Isokinetic Line

Threatment guide

Rev. E

2012/04/24

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THREATMENT GUIDE (ONLINE MANUAL ONLY)

Isokinetic testing and training: general methodologies

An isokinetic exercise consists in a motion at constant speed, in which resistance matches the force applied, provided that speed is consistent. This kind of motion guarantees maximum muscular contraction during the whole exercise and for each degree of articular motion. By using sophisticated equipment it is possible to set-up exercises customized according to the age, sex and pathology and define the best training/rehabilitation therapy for the muscular structures at a specific time frame of the athletic or rehabilitation project.

The duration of the really isokinetic part of the motion varies in function of the specified speed. Speed is in fact indirectly proportional to the resistance of the equipment; the lowest the speed and the highest will be the resistance to the motion. If the duration of the exercise is specified, more time is required to reach a high speed (acceleration); a consideration that should always be taken into account in the planning phase. It is in fact important to remember that some articular groups (like the ankle) have a rather limited articular excursions. In this case it is not possible to specify a very high angular speed due to the limited ROM. In fact a high articular speed would never enable to maintain the required isokinetic speed until the end of the exercise (deceleration phase).

Isokinetic motions are generally characterized in function of their speed, which can be high, medium or low, depending on the range, i.e. equivalent to 250-400 °/sec, 100-250 °/sec and 0-100 °/sec.

During isokinetic contraction, our dynamometers perform a concentric muscular contraction movement only, which guarantees a high level of safety and easiness of use.

ISOKINETIC TEST

Introduction to isokinetic tests

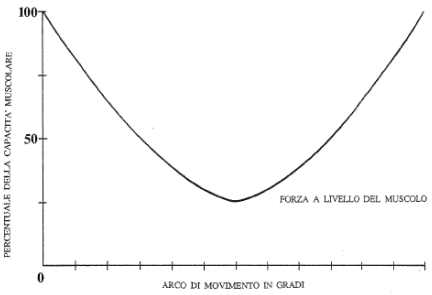
Isokinetic exercises enable to perform muscular contractions at a maximal degree, while maintaining a constant speed during the whole movement. The maximum load applied at all stages of the exercise can be recorded on a PC, plotted in the form of a chart and reviewed for clinical purposes. In other words, isokinetic dynamometers provide physicians with information that would otherwise be difficult to attain. However, information provided by isokinetic tests should always be carefully reviewed, integrated and examined in relation to the clinical condition of the patient. Only an approach of this kind enables to gain a full view of the conditions of the patient and correctly

evaluate the test. It is in fact useful to remember that isokinetic tests do not have an absolute diagnostic relevance, though they can be used to confirm clinical diagnoses.

Advantages of isokinetics as compared to traditional methods (isometrics, isotonics)

Isometric exercises offer a good level of muscular contraction, because they do not cause articular excursions and because the minimize damage, although this sometimes has a negative impact on the gain in terms of strength and on the neuromotory recovery, especially if performed at a single degree of articular excursion.

The isotonic exercise offers a more effective method, but it is limited by the intrinsic characteristics of the method. The maximum load, even using lever adapters (i.e. Physiological cams), it is only applied to the ends of the movements, does not offer a flexible and optimum resistance during the whole movement and guarantees therefore a limited recovery of the muscular trophic tone.



Isotonic contraction

Isokinetic contraction (Hislop, 1967)

Isokinetics also offers the possibility of objectively carrying out dynamic evaluations (it is useful to remember that muscular structures are the most dynamic structures of the body), which can be quantified and reproduced by means of numerical values and stored on a PC.

Easytech equipment enables to select different contractions, in addition to isokinetic contractions. The software enables in fact to choose between the isotonic-inertial and hydrodynamic methods. The former can be used to apply a resistance equivalent to ordinary systems with weights, while the latter enables to simulate the fatigue of

exercises in water or in fluids, thus enabling the operator to select the desired viscosity. These two methods enable the equipment to be used also in presence of limited muscular functionality (hydrodynamic method) like in the beginning of rehabilitation, or as support system in cases in which it is necessary to improve the muscular tone and trophism (isotonic-inertial method).

Type of patients and pathologies to which the method can be applied

The isokinetic method can be used in several fields of applications mainly because of the fact that it can be flexibly adapted to the motion being generated. Patients who may benefit from the use of this method range from athletes who wish to increase their performance and need to continue training after a competition to patients with neurological problems who are often treated with this method for research purposes, as specified in scientific literature.

Suitable patients can be grouped in the following categories:

1. Subjects of any age who have to follow a conservative rehabilitation therapy of the osteoarticular system
2. Subjects of any age who have to follow a rehabilitation therapy after surgery on the osteoarticular system
3. Subjects of any age who need to strengthen, increase the power or the resistance of the osteoarticular system
4. Subjects of any age who require osteoarticular assessment due to neurological clinical events
5. Subjects of any age who require an osteoarticular assessment for insurance, clinical or legal purposes.

Planning the isokinetic test: what to assess and when to carry out the test (pre-post, controlateral, speed, etc.)

An isokinetic test enables to assess the performance of the osteoarticular functions. It is obviously necessary to enter several variables related to the man/machine performance, which vary according to the environment in which the test is carried out, the responsiveness of the patient and the mode selected by the tester or any other person performing the test.

Before performing the actual test, it is essential to specify a few basic practical rules specifically in order to determine the correct technique and the angular speeds required to stimulate the articulation being rehabilitated.

The data resulting from our experience, which has been compared with those of other operators, shows that it is generally sufficient to use two different angular speeds to test most of the articular groups, i.e. to respectively explore the strength and power of the articular groups and to assess their resistance. The recommended speeds are 90 and 180 °/sec for the knee; a variable value for other articular groups values (due to the difficulty of intrinsically reproducing the test); 40 and 90 °/sec for the ankle; and 60 and 120 °/sec for the shoulder. Specific values may have to be selected when performing exercises based on a closed kinetic chain, where it is preferable to use low speeds for triple extensions and high values for triple flexions, due to the difficulty of interpreting the data related to the flexion structures of closed kinetic chains.

The number of repetitions varies according to the examined muscular capacity. It is generally advisable to reduce the number of repetitions for “explosive force” tests to a maximum of 4-5, and maintain it around 20 to further explore the resistance force and observe the enduranc indexes that can be attained from the ratios between the work in the initial and final repetitions of the test.

A correct positioning of the patient is fundamental to ensure the precision of the test and the reproducibility of the measured values. However, it is important to notice that position is not so relevant in terms of reproducibility when the test is performed on the shoulder, ankle and with a closed kinetic chain. The considerations applicable to knee tests are illustrated in detail in the sections that follow. The patient must be placed in an environment with a suitable microclimate, seated, and oriented so that the knee joint is aligned with the rotation axis of the dynamometer. The inclination of the back of the machine must be perpendicular to the seat so that the variables related to variations caused by the movement of the hip do not affect the test results.

Preparing the isokinetic test

Stretching and warm-up

Only a few operations are required to prepare dynamic structures, like muscles, so that they can generate maximum activity during the test. The preliminary operation consists in warming-up the patient for the test by means of a bike or treadmill. If the articulation being examined is the shoulder, it is possible to use a Dynatorq or other equipment, along with elastic bands with a medium resistance. The warm-up phase should last approximately 5-10 minutes and should be followed by a series of stretching movements of all the muscular structures that will be stimulated during the test.

Patient instructions and familiarization with the machine

Before starting the test, it is essential to provide the patient with a few clear instructions regarding the performances required, the maximum target that must be achieved during the test, the movements that must be performed and the fluidity of movement expected. This is particularly important if the patient has never performed isokinetic exercises before.

Entering the patient's data and programming the dynamometer

Selecting the patient

Access the patient database to select an existing patient or enter a new one.

The selected patient will automatically be linked to the next exercise. Thus, the data displayed will refer to the selected patient only.

Selecting the segment

Select the segment in which the session must be carried out (i.e. Knee, Ankle, Shoulder or CKC). It is possible to select the right or left side and change it later in the exercise menu.

Once the joint/limb has been selected, the software will automatically change all the information displayed on the screen and in the printouts, which refer to the names of the motions and muscles affected.

If you select the knee, the motions required will be flexion and extension. For example if you select the shoulder, the motions required will be internal and external rotation.

Setting the session parameters

After starting a session (with START), it is also necessary to select the operating parameters:

- Select the operating mode: (Test, Exercise, Videogame)
- Select the type of movement (Isokinetic, Inertial (Isotonic), Hydrodynamic)
- Select the side (Right, Left and, where provided, Bilateral)
- Use the appropriate command to set the number of repetitions in analogue and/or digital mode (0-99)
- Use the appropriate commands to set the isokinetic flexion and extension speeds in analogue and digital mode (40-400 degrees/sec), for the isokinetic motion.

or

- Use the appropriate controls to set the viscosity during flexion and extension in analog and/or digital mode (0-100), for the hydrodynamic motion.

or

- Use the appropriate controls to set the flexion and extension loads in analogue and digital mode (0-100 units) for the inertial motion

    1. Use, if desired, the appropriate commands to set the limit flexion and extension angles in analogue and digital mode. Angles can be set in two different ways: by numerically specifying their value or by manually moving the limb to the desired angle and pressing “A” on the right of the scroll bar (separately for flexion and extension).
    2. Use the appropriate command (icon) to enable or disable these software stops related to the limit angles configured.

    - Use the two buttons available to calibrate the current angular position of the limb. The operator should position the limb at a known angle (0 or 90 degrees according to eventual patient impairments) before pressing one of the two calibration buttons (0 or 90).

- Enter the name of the physician who has prescribed the exercise (optional) in one line.
- Enter the name of the therapist who has attended to the exercise (optional) in one line.

1 Press the confirmation key to start the exercise. Press the cancel button during the test to stop it immediately without altering the settings.

Specific warm-up at the test speed

This is an essential step. As explained above, each speed and motion species determine specific response forces. It is therefore natural to try setting a speed slightly below the maximum value in order to find the speed that is most suited for the test. Experimenting different positioning settings without performing a trial test may result in the failure of the test itself.

Test sequence

It is generally advisable to use at least two angular speeds in order to evaluate the explosiveness and to measure the endurance capability of the muscular fibers being examined. Literature recommends several speed tests. In our tests, we have applied the recommendations of SIMFER and GISMI, which suggest that the best speeds for test purposes are 90°/sec and 180°/sec. The first speed must be used with a sequence of 4 repeated movements, while the second one should be used with a sequence of 20 repeated contractions in order to accurately identify the explosiveness and resistance, as explained above. In our experience it is generally preferable to start the test with the reference limb, which is assumed to be healthy. This eliminates potential fears and reduces the risk of additional lesions, which could occur if the patient performs the test incorrectly with the affected limb.

Running the isokinetic test

Setting the articular angle

In order to ensure precision and reproducibility, the isokinetic dynamometer needs to know the position of the reference limb for the specific structure being examined. This means that it is necessary to calibrate the angular position to the patients' anatomy. This can be done in two ways. The first method, which is particularly fast and reliable, implies asking the patient to extend the limb as much as possible and selecting 0 on the display. The second one consists in measuring the 90° position of the knee with a goniometer and by selecting 90 on the display. Both are possible and usable. In our experience the first method is more practical (if usable) and enables to correctly use the dynamometer.

Compensation of gravity force

To allow the gravity (weight of the limb of the patient and lever) to be taken into account in the measurement of the forces that can be calculated with the dynamometer, it is necessary to perform a "weighing" phase before the actual test is started. This operation is optional, but recommended if the movement occurs along the vertical plane. It consists in asking the patient to extend the limb and successively to let it fall down without applying an active force, so that the limb bends due to gravity only.

During this phase the unit automatically calculates the gravity force that must be taken into account.

Biofeedback and verbal coaching

It is very important to continue stimulating the patient during the exercise. Verbal coaching enhances the performance of the test. Failure to do so may result in a poor performance of the patient.

Repetition of the test at controlled speed or controlateral test

Requisites for tests with the controlateral limb or at different speeds are the same as those described above.

Defatiguing the patient

After the test is completed, it may be advisable to allow the patient to cool down by asking him to repeat some contractions at speeds similar to those used for the test.

Analysis of results and reporting

The main parameter of the isokinetic test is the “momentum of force” or “torque” measured during the exercise. The recording of this parameter is linked to the measurement of the joint excursion angle. This basically means that it must be possible to relate all variations of the torque to each articular angle.

The most important parameters are:

- Peak torque

2. Represents the highest torque during the test
3. Can be regarded as the maximum torque that can be achieved by the muscular group at the examined angular speed
4. Unit of measurement: Nm

- Work

6. Is the result of the multiplication of the torque by the angular distance covered

7. The amount of work measured represents a good index of the capacity of the patient of generating the required force during the movement

8. Work values can be examined for single repetitions or as sum of single repetitions. In the latter case, it offers a good index of the resistance capacity of the muscular group examined, provided that a high number of repetitions have been performed.

9. Unit of measurement: Joule

- Power

11. Work in the time unit. It can be calculated by comparing the work produced with the time required to complete the isokinetic exercise

12. Unit of measurement: Watt

- Agonist/Antagonist muscles ratio

14. Represents the balance index between the muscular groups examined during the isokinetic exercises, provided that the muscles have antagonist functions

15. Unit of measurement: percentage ratio or value normalized to the body weight.

Recorded parameters must be examined both numerically, to highlight the differences between the two limbs through comparison, and graphically to highlight the anomalies in the articular dynamics.

Analysis of curves

To correctly interpret data, it is necessary to start from the lowest measured angular speed.

Ordinary chart

The main aspects are:

1. Peak of torque

1. It must have similar values and occur at the same height of the recorded curve

2. Slope of the increasing curve

1. Expresses the rapidity with which the muscle generates force. A higher slope indicates that the patient has fully understood the instructions of the operator, while a low slope indicates that the patient is unable to correctly contract the muscle at the beginning of the articular movement.

3. Slope of the decreasing curve

1. As above, only reversed in terms of joint movement

4. Underlying area of the curve

1. Corresponds to the work carried out and expresses the capacity of producing force during the whole movement

5. Transition point between the groups examined

1. Should occur without interruptions. A measurement of a significant interval of time should be considered physiological if not voluntary.

Analysis of numerical parameters

Peak Torque

This parameter can be analyzed as absolute value or compared with the values related to the controlateral limb.

Analyzing the absolute value can be difficult also because of the significant differences between the values related to single patients and the isokinetic instruments. Despite this, the concept of Davies, developed a few years ago, applies in all cases: the explosive force must be analyzed taking into account the chart with the lowest angular speed, while power must be reviewed using the chart related to the highest angular speed.

Comparative analysis offers instead the most important parameters that can be recorded. This parameter is easy to understand and calculate, and is generally considered compliant with physiological data, if the difference is around 10-15% of the values of the two limbs examined. It is however important to perform the comparison very carefully because of the potential influences caused by the dominance of one limb. In this case, the assessment must be

carried out taking into consideration an influence of 5-10%, which corresponds to the value of a healthy and non trophic limb. This general observation must always be considered when integrating the single values resulting from the graphical and numerical sections of the chart.

Work

It can be regarded as the capacity of maintaining high strength values during the whole motion.

In terms of a single repetition, there is a direct link between the peak torque and its expression represented by work. This means that the operator will have to adopt the same precautions described above and analyze the chart to identify potential anomalies and optimize the final target of the rehabilitation program.

The total work, which is measured at the highest angular speed, is a sum of the work measured during single repetitions and is therefore related to the fatigue index of the patient. This means that this parameter can be particularly useful to correctly understand the meaning of the index. There are in fact close links between the capacity of displaying the work for all repeated phases and the resistance to fatigue. Some authors have highlighted that this close relation actually improves the representativeness of the index.

Ratio between agonist and antagonist muscles

This is a very important value, which is however significantly influenced by the freedom of motion of articular biomechanics, dysfunctional anomalies in the articular mechanics, age, sex, physical activity and sports training.

This means that it is not possible to define a unique absolute value and that it is extremely difficult to determine the optimum values for single articulations. As far as the knee is concerned, the point in which this parameters appears to have a higher validity, we can state that:

- The force peak is physiologically always higher for the quadriceps system
- The relation between flexion and extension reduces in function of the increase of angular speed
- This parameter can acquire variable values if physical activity is performed with the physiological values at a 90°/sec by:

4. Male, sportsman App. 75 %

5. Male, sedentary App. 70 %

6. Female, sportswoman App. 65%

7. Female, sedentary App. 55%

Example of test results for the most common pathologies; sample graphs

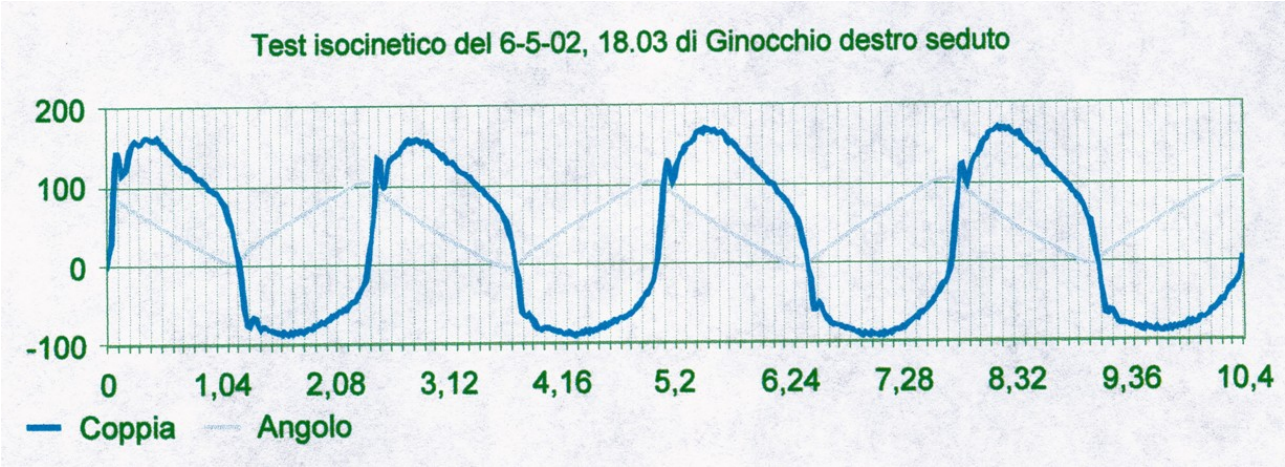


Figure 1 Isokinetic test of a patient with a lesion of the meniscus

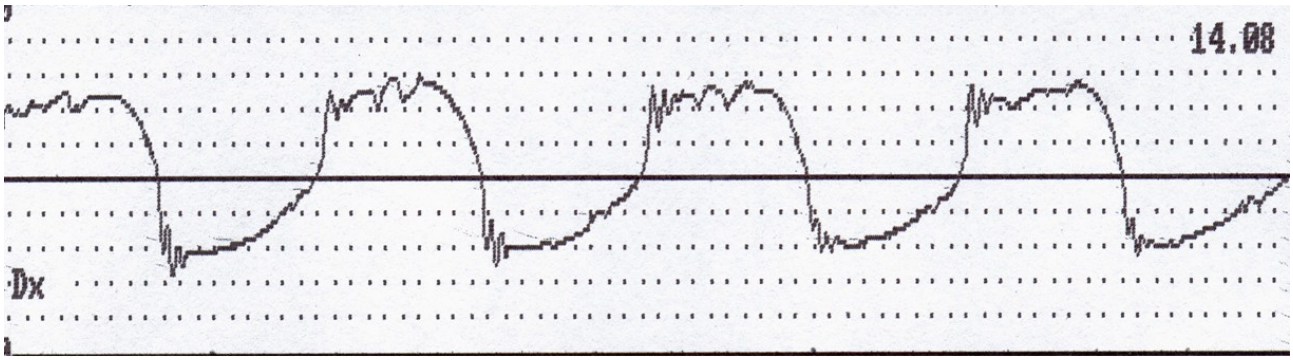


Figure 2 Isokinetic test of a patient with a severe chondromalacia of the knee cap

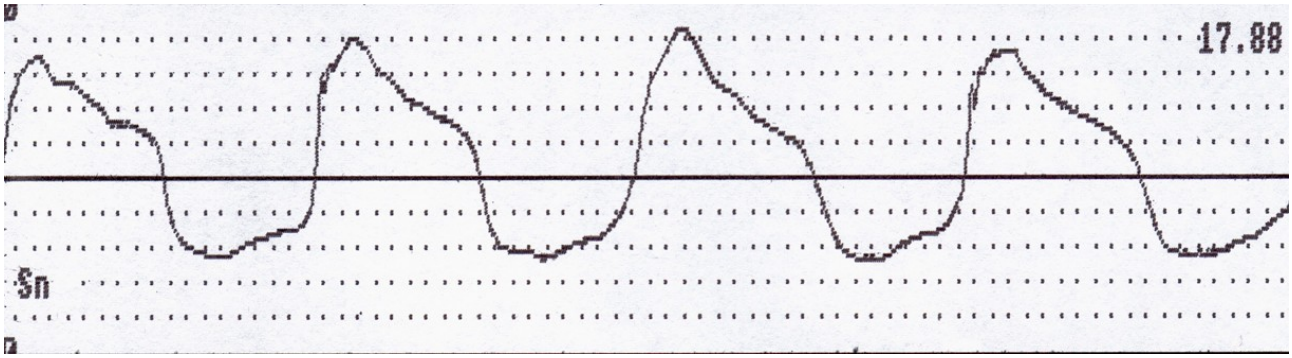


Figure 3 Isokinetic test of a patient with anterior knee pain

REHABILITATION AND TRAINING WITH ISOKINETIC METHODS

The five phases of rehabilitation

Each rehabilitation program implies carrying out a sequence of specific steps that are described in detail below. The general phases of a project are:

– Control of pain and inflammatory reaction

A necessary requirement for starting a rehabilitation program is the lack of pain. Pain can be eliminated with appropriate drugs, but also with suitable physical therapies, i.e. therapies based on known physical principles and biological mechanisms. Today, it is possible to use methods like hyperthermia, which enables to control the effects and therefore to treat physical energies in terms of dosimetry. These physical therapies can also be used to control reactions caused by rehabilitation loads.

– Recovery of articular mobility (Range Of Motion)

After removing or controlling the pain, the next step consists in recovering mobility, i.e. R.O.M. In this phase, it is generally advisable to use equipment that stimulates passive movements and devices like elastic straps that enable to adjust resistance and return energy in order to simplify the motion. It is useful to take into account the contribution on the extensibility of collagen, which can be guaranteed through the use of thermotherapy therapies and that should ideally precede all kinesitherapy sessions.

– Recovery of strength and muscular resistance

1. *This phase is generally carried out using electrostimulation techniques along with isometric, isotonic, isokinetic and elastodynamic exercises.*

2. *The program should be progressive, which means applying modest loads during the initial sessions to assess the responsiveness of the patient and prevent overloads. The most effective solutions are those that enable to control the load and quantitatively verify work and results.*

– Recovery of coordination

1. *Every trauma or lesion that affects perarticular soft tissues alters the perception of kinestesy (awareness of articular movement) and proprioception (awareness of the position of the limb), which have to be recovered during the rehabilitation program. The most effective instruments are traditional or electronic unstable tables, which are usually designed to stimulate the lower limbs. Today, some manufacturers have developed original and innovative solutions also for the upper limbs.*

– Recovery of gesture-specific ability

1. Work is now applied to specific gestures. This may imply returning to training sessions for football players or recovering ordinary activities for ordinary patients.

Isokinetics is generally included in rehabilitation programs starting from 3.1.3. As the rehabilitation program progresses, it is naturally necessary to increase the frequency of weekly sessions, the fatigue resistance and the specific targets for each patient, so that it is possible to complete the whole rehabilitation project, which generally implies recovering the ability to carry out ordinary activities or return to training sessions for a football player.

However, it is necessary to consider that a transition to a phase does not coincide with its completion or with the achievement of the specified targets, because all phases are strictly linked to one another. Therefore, transition is a natural progression in most cases or may involve the simultaneous transition to different phases.

Types of rehabilitation (post-surgery, post-traumatic, neurological, conservative and prevention of accidents)

Isokinetic is widely used in rehabilitation.

Thanks to its characteristics, it can be considered an essential and unique tool of all rehabilitation phases.

The use of an isokinetic test, as explained above, enables to accurately quantify deficit and use it to optimize the rehabilitation program or to document stabilized damage for clinical, insurance and legal purposes. In the last few years, literature has increasingly focused on the use of isokinetic dynamometers for research purposes for subjects affected by neurological lesions, stressing the fact that the parameters output by this instrument can be effectively used to perform clinical assessments.

The use of the isokinetic dynamometer for ordinary rehabilitation programs offers the advantage of enabling the operator to adapt each session to the clinical conditions of the patient, which may have varied as compared to the previous one. This explains why this instrument can be effectively used to prevent accidents on osteoarticular tissues that exhibit perfect relations between the structures, for post-surgery rehabilitation where the damage caused by the lesion combined with the "damage" of the healthy tissue next to the lesion caused by the surgeon.

These two applicative examples delimit a wide range of conservative rehabilitation needs, where surgery is ineffective or cannot be used, and in which isokinetic enables to effectively reduce recovery times and improve the quality of rehabilitation.

Rehabilitation for the most common pathologies and case, protocols and criteria

Knee

Lesion of the anterior cruciate ligament

Post-surgery rehabilitation

Complementary rehabilitation considerations

Muscular training

Starting muscular training at an early stage is essential to prevent atrophy and muscular hyposthenia. *Electrostimulation* can be used to start muscular activities in patients who are unable to voluntary oppose reflected inhibition. *Biofeedback* (like the VMO feedback) can be used to increase the strength of muscular contraction. Loads are useful to reactivate the functionality of muscles. *Muscular balance*, which enables to achieve a correct balance between the quadriceps and hamstring (ischiocrurals) muscles, improves the dynamic protection of the ACL. Barratta and colleagues(1988) have shown that the risk of accidents increases if the hamstring muscles are not sufficiently activated, and that exercise improves the coactivation relation. It has been demonstrated that *fatigue* significantly reduces not only the force of muscular contraction, but also the electromechanical response time and the amount of muscular force generated.

As the deficits of these elements, which are critical for the dynamic stabilization of the knee, reduce the protection of the knee during ordinary activities, it is obvious the introduction of resistance training in the rehabilitation program.

Exercises based on open and closed kinetic chains

The effectiveness of exercises based on open and closed kinetic chains, after the reconstruction of the ACL, has been widely debated in the last few years. **In theory, exercises based on a closed kinetic chain increase the compression force on the knee, contracting at the same time the quadriceps and hamstrings muscles.** It has been suggested that these two factors help to reduce the shear translational forces of the knee, which would

otherwise be applied to the ACL that has not yet recovered its full functionality. The possibility of carrying exercises based on closed kinetic chains at an early stage enables to guarantee an effective dynamic stabilization of the knee, reducing at the same time potentially dangerous shear forces.

Several studies show that the stress applied to the ACL is negligible or non existent during the individual contractions of the hamstring muscles and that the contraction of these muscles together with the quadriceps guarantee an effective protection of the hamstring muscles. The simultaneous contraction of the quadriceps and hamstring muscles occurs during exercises based on closed kinetic chain, because the activity of hamstring muscles reduces as the flexion angle of the knee increases. Simultaneous contraction has not been reported at any stage during exercises based on open kinetic chains.

Exercises based on closed kinetic chains stimulate the agonist muscles, do not ensure a selective reinforcement of the muscle, but guarantee a safer environment for the ACL in terms of fatigue.

To summarize, it is possible to state that exercises based on closed kinetic chains can be safety used during the rehabilitation of the ACL, because they appear to generate a lower front translational force and a modest motion of the tibia during most flexion motions. However, it is useful to notice that some studies have found that some exercises based on closed kinetic chains with small flexion angles stimulate the application of stress to the same extent of exercises based on an open kinetic chain, which would suggest that they are less safe than expected.

Electrostimulation and biofeedback

Electrostimulation and biofeedback can be used to complement traditional muscular training. Although there are no convincing results that show that *electrostimulation* alone is more effective than voluntary muscular contraction in terms of stimulating the reinforcement of the muscle after surgery, it could however be useful in the post-surgery stage because of the fact that the reflected inhibition of the quadriceps caused by pain and oedema prevents the initiation of voluntary muscular activities. Anderson et Lipscomb (1989) have noticed that electrostimulation is effective in limiting the loss of strength of the quadriceps and the femur and patella crepitation after the reconstruction of the ACL. However, it is worth noticing that electrostimulation generally offers the best results when combined with voluntary muscular contraction after surgery.

Even *biofeedback* can be used to rehabilitate the muscles. Electromyografic monitoring enables to send a visual or acoustic signal to the patient as soon as the muscular contraction threshold is reached. Threshold limits can be

changed in function of the improvement of the patient. To allow the patient to reach the "final result", biofeedback encourages the patient to increase muscular contraction during rehabilitation. This technique can also reduce the muscular activation time, thus contributing to the stabilization of the knee.

It is possible to provide information on the effective muscular performance carried out during the exercise either visually or acoustically. This increase of the voluntary contraction capacity effectively contributes to the reduction of recovery time.

Proprioception

The role of the ACL in the proprioception of the knee is still under investigation. It has been demonstrated that an altered proprioception reduces the capacity of the patient of protecting the knee and exposes the ACL to repeated traumas and ultimately fractures. It has been noticed that in patients without ACL lesions, proprioceptive capacities are extremely limited and therefore negatively affect the dynamic stabilization of hamstring muscles. It has been demonstrated that after an ACL lesion there is a significant proprioception difference between symptomatic and asymptomatic patients. Researchers have documented a correlation between proprioception and improvement after the reconstruction of the ACL. It is not clear how rehabilitation after the reconstruction of the ACL actually improves proprioception. However, after proprioceptive training programs, improvements have been reported both for patients with reconstructed ACL and for normal ones.

Rehabilitation protocol

After the reconstruction of the ACL

Phase 1: weeks 0-2

Scope

- Protect fixation
- Control inflammation
- Attain maximum extension and a 90° flexion of the knee
- Provide information on the rehabilitation program to the patient

Load

- The load is applied with two crutches
- If possible remove the crutches after 7 days (if the patient is able to effectively control the quadriceps)

Therapeutic exercises

- Wall Slides
- Reinforce the quadriceps and the hamstring muscles (with electrostimulation if required)
- Mobilization of the patella
- *Stretching* to remove the load from the triceps sura and hamstring muscles
- Assisted flexion motions with weighted bands in seated position
- Extension motions with weighted bands in prone position
- Flexion of the hip with extended knee (SLR) and aid blocked in extension, until the force of the quadriceps prevents the uncontrolled flexion of the leg.

Phase 2: weeks 2-4

Criteria for the transition to phase 2

- Good force of quadriceps, SLR with no knee flexion
- Flexion of the knee at about 90°
- Full extension
- No sign of inflammation

Scope

- Recover ordinary deambulation
- Recover full ROM
- Protect the fixation of the implant
- Increase the force, resistance and proprioception to prepare the patient for functional activities

Load

- For patellar tendon implants: continue with deambulation keeping the fixed aid extended, loosening it when the patient is seated or at nighttime. The aid can be removed during articular exercises
- For implants of the tendon of hamstring muscles and allo-implants: remove the bracings as soon as the patient has recovered his ordinary deambulation and is able to effectively control the quadriceps.

Therapeutic exercises

- Small squat movements (0-30°)
- Cycling (starting with the seat fully lifted and with a low resistance)
- Extension exercises based on closed kinetic chain (0-30° leg press)
- Standing on the toes

• Continue with *stretching* exercises for hamstring muscles and start the *stretching* of the sura triceps to which the load has been applied

• Continue extension in prone position, adding progressively higher loads to the ankles until the patient is able to completely extend the limb

Phase 3: 6 weeks-4 months

Criteria for the transition to phase 3

• Ordinary deambulation

• Complete articular movement

• Force and proprioception suited to allow the start of functional activities

• Stability of fixation determined by clinical tests

Scope

• Improve the trust of the patient in the healthiness of his knee

• Avoid excessive stress when the implant is fixed

• Protect the articulation of the femur and patella

• Increase the strength, power and proprioception to prepare the patient for functional activities

Therapeutic exercises

• Exercises aimed at strengthening the muscles. Hip: elastodynamic exercises and measurement of the resistance in the area near the inguinal region

• Continue with mobilization exercises, adapting them to the condition of the patient

• Start more complex reinforcement exercises based on a closed kinetic chain (squat on one limb, *leg press* exercises at 0° and 60°)

• Perform isokinetic tests based on a closed kinetic chain at low speed (60°/sec -90°/sec) with triple extension and at high speeds (300°/sec -400°/sec) with triple flexion, in seated or supine position, in sequences multiple of 2, each with 10-15 repetitions and pauses of 45 seconds

OVERALL SETUP:

Position: Seated

ROM Limits: NO

Joint: Closed Kinetic Chain

PROTOCOL: "KNEE1_CKC"

Motion Mode: Isokinetic

Vel Ext: 60°/Sec

Vel Flex: 400°/Sec

Repetitions: 2x15

Rest Time: 45 Sec

And eventually continue with:

OVERALL SETUP

Position: Supine

ROM Limits: None

Joint: Closed Kinetic Chain

PROTOCOL: “KNEE1_CKC”

Motion Mode: Isokinetic

Vel Ext: 60°/Sec

Vel Flex: 400°/Sec

Repetitions: 2x15

Rest Time: 45 Sec

• Perform isokinetic tests based on a open kinetic chain at intermediate speeds (120°/sec – 150°/sec) with ROM at 90°- 60°, starting approximately 90 days after the surgery. Perform sequences in multiples of two, each with 10-15 repetitions with pauses of 45 sec

OVERALL SETUP:

Position: Seated

ROM Limits: 90° Flex, 60° Ext.

Joint: Knee

PROTOCOL: “KNEE2”

Motion Mode: Isokinetic

Vel Ext: 120°/Sec

Vel Flex: 120°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel Ext: 150°/Sec

Vel Flex: 150°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel Ext: 120°/Sec

Vel Flex: 120°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

- *Elliptical stepper*
- Simulator of cross-country skiing

Phase 4: 4 months

Criteria for the transition to phase 4

- Complete and painless articular mobility
- No sign of inflammation in the femur and patella joint
- Force and proprioception sufficient to allow the start of functional rehabilitation
- Start complex exercises based on closed kinetic chain (if recommended by the physician) and continue with functional exercises

• Stability of fixation determined by clinical tests

Scope

• Recovery of ordinary activity

Isokinetic test

• Seated position, speed of 90°/sec and 180°/sec, 4 sequences with 20 repetitions and pauses of 45 sec

OVERALL SETUP

Position: Seated

ROM Limits: None

Joint: Knee

UNAFFECTED LIMB

PROTOCOL: "KNEE_TEST"

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 20

Then change to:

AFFECTED LIMB

PROTOCOL: “KNEE_TEST”

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 20

Therapeutic exercises

- Continue with mobilization and *stretching*.
- Isokinetic exercises based on closed kinetic chain

OVERALL SETUP:

Position: Seated

ROM Limits: NO

Joint: Closed Kinetic Chain

PROTOCOL: “KNEE1_CKC”

Motion Mode: Isokinetic

Vel Ext: 60°/Sec

Vel Flex: 400°/Sec

Repetitions: 2x15

Rest Time: 45 Sec

And eventually continue with:

OVERALL SETUP

Position: Supine

ROM Limits: None

Joint: Closed Kinetic Chain

PROTOCOL: “KNEE1_CKC”

Motion Mode: Isokinetic

Vel Ext: 60°/Sec

Vel Flex: 400°/Sec

Repetitions: 2x15

Rest Time: 45 Sec

• Isokinetic exercises based on open kinetic chain, at low and high speeds (90°/sec – 240°/sec), from ROM initially limited at 90°- 60° to full ROM, 3 sequences, repeated at low speeds for 5 times and at high and intermediate speeds for 10 times, with pauses of 45 seconds

OVERALL SETUP:

Position: Seated

ROM Limits: 90° Flex, 60° Ext.

Joint: Knee

PROTOCOL: "KNEE3"

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel Ext: 120°/Sec

Vel Flex: 120°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 150°/Sec

Vel Flex: 150°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 120°/Sec

Vel Flex: 120°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then in the following training session:

OVERALL SETUP:

Position: Seated

ROM Limits: 90° Flex, 60° Ext.

Joint: Knee

PROTOCOL: “KNEE4”

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel Ext: 120°/Sec

Vel Flex: 120°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 240°/Sec

Vel Flex: 240°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 120°/Sec

Vel Flex: 120°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then In the following training session:

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Knee

PROTOCOL: "KNEE5"

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 240°/Sec

Vel Flex: 240°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

- Possible use of the intermediate speeds

- Possible inversion of the speed sequence

Phase 5: return to sports activity

Criteria for the transition to phase 5

- Lack of problems in the femur and patella joints or soft tissues
- Conditions required to return to sports activity
- Physician recommendation
- 80% of controlateral force

Scope

- Safe return to sports activity
- Maintenance of strength, resistance and proprioception
- Recommendations on limitations

Isokinetic tests

- Seated position , speed of 90°/sec and 180°/sec, 4 and 20 repetitions, with pauses of 45 sec

OVERALL SETUP

Position: Seated

ROM Limits: None

Joint: Knee

UNAFFECTED LIMB

PROTOCOL: “KNEE_TEST”

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 20

Then change to:

AFFECTED LIMB

PROTOCOL: “KNEE_TEST”

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 20

Aids

• The physician may recommended the use of a functional bracing to protect the limb during sports activity and psychologically reassure the patient.

Therapeutic exercises

• Gradual return to sports activity

• Continue with reinforcement programs and isotonic and isokinetic resistance exercises

• Isokinetic exercises based on open kinetic chain, full ROM targeted to specific sport and training needs, at high speeds for sports based on resistance and at low speeds for sports that require the strengthening of muscular force

• Continue with exercises based on specific gestures

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Knee

PROTOCOL: “KNEE6”

Motion Mode: Isokinetic

Vel Ext: 60°/Sec

Vel Flex: 60°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 60°/Sec

Vel Flex: 60°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Or:

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Knee

PROTOCOL: “KNEE5”

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 240°/Sec

Vel Flex: 240°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

- Possible use of the intermediate speeds

- Possible inversion of the speed sequence

• Continue with exercises based on specific gestures

Rehabilitation protocol

Post-meniscectomy in arthroscopy

Phase 1: acute phase

Scope

• Reduce inflammation and oedema

- Recover articular mobility
- Restore the articular mobility of the quadriceps

Days 1-3

- Criotherapy
- Electrostimulation of the quadriceps
- Reinforcement of the quadriceps
- Isometric exercises for the quadriceps
- Hip abductions and adductions
- Passive extension of the knee
- Half squat movements
- Assisted *stretching* based on the type of limb, aimed at enabling the patient to fully extend the knee (flexion based on tolerance).
- Exercises with loads, depending on the tolerance of the patient (with two crutches)
- Light compression bandage

Days 4-7

- Criotherapy
- Electrostimulation of the quadriceps
- Reinforcement of the quadriceps
- Extension of the knee from 90° to 40°.
- Isometric exercises
- Hip abductions and adductions
- Half squat movements

- Balancing and proprioception exercises in seated position
- Assisted passive and active ROM exercises
- 0-115° ROM (minimum)
- *Stretching* (hamstring muscles, triceps of sura and quadriceps)
- Exercises with loads, depending on the tolerance of the patient (with one crutch)
- Continue with light compression bandaging

Days 7-10

- Continue with all exercises
- Elastodynamic exercises based on closed kinetic chain (low loads)
- Standing on the toes
- Flexion of knee with elastodynamic resistance
- Cycling (with 0-120° ROM and lack of oedema)

Phase 2: intermediate phase

Scope

- Recover and improve muscular strength and resistance
- Recover a full and painless ROM
- Gradual recovery of functional activities

Days 10-17

- Cycling for mobility and resistance
- Side flexions
- Front flexions

- Half squat movements
- Elastodynamic exercises based on closed kinetic chain (low loads)
- Side stepping
- Extension of knee from 90° to 40°
- Flexion of knee with elastodynamic resistance
- Hip abductions and adductions
- Hip flexions and extensions
- Standing on the toes
- Balancing and proprioceptive training
- *Stretching* exercises
- Assisted passive and active ROM exercises for the knee (if required)
- *Stepper* or *elliptical trainer*

Day 17-Week 4

- Continue all exercises
- Program in rehabilitation pool (running in deep pool and exercises for lower limbs)
- A compression aid should be ideally used during the execution of exercises

Phase 3: advanced activity phase – Week 4-7*

Criteria for the transition to phase 3

- Complete and painless articular mobility
- Lack of pain or sense of pain
- Satisfactory isokinetic test
- Satisfactory objective examination (minimum oedema)

Scope

- Increase muscular strength and resistance
- Maintain complete functionality of joints
- Recovery of functional/sports mobility
- Continue performing exercises based on a closed kinetic chain
- Start Plyometric exercises (if possible)
- Start running and agility exercises
- Isokinetic exercise at high speed (180-240°/sec)

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Knee

PROTOCOL: "KNEE5"

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 240°/Sec

Vel Flex: 240°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

- Possible use of the intermediate speeds

- Possible inversion of the speed sequence

Rehabilitation protocol

Patello-Femoral tendonitis (Anterior Knee Pain)

Phase 1

Scope

- Reduce pain and inflammation
- Increase the mobility of the patella, mobilize retracted structures in the patella region
- Recover control of quadriceps
- Improve the mobility of the femur and patella

Adhesive bandages/aids

- Can be used

Therapeutic exercises

- Ice, electrostimulation and Anti-inflammatory drugs to reduce inflammation and pain
- Isometric tests for the quadriceps at different angles
- Hip adduction, abduction, flexion and extension exercises
- Start with patella mobilization techniques
- Passive mobilization of the tissues around the patella

Phase 2

Criteria for the transition to phase 2

- Good strength of quadriceps and lack of extension deficits
- Improve articular mobility
- Improve patella mobility

Therapeutic exercises

- Continue with the mobilization of the patella
- Use an adhesive bandage or aid
- Continue with ice and electrostimulation (especially after exercises) and Anti-inflammatory drugs
- Quadriceps isometric exercise
- Exercises to extend quadriceps, hamstring muscles, ileotibial band and triceps of sura
- Exercises based on closed kinetic chain: limited flexions, sliding against walls, side stepping, small squat movements, and elastodynamic exercises

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Closed Kinetic Chain

PROTOCOL: "KNEE1_CKC"

Motion Mode: Isokinetic

Vel Ext: 60°/Sec

Vel Flex: 400°/Sec

Repetitions: 2x15

Rest Time: 45 Sec

And eventually continue with:

OVERALL SETUP

Position: Supine

ROM Limits: None

Joint: Closed Kinetic Chain

PROTOCOL: “KNEE1_CKC”

Motion Mode: Isokinetic

Vel Ext: 60°/Sec

Vel Flex: 400°/Sec

Repetitions: 2x15

Rest Time: 45 Sec

• Avoid cycling, significant flexion movements of the knee, complete squat movements, and knee extension movements with resistance

• Exercises in rehabilktation pool and swimming

Phase 3

Criteria for the transition to phase 3

• No increase of pain or inflammation

• Good muscular strength in the quadriceps

Scope

• Recover full mobility of the knee

• Increase strength and flexibility

Aids

• If required, continue using the aid or adhesive bandage

Therapeutic exercises

• Complex exercises to reinforce hamstring muscles

• Isokinetic exercises based on open kinetic chain, at high speed (150-240°/sec); gradually extend the speed range to 90° /sec

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Knee

PROTOCOL: "KNEE7"

Motion Mode: Isokinetic

Vel Ext: 150°/Sec

Vel Flex: 150°/Sec

Repetitions: 1x10

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 1x10

Rest Time: 45 Sec

Then:

Vel Ext: 240°/Sec

Vel Flex: 240°/Sec

Repetitions: 1x10

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 1x10

Rest Time: 45 Sec

Then:

Vel Ext: 150°/Sec

Vel Flex: 150°/Sec

Repetitions: 1x10

Rest Time: 45 Sec

And in the following training session:

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Knee

PROTOCOL: “KNEE8”

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel Ext: 240°/Sec

Vel Flex: 240°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

- Possible use of the intermediate speeds

- Possible inversion of the speed sequence

- Possible Bilateral operation

• Elastodynamic exercises for hamstring muscles and quadriceps

• Cycling, swimming, steps or walking to increase cardiovascular and muscular resistance; increase first the length then speed

• Continue with extension exercises

• Start exercises based on closed kinetic chain

Phase 4

Criteria for the transition to phase 4

• Full knee mobility

• Strength of quadriceps equivalent to 80% of ordinary strength

Scope

• Recover the capacity of carrying out all activities

Aids

• Aids or adhesive bandage can be used during sports activities, if required. Adhesive bandage must be used for at least 6 weeks and removed. The patient may continue to use the aid.

Isokinetic test

OVERALL SETUP

Position: Seated

ROM Limits: None

Joint: Knee

UNAFFECTED LIMB

PROTOCOL: “KNEE_TEST”

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 20

Then change to:

AFFECTED LIMB

PROTOCOL: “KNEE_TEST”

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 20

Therapeutic exercises

- Slow recovery of running capability, increasing first length then speed
- Effective warm-up exercises

- Use ice after training

- Isokinetic exercises in open kinetic chain, multiple speeds, with progressive increase of sequences

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Knee

PROTOCOL: "KNEE5"

Motion Mode: Isokinetic

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 240°/Sec

Vel Flex: 240°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 180°/Sec

Vel Flex: 180°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel Ext: 90°/Sec

Vel Flex: 90°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

- Possible use of the intermediate speeds

- Possible inversion of the speed sequence

- Possible Bilateral operation

• Elastodynamic exercises for hamstring and quadriceps muscles

• Continue with aerobic exercises

• Start jumping, *cutting* and other gesture-oriented exercises

Recovery of full activity

• Complete and painless ROM

- Isokinetic test, at 85% as compared to ordinary parameters

Shoulder

Impingement syndrome

Conservative rehabilitation

Complementary rehabilitation considerations

Muscular reinforcement is generally introduced in the rehabilitation program depending on the diagnosis and treatment.

Shoulder muscles can be reinforced with several exercises. The most effective exercises are those based on a closed kinetic chain, because they cause the contraction of both the agonist and antagonist muscles. These exercises closely mirror ordinary physiological motor schemes, stabilize the shoulder and limit the amount of shear forces that are applied to the articulation. Stabilization is essential to ensure a correct functionality of the limb, especially when high forces are generated with relatively simple movements, as shown in the table below.

Forces and loads applied to the shoulder during ordinary athletic activities

Rotational speed

Baseball 7000 degrees/sec

Serve (tennis) 1500 degrees/sec

Forehand (tennis) 245 degrees/sec

Backhand (tennis) 870 degrees/sec

Angular speed

Baseball 1150 degrees/sec

Acceleration speeds

Internal rotation 60 Nm

Horizontal abduction 70 Nm

Front cutting 400 Nm

Deceleration forces

Horizontal abduction 80 Nm

Rear translational 500 Nm

Compression 70 Nm

It is very important to make sure that the stabilizers of the scapula are reinforced at an early stage of the rehabilitation program. As recovery and mobility improve, it is possible to introduce more aggressive exercises. Exercises based on closed kinetic chain can be replaced with exercises based on open kinetic chain in which the hand is no longer immobilized against a fixed object. This increases the shear forces applied to the shoulder. Internal and external rotation exercises are exercises based on an open kinetic chain and should be preferably carried out keeping the shoulder at the same height of the scapula. The position of the scapular plane can be recreated by placing the arm 30°-60° degrees in front of the anterior plane of the chest or at approximately half way between the front and sagittal planes. It has been demonstrated that this orientation minimizes the stress applied to the articular capsule and places the shoulder in the position that corresponds to the functional movement. Rotation exercises must be initially carried out with the arm hanging along the side and gradually moving it to 90°, depending on the required degree of recovery and the level of tolerance of the patient.

The change of position positively stimulates the dynamic stabilizers because they reduce the stability of the glenohumeral joint (GO), from maximum stability (i.e. when the arm is hanging down the side) to minimum stability (i.e. when the arm is placed at a 90° abduction).

The most effective exercises based on an open kinetic chain are those that involve the use of plyometric, because they consist in a sequence of stretching and compression exercises of the muscle. These exercises are an essential component of all athletic activities.

The muscle is first eccentrically stretched then slowly loaded. Because of the high level of stimulation on the tissues, these exercises are generally included in the rehabilitation program only after full recovery of the shoulder mobility and functionality.

Shoulder rehabilitation programs should also take into account the muscular and skeletal system. A global conditioning program should simultaneously include *stretching,* reinforcement and resistance training of all the components of the kinetic chain.

The patient's motivation critically influences the success of the rehabilitation program as any program is destined to fail if the patient is not motivated to complete it.

Conservative treatment is very effective and usually comprises a combination of therapeutic methods like anti-inflammatory drugs and a suitably organized therapeutic plan. The complete rehabilitation programs for primary and secondary conflicts are similar and must be generally carried out after the completion of the post-surgery rehabilitation program, especially for patients that have suffered a subacromial decompression and have an ordinary rotator cuff. The primary scope of the program is to eliminate pain and enable the patient to recover mobility. The most acute stages of the inflammatory phase can generally be controlled with the use of drugs administered orally and with a reasonable administration of corticosteroids.

Pain can also be effectively controlled with methods like criotherapy and ultrasounds. The reduction of pain enables to improve mobility and muscular strength. As the cuff is intact, ROM exercises can be either active or passive.

Exercises are initially carried out with an abduction below 90° to avoid conflicts with the cuff. As conditions improve, it is possible to increase the extension of the ROM. These exercises aim at recovering the capacity of the cap of the rotatory muscles to depress and stabilize the head of the homer, which causes a gradual increase of the subacronomial space. In patients with secondary conflicts, reinforcement starts without moving the limb from the body to avoid positions that could cause instability, like abduction with external rotation. As soon as the stabilizers start responding to the reinforcement program, it is possible to add exercises with a higher abduction level. As a general rule, the scope of the initial phase is not that of attempting to reinforce the deltoid muscle, as this would cause an disproportionate increase of the forces applied to the upper section of the homer.

Conservative treatment fails when there are no signs of improvement within 3 months from the start of the a clinical and rehabilitation program. It is useful to remember also that most patients reach the maximum improvement that can be achieved with this type of treatment after approximately 6 months. An unsuccessful treatment or an insufficient recovery plateau generally indicates that surgery is required.

Treatment

Conservative treatment

Phase 1: maximum protection - acute phase

Scope

- Reduce pain and oedema
- Reduce inflammation
- Delay muscular atrophy
- Maintain and improve mobility

Active rest

- Eliminate activities that could worsen symptoms.

ROM

- Pendulum exercises
- Assisted ROM exercises in the painless area
- Rope and pulley
- Flexion
- Neutral external rotation

Articular mobilization

- Upwards and backwards “sliding movements” along the scapular plane

Therapy with equipment

- Laser therapy
- Ultrasound
- Criotherapy
- Transcutaneous electric stimulation (TENS)

Reinforcement exercises

- Isometric exercises (sub-maximal)
- Elastodynamic exercises with external rotation
- Elastodynamic exercises with internal rotation
- Elastodynamic exercises for biceps

Education of patient and modification of activities

- Depending on activities, pathologies and avoiding exercises "above the head" and lifting activities.

Phase 2: movement phase – sub-acute phase

Criteria for the transition to phase 2

- Reduction of pain and/or symptoms
- Increased ROM
- Presence of pain during abduction
- Improved muscular functionality

Scope

- Recover a complete and painless ROM
- Normalize the kinematics of the shoulder joints
- Delay muscular atrophy without increasing pain

ROM

- Rope and pulley
- Flexion
- Abduction, only if the movement doesn't cause pain
- Flexion
- Abduction (painless movement)
- External rotation with 45° abduction, continuing with a 90° abduction
- Internal rotation with 45° abduction, continuing with a 90° abduction
- Start the *stretching* of front and rear faces of the cap

Articular mobilization

- Lower, front and rear "sliding movements"
- Combined "sliding movements" depending on needs

Therapy with equipment

- Laser therapy
- Criotherapy
- Ultrasound/ionophoresis

Reinforcement exercises

- Continue with isometric exercises
- Isokinetic exercises with high angular speeds (240°/sec - 300°/sec), limited painless ROM for RI and RE with 2 sequences each with 10 repetitions and pauses of 45 seconds

OVERALL SETUP:

Position: Standing

ROM Limits: None or Pain Limited

Joint: Shoulder

PROTOCOL: “SHOULDER1”

Motion Mode: Isokinetic

Vel IR: 240°/Sec

Vel ER: 240°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel IR: 300°/Sec

Vel ER: 300°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel IR: 240°/Sec

Vel ER: 240°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

• Elastodynamic exercises with external rotation and 45° abduction, followed by a 90° abduction

- Elastodynamic exercises with internal rotation and 45° abduction, followed by a 90° abduction

Start the reinforcement exercises of the scapular and thorax muscles (see related section)

- Start the neuromuscular control exercises

Phase 3 – Intermediate reinforcement phase

Criteria for the transition to phase 3

- Reduction of pain and symptoms
- Assisted active exercises for ordinary ROM
- Improvement of muscular strength

Scope

- Normalize ROM
- Ordinary activities without pain
- Improve muscular performance

ROM

- Assisted active mobilization on all planes
- Continue with *self-stretching* of capsule (front and rear)

Reinforcement exercises

- Isotonic exercises with handle
    - On one side, neutral position
    - Internal rotation
    - External rotation
    - Pronation

- Extension
- Horizontal abduction
- Standing
- Flexion at 90°
- Supra-spinatus

• Start exercises with anterior dentate muscle

- *Push-up* against the wall

• Isokinetic exercises with high angular speeds (240°/sec - 300°/sec), complete ROM for RI and RE, with two sequences each with 10 repetitions, and pauses of 45 seconds

OVERALL SETUP:

Position: Standing

ROM Limits: None

Joint: Shoulder

PROTOCOL: "SHOULDER1"

Motion Mode: Isokinetic

Vel IR: 240°/Sec

Vel ER: 240°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel IR: 300°/Sec

Vel ER: 300°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel IR: 240°/Sec

Vel ER: 240°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Phase 4 – Advanced dynamic reinforcement phase

Criteria for the transition to phase 4

- Complete painless ROM
- Lack of spontaneous pain or sense of pain
- 70% of controlateral force

Scope

- Increase force and resistance
- Increase power
- Improve neuromuscular control

Isokinetic test

• Internal and external rotation in neutral position, modified in scapular plane at 60°/sec an 180°/sec, repeated from 4 to 20 times

OVERALL SETUP

Position: Standing

ROM Limits: None

Joint: Shoulder

UNAFFECTED LIMB

PROTOCOL: "SHOULDER_TEST"

Motion Mode: Isokinetic

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel IR: 180°/Sec

Vel ER: 180°/Sec

Repetitions: 20

Then change to:

AFFECTED LIMB

PROTOCOL: “SHOULDER_TEST”

Motion Mode: Isokinetic

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel IR: 180°/Sec

Vel ER: 180°/Sec

Repetitions: 20

Isokinetics

- Reduce angular speed (180°/sec. – 60°/sec , or 30°/sec for athletes)
- Increase series and repeated requests

OVERALL SETUP:

Position: Standing

ROM Limits: None

Joint: Shoulder

PROTOCOL: “SHOULDER2”

Motion Mode: Isokinetic

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

Then:

Vel IR: 90°/Sec

Vel ER: 90°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel IR: 150°/Sec

Vel ER: 150°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel IR: 90°/Sec

Vel ER: 90°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

Then in next training session:

OVERALL SETUP:

Position: Standing

ROM Limits: None

Joint: Shoulder

PROTOCOL: “SHOULDER3”

Motion Mode: Isokinetic

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel IR: 90°/Sec

Vel ER: 90°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel IR: 150°/Sec

Vel ER: 150°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel IR: 90°/Sec

Vel ER: 90°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Phase 5: return to activity phase

Criteria for the transition of phase 5

- Complete ROM without pain
- Lack of pain in idle conditions or sense of pain
- Isokinetic test at 80% of controlateral force

• Satisfactory clinical examination

Scope

• Enable all form of activities without symptoms

Isokinetic test

• Internal and external rotation in neutral position, modified in scapular plane at 60°/sec an 180°/sec, repeated from 4 to 20 times

OVERALL SETUP

Position: Standing

ROM Limits: None

Joint: Shoulder

UNAFFECTED LIMB

PROTOCOL: "SHOULDER_TEST"

Motion Mode: Isokinetic

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel IR: 180°/Sec

Vel ER: 180°/Sec

Repetitions: 20

Then change to:

AFFECTED LIMB

PROTOCOL: "SHOULDER_TEST"

Motion Mode: Isokinetic

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel IR: 180°/Sec

Vel ER: 180°/Sec

Repetitions: 20

Maintenance exercises

Mobility exercises

- Flexion
- External rotation
- *Self-stretching* of capsule

Isotonic exercise

- Supra-spinatus
- Extension from prone position
- Horizontal abduction from prone position
- Push-up for the dentate muscle

Elastodynamic exercises

- Internal and external rotation
- Neutral position or 90/90

Isokinetics

- Increase the spectrum of angular speeds (300° - 180°/sec. – 60°/sec or 30°/sec for athletes)
- Increase number of series and repetitions

OVERALL SETUP:

Position: Standing

ROM Limits: None

Joint: Shoulder

PROTOCOL: “SHOULDER4”

Motion Mode: Isokinetic

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

Then:

Vel IR: 150°/Sec

Vel ER: 150°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel IR: 240°/Sec

Vel ER: 240°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel IR: 150°/Sec

Vel ER: 150°/Sec

Repetitions: 3x10

Rest Time: 45 Sec

Then:

Vel IR: 60°/Sec

Vel ER: 60°/Sec

Repetitions: 3x5

Rest Time: 45 Sec

- Possible use of the intermediate speeds

- Possible inversion of the speed sequence

Ankle

Ankle sprain (lateral compartment)

Rehabilitation and complementary considerations

According to current literature, ankle sprains are best treated with functional rehabilitation, which enables the patient to recover their physical mobility and activity quicker as compared to plastering, while minimizing the rate of late symptoms (instability of the ankle, stiffness and muscular hyposthenia).

In the **acute phase**, i.e. after the injury has occurred, these kind of sprains are treated with the so-called PRICE principle (protection, rest, ice, compression and elevation). It is also possible to combine hyperthermia and criotherapy to stimulate lymphatic drainage in the perilesional area in the most acute phase.

The scope is to reduce hemorrhages, oedema, inflammation and pain. Depending on the seriousness of the lesion, it is generally advisable to immobilize the ankle in an appropriate position.

In the **sub-acute phase** the scope is mainly to continue reducing oedema, inflammation, and to ask the patient to start making a few movements, reinforcement exercises and appropriate exercises with loads. In this phase, the proliferation of fibers of collagen and excessive stress on the ligaments could weaken the tissues.

The **functional phase** focuses on increasing force, balance and the proprioception of the load. During the cicatrisation phase of the ligament, which usually occurs 3 weeks after the lesion, a controlled *stretching* of the muscles and movement of the articulation usually contributes to a more consistent distribution of the collagen fibers along a parallel line as compared to the tension lines. Studies have demonstrated that repeated exercises during this phase increase the mechanical and structural force of the ligament.

Rehabilitation protocol

Treatment of sprains of the lateral collateral

Phase 1: acute phase

Timing

- First degree sprain: 1-3 days
- Second degree sprain: 2-4 days
- Third degree sprain: 3-7 days

Scope

- Reduce oedema
- Reduce pain
- Prevent relapses
- Maintain a suitable load condition

Protective options

- Adhesive bandages
- Functional aid
- Rest (use of crutches to promote deambulation without altering posture)

Ice

- Criotherapy on cap
- Ice packs.

• Ice with other physiotherapy treatments (interference currents, laser therapy, ultrasounds, combination of deltathermia and criotherapy)

Light compression

• Elastic bandage

Elevation

Phase 2: sub-acute phase

Timing

• First degree sprain: 2-4 days

• Second degree sprain: 3-5 days

• Third degree sprain: 4-8 days

Scope

• Reduce oedema

• Reduce pain

• Reduce ROM without pain

• Start the reinforcement phase

• Start proprioceptive training without loads

• Provide a protective support, if required

Physiotherapy techniques to reduce pain and oedema

• Ice or combination of deltathermia and criotherapy

• Electrostimulation (interferential or TENS)

• Ultrasounds

• Laser therapy

• Transversal massage (delicate)

Load

• Application of progressive loads depending on symptoms

• Transition from partial to full load, if the patient shows signs of pain while walking

Therapeutic exercises

• Active ROM exercises

• Flexion of back

• Supination

• Circunduction of foot

• Plantar flexion

• Pronation

• Tracing alphabet letters

• Reinforcement exercises

• Isometric ROM exercises in absence of pain

• Isokinetic exercises with plantar and dorsal flexion at high speeds (150°/sec - 240°/ sec), 2 sequences repeated for 10-15 times with pauses of 45 seconds

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Ankle

PROTOCOL: “ANKLE1”

Motion Mode: Isokinetic

Vel PF: 150°/Sec

Vel DF: 150°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel PF: 240°/Sec

Vel DF: 240°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel PF: 150°/Sec

Vel DF: 150°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

- Possible use of the intermediate speeds

- Possible inversion of the speed sequence

• Bend and stretch fingers with a towel

• Grasp objects with fingers (fabrics, marbles)

- Proprioceptive training on oscillating table (ideally computerized) in seated position
- Passive ROM: only dorsal and plantar flexion in the area without pain, without supination or pronation
- *Stretch* of Achilles' tendon (delicate)
- Mobilization of articulation (degrees 1 and 2 for dorsal and plantar flexion)

Phase 3: functional phase

Timing

- First degree sprain: 1 week
- Second degree sprain: 2 weeks
- Third degree sprain: 3 weeks

Scope

- Increasing painless ROM
- Progressive reinforcement
- Progressive proprioceptive training
- Increasing ordinary activities without causing pain
- Applying full load without pain, deambulation and compensation

Therapeutic exercises

- *Stretching* of gastrocnemium and soleum muscles with increasing intensity
- Mobilization of articulation
- Reinforcement
- Exercises with loads
- Lifting loads
- Lifting the toes

- Placing the foot on a step
- Elastodynamic exercises
- Supination
- Pronation
- Plantar flexion
- Dorsal flexion
- Reinforcement of peroneous muscles
- Isokinetic exercises with plantar and dorsal flexion, without blockage of subastragalic joint, at low speed (40°-60°/ sec) , 2 series, repeated for 5 times, with pauses of 45 seconds

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Ankle

PROTOCOL: “ANKLE2”

Motion Mode: Isokinetic

Vel PF: 40°/Sec

Vel DF: 40°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

Then:

Vel PF: 60°/Sec

Vel DF: 60°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

Then:

Vel PF: 40°/Sec

Vel DF: 40°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

- Possible inversion of the speed sequence

• Proprioceptive training (continuation of exercises with and without load, until the full load can be tolerated) in standing position on oscillating table (preferably computerized), in monopodalic or bipodalic posture

• Continuation of physiotherapy techniques, depending on needs, especially after exercises, to prevent the reoccurrence of pain and oedema

• Use of adhesive supporting bandage and aids, depending on needs

Phase 4: recovery of activity

Timing

• First degree sprain: 1-2 weeks

• Second degree sprain: 2-3 weeks

• Third degree sprain: 3-6 weeks

Scope

- Recover full strength
- Ordinary biomechanics
- Recovery of activity
- Protection and reinforcement against potential slight articular instability
- 80% of controlateral limb strength

Isokinetic test

Two speed test (60°/sec – 180°/sec), repeated from 4 to 20 times

OVERALL SETUP

Position: Seated

ROM Limits: None

Joint: Ankle

UNAFFECTED LIMB

PROTOCOL: "ANKLE_TEST"

Motion Mode: Isokinetic

Vel PF: 60°/Sec

Vel DF: 60°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel PF: 180°/Sec

Vel DF: 180°/Sec

Repetitions: 20

Then change to:

AFFECTED LIMB

PROTOCOL: “ANKLE_TEST”

Motion Mode: Isokinetic

Vel PF: 60°/Sec

Vel DF: 60°/Sec

Repetitions: 4

Rest Time: 45 Sec

Then:

Vel PF: 180°/Sec

Vel DF: 180°/Sec

Repetitions: 20

Therapeutic exercises

- Continue with ROM and reinforcement exercises

• Isokinetic exercises with dorsal and plantar flexion, without blockage of subastragalic joint, at low and intermediate speeds (40°/sec - 120°/ sec) , several speeds, sequences in multiples of 2, repeated 5 times with pauses of 45 seconds

OVERALL SETUP:

Position: Seated

ROM Limits: None

Joint: Ankle

PROTOCOL: "ANKLE3"

Motion Mode: Isokinetic

Vel PF: 40°/Sec

Vel DF: 40°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

Then:

Vel PF: 60°/Sec

Vel DF: 60°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

Then:

Vel PF: 120°/Sec

Vel DF: 120°/Sec

Repetitions: 2x10

Rest Time: 45 Sec

Then:

Vel PF: 60°/Sec

Vel DF: 60°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

Then:

Vel PF: 40°/Sec

Vel DF: 40°/Sec

Repetitions: 2x5

Rest Time: 45 Sec

- Possible inversion of the speed sequence

• Specific sports reinforcement and training exercises are required

Progress in running

• Alternate running at low speed, walking, and running at low speed on flat and straight surfaces

• Alternate sprint, running at low speed and sprint on flat and straight surfaces

• Running following the pattern of number 8, zig-zag, with abrupt changes of direction

• Agility exercises

- *Carioca.*

- Pilate exercises, on site and with elastodynamic equipment, specific for different kinds of sports

- Multidirectional balancing exercises with progressive loads and motor activities

Recovery of competition fitness

- Athletes may resume training if they are able to perform the exercises described above at full speed

- Athletes may start competing when they are able to complete ordinary training

Phase 5: Preventive phase

Scope

- Prevent lesions

Therapeutic exercises

- Functional exercises

- Exercises on multidirectional balancing tables

- Preventive reinforcement (insist on the pronation of the peroneus muscles) with isotonic and isokinetic exercises

Training with isokinetic exercises

Muscles are extremely sensitive to stresses and respond in a specific manner. The response of muscles varies according to the type of training and to the intensity of the loads applied.

Training can be generically divided into two types: resistance training and strength training.

Resistance training is typically followed by marathoners and cross-county skiers. This type of exercise consists in applying relatively low loads for a varying length of time in order to increase the ability of the person of performing the exercise in time. This type of training affects mainly some metabolic processes, stimulating slow fibers (or Type I fibers). More specifically, this kind of training tends to increase the capacity of the muscles of using fats through oxidation and produces an increase of capilarization, mitochondrion and oxidative enzymes.

Strength training is typical of power sports (running at high speeds, jumping, throwing, etc.) and consists in applying high loads for a varying length of time. This type of training stimulates fast fibers (or Type II fibers) and aims at increasing the capacity of using energy phosphates and the glycogen of the muscles. The scope of this training is to increase strength along with the muscular mass.

Resistance and strength training, as they have been described above, represents the two limits of a range of motion that can provide several stimuli. The type of exercise, the intensity, the length and the type of load that can be applied have to be chosen by the trainer and depend on the type of sport practiced and on the characteristics of the work that is required from time to time.

It is useful to consider that the expression "training" generally refers to a healthy athlete who regularly practices agonistics sports activities, has a good level of fitness and does not suffer specific pathologies, except perhaps slight strength deficits between the antagonist or controlateral muscles, which can be easily corrected during ordinary training.

Strength training with isokinetic equipment

Strength training has always been the most effective method to reach high sports performances.

Training techniques have been significantly increased over the last 20 years both thanks to the results of tests and scientific studies and thanks to the alternative trends and methods. In this sense isokinetics is a training method that has been developed after accurate studies and thanks to the experience gained by thousands of trainers and technicians.

Isokinetics is particularly useful to trainers because it is focused on speed, which means that it is possible to select the speed at which a specific gesture is generally performed.

Selecting angular speed

Isokinetic equipment enables to change the angular speed of movement (during in vivo isokinetic conditions it is not correct to speak of muscular contraction speed), which means that it is possible to influence the relation between the strength moment and the angular speed of a specific muscular group. This relation is graphically very similar to the traditional relation between the force and speed of single muscles, but cannot be considered equivalent to it for several reasons.

It has been ascertained that isokinetic training carried out at a specific speed increases the strength in function of the speed used. Training carried out at low angular speeds yields improvements at low speeds only, while training at high speeds (above 180°/s) enables to increase strength both with high and low angular speeds. According to the data available, it is not possible to exclude effects at higher speeds.

Training at maximum strength offers optimum results when it is carried out at low speeds. The contraction of muscles at low speeds produces high tensions that are maintained for quite a long time, unlike those at high speeds that yield lower tensions. In addition to this, it is necessary to consider that a contraction at low speed also enables to stimulate type II fibers.

Data concerning training at high speeds (above 180°/s) are not univocal. Although several authors have reported significant improvements with high speed training, especially in relation to exercises like jumping, we believe that this is not sufficient to consider high speed training as more effective as compared to low speed training. According to our experience, it is generally preferable to use low speed exercises to allow athletes engaged in power sports to express their maximum strength. These exercises are generally followed, during the same session, by exercises at high speeds (above 180°/s) in order to transform the strength into fast strength. Exercises are generally completed with speed that are as close as possible to those used to perform the required sports gesture, with

movements that involve several articulations. This training plan is repeated for two-three weeks, after which the loads at low speeds are reduced and the specific work at high speeds is increased.

Optimum number of series and repetitions

One of the most problematic issues of training consists in establishing the optimum number of sequences and frequency at which the exercises must be repeated during each session. Data in literature shows that repeating the exercise for 5, 10 or 15 times at three different angular speeds does not enable to attain significant differences. Even 10 sequences of flexions and extensions of the knee at 180°/s, each with a maximum duration of six seconds, with 2 sequences of thirty seconds each, performed four times a week for seven weeks do not appear sufficient to significantly increase strength. Several authors believe that the number of repetitions of a specific isokinetic training session is not important. According to others, the maximum muscular tension developed during a muscular contraction, which is developed during most of the motion, is sufficient to stimulate all activities. In reality, this only occurs if the person is trained and knows the techniques of isokinetic training. The data of a study carried out in our laboratory shows that for sedentary active patients, training with a single daily repetition of the exercise at 120°/s for two weeks does not generally improve trophism and muscular strength, regardless of the speed. To increase strength, it is generally necessary to perform at least 3-4 sequences that include at least 3-4 consecutive repetitions at speed ranging from 60 and 180°/s. To understand why, it is necessary to take into account that maximum strength is seldom reached during the first repetition, as occurs during the second or sometimes the third repetition, and that at the fourth repetition fatigue, originating from the lack of energy phosphates generally cause a reduction of performances.

The number of repetitions and sequences that have to be carried out varies mainly according to the strength that has to be stimulated. A few repetitions (3-4) are generally sufficient to stimulate the capacity of expressing maximum strength, while a higher number of repetitions (10 and above) usually enables to stimulate the capacity of expressing resistance strength, which is obviously related to a specific speed.

Isokinetic exercise and aerobic power

As for the effects on aerobic power, it has been demonstrated that an isokinetic circuit training on different muscular groups increases the maximum consumption of oxygen by 8% in 20 weeks. It is worth noticing that this

improvement is far below the one that can be attained by running or cycling at a training level for the same amount of time.

On the other hand, after a 10 minute training on a treadmill at an intensity around 60-70% of the maximum value, for three times a week and for four weeks, the increase of maximum aerobic power (maximum consumption of oxygen) is generally around 12-15%, without alterations in terms of the strength/speed relation of the knee extension muscles.

Isokinetic training is often used to train athletes that practice long term sports. Marathoners, for example, have a relatively low muscular strength in the lower limbs as compared to other athletes. Therefore, in this case an adequate isokinetic muscular strengthening is usually useful to prevent accidents. It is generally necessary to adopt a protocol with several sequences of 15-30 seconds at medium speeds (150-180°/s), which enables to specifically stimulate resistance to strength and Type I muscles. These exercises must be ideally inserted at specific times during training.

Can isokinetics really be considered the best strength training method?

The advantages offered by isokinetics as compared to other methods originates mainly from the possibility of maximizing the stimulation of the muscular group during most of the motion without increasing the potential energy of the machine, as occurs when you lift a weight. It is worth noticing that maximum muscular stimulation occurs in presence of maximum contraction and when the speed of the movement is not particularly high. If these two conditions are met, strength increases rapidly (generally with a lower number of sessions as compared to other methods) because of the more effective stimulation of the nerve mechanisms that control the expression of maximum strength. In this sense, the use of a visual biofeedback is essential because it enables to continuously control the level of strength required.

We don't believe it is appropriate to state that one method is more effective than another. As we have observed above, the muscle is a rather plastic organ that responds according to the stimuli applied. Modern training principles recommend the use of several methods, with varying sequences and intensities, to attain the maximum performance for a specific sports discipline. Isokinetics is one of the available methods and should be considered as such.

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