyex Gait Trainer Evaluation
- TEST: Biodyex Balance System (bi/unilateral)

## Clinical Treatment Options:
- Rehabilitation process education
- Assisted ambulation device fitting / training
- Reduce edema / inflammation and spasm / pain
- PRI.C.E.
- High-Volt ES to reduce pain
- Muscle re-education of QUAD with ES
- Flexibility training of QUAD with ES
- ROM: Biodyex passive @ 2 deg/sec for 5-15 min.
- Strengthening:
  - Biodyex isometric QUAD @ 60; HAM @ 30
  - Biodyex isokinetic/passive @ 30/60/90 degrees
  - Gait and Quad sets
- Stability: Biodyex Balance System with Unweighing System
- Cardiovascular training: Biodyex UBC or LBC
- Non-WB Proprioception training: Biodyex MJ5
- Gait: Biodyex Gait Trainer with Unweighing System
- Reduce edema / spasm / pain
- PRI.C.E.
- High-Volt ES to reduce pain
- ES of QUAD with isometric contractions PRN
- Flexibility training (H.S, QU, hip F/E)
- Knee Strengthening:
  - Biodyex isokinetic wide-arc QUAD/HAM @ 180/300 deg/sec
  - Biodyex isokinetic high speed QUAD/HAM @ 300 deg/sec
  - Biodyex isotonic terminal knee extension
  - Biodyex isotonic wide-arc knee flexion
- Hip Strengthening: ABD/ADD SLR
- Stability: Biodyex Balance System with Unweighing System
- Cardiovascular training:
  - Biodyex UBC @ 60 RPM 15-30 min.
  - WB and Non-WB Proprioception training
- Gait Biodyex Gait Trainer

## Supervised Program:
- Control edema and manage pain
- PRI.C.E.
- Muscle re-education
- PROM of hip, knee and ankle
- Cardiovascular training: Biodyex UBC or LBC
- Control pain and edema
- Strengthening of hip, calf and knee
- Flexibility training of hip, knee and ankle
- Cardiovascular training

## Home Program:
- Control pain and swelling
- PRI.C.E.
- PROM of hip, knee and ankle
- Strengthening exercises: SLR and Quad sets
- Control pain and edema
- ROM: active and passive
- Non-WB strengthening of hip, calf and knee
- Cardiovascular training
- Flexibility training of hip, knee and ankle

## Reports:
- Pain scale
- Functional status (Biodyex Stability Index)
- Biodyex bilateral isometric QUAD @ 60; HAM @ 30 degrees
- Knee OA Index
- Pain scale
- Functional status (Balance Index)
- Bilateral comparison: isokinetic QUAD/HAM @ 300 deg/sec
- Knee OA Index
- Biodyex Gait Trainer Analysis
EVIDENCE BASED CLINICAL PROTOCOL FOR THE MANAGEMENT OF:

**knee osteoarthritis**

<table>
<thead>
<tr>
<th>phase III:</th>
<th>phase IV:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>goals:</strong></td>
<td><strong>goals:</strong></td>
</tr>
<tr>
<td>- No post-exercise swelling or discomfort</td>
<td>- No pain or swelling post-exercise</td>
</tr>
<tr>
<td>- Pain-free performance of OKC exercises</td>
<td>- Increased running speed and distance with optimal gait</td>
</tr>
<tr>
<td>- Identify specific deficiencies of functional activities</td>
<td>- Unrestricted work/sports activity</td>
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<td>- Identify potential work activity restrictions</td>
<td>- Optimal knee function (endurance QUAD/HAM)</td>
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<tr>
<td>- Increased walking speed and distance</td>
<td>- Optimal QUAD strength PT/BW &gt; .90 @ 60 deg/sec and &gt; .40 @ 300 deg/sec</td>
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<tr>
<td>- Increased tolerance for prolonged WB activity</td>
<td>- Optimal HAM strength PT/BW &gt; .50 @ 60 deg/sec and &gt; .35 @ 300 deg/sec</td>
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<tr>
<td>- PROM &lt; 10% deficit</td>
<td>- Pain-free performance of eccentric and plyometric exercises</td>
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<td>- OKC Proprioception &lt; 10% deficit</td>
<td>- Identify specific deficiencies contributing to impact knee load</td>
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<tr>
<td>- Isokinetic strength QUAD/HAM &lt; 10% deficit</td>
<td>- Identify potential problems associated with patient lifestyle/vocation</td>
</tr>
<tr>
<td>- Isometric strength QUAD/HAM &lt; 30% deficit @ 300 deg/sec, &lt; 45% deficit @ 180 deg/sec</td>
<td>- Knee OA index &gt; 80</td>
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<tr>
<td>- Cardiovascular conditioning &gt;30 min @ 60-80% MHR</td>
<td>- OKC Proprioception equal bilaterally</td>
</tr>
<tr>
<td>- Increase Balance Index</td>
<td>- Balance Index normal for age group</td>
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<td></td>
<td>- Postural stability and neuromuscular control of lower extremity</td>
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<td>- ROM testing: AROM and PROM</td>
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<tr>
<td></td>
<td>- TEST: Biodex bilateral isokinetic QUAD/HAM @ 30/60/90 degrees</td>
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<td></td>
<td>- TEST: Biodex bilateral isokinetic QUAD/HAM @ 180/300 degrees</td>
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<tr>
<td></td>
<td>- TEST: Biodex bilateral proprioception QUAD/HAM</td>
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<td></td>
<td>- TEST: Biodex Gait Trainer Assessment</td>
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<td>- Test: Biodex Balance System bilateral stance</td>
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<table>
<thead>
<tr>
<th>clinical options:</th>
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<tbody>
<tr>
<td>- Reduce edema / inflammation and spasm / pain P.R.I.C.E.</td>
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<tr>
<td>- High-Volt ES to reduce pain</td>
<td>- ROM</td>
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<tr>
<td>- Flexibility training (HS, QU, hip-F/E)</td>
<td>- PER.I.E.</td>
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<tr>
<td>- Analysis of critical functional demands of job</td>
<td>- Flexibility training of lower extremity</td>
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<td>- Knee Strengthening: isokinetic wide-arc</td>
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<td>- Quads/Hams @ 180/300 degrees</td>
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<td></td>
<td>- Hip Strengthening: 4-way tubing exercises</td>
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<td>- Stability: Biodex Balance System bilateral and unilateral stance</td>
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<td></td>
<td>- Cardiovascular training &gt;30 min @ 60-80% MHR</td>
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<td></td>
<td>- WB and Non-WB Proprioception training</td>
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<td></td>
<td>- Biodex Gait Trainer: Lunge walking forward and backward</td>
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<td>- Analysis of critical functions</td>
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<td>- Review HEP</td>
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<tr>
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<tr>
<td>- Control pain and swelling (ESU as needed)</td>
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<tr>
<td>- Isokinetic strengthening of hip, calf and knee</td>
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<td></td>
<td>- Flexibility training of hip, knee and ankle</td>
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<td></td>
<td>- Cardiovascular training: Biodex UBC, LBC or Treadmill</td>
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<tr>
<td></td>
<td>- Supervised work specific functional tasks</td>
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<td>- Cardiovascular training: Biodex UBC, LBC or Treadmill</td>
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<td>- ROM: active and passive</td>
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<tr>
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<td>- Unilateral postural balance exercises</td>
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<tr>
<td>- Pain scale</td>
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<tr>
<td>- Functional status</td>
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<tr>
<td>- Biodex Balance System unilateral stance</td>
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<tr>
<td>- Knee OA Index</td>
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