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Athlete Neuromuscular Training with a Focus on the Knee Joint

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ABSTRACT

Neuromuscular training is a physically and mentally demanding process. These programs are intended to improve joint strength, particularly in the knees, as well as to raise the athlete's awareness of good balance and technique. Warm-ups, strengthening, plyometrics, and stretching exercises are typical in Neuromuscular regimens. The stability of the knee is affected by a variety of factors. The static and dynamic knee stabilizers are the two most significant. Static stabilizers are the Anterior cruciate ligament, posterior cruciate ligament, Medial collateral ligament and, Lateral collateral ligament. Dynamic stabilizers of the knee are the muscles and tendons that surround the joint. These muscles and tendons are controlled by neuromuscular input; the unconscious activity of these tissues helps to control joint position. Neuromuscular training is utilized to create better knee stability practices. Training allows one to keep the knee joint in a more solid position during jumping, landing and rotating. These programs aim to improve both cognitive awareness and muscle memory, strengthen the entire knee joint, and make it less prone to injury. Thus, this paper is to raise awareness regarding the significance and necessity of neuromuscular training for athletes.

KEYWORDS: *Neuromuscular training, Athlete, Exercise*

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INTRODUCTION

Neuromuscular training (NMT) is a type of training focusing on sensory-motor integration. The principles used are recognized at an early stage in the profession of physical therapy. This type of training aims to improve the nervous system's ability to generate fast and optimal muscle firing patterns, decrease the joint force, and relearn movement patterns and skills. Research reports, decreased proprioceptive sense, longer muscle response time, and declined balance of the leg after an Anterior Cruciate Ligament (ACL) injury. The bony architecture of the knee provides little stability to the joint due to incongruity of the tibia and femoral condyles. The knee is dependent on the strength of muscles, ligaments, and capsules for its stability. Not only mechanical aspects; but also sensory-motor integration (neuromuscular control) is important for stability. The knee joint is subject to high forces and movements during sports activities, and ligament injuries are common among athletes. Of the four major ligaments of the knee, the ACL is the most frequently injured. Research has shown a decrease in the proprioceptive sense after an ACL rupture. Due to the disturbed sensory feedback from the joint after a ligament injury, motor programs have to be relearned. The term Neuromuscular Training (NMT) is increasingly used to describe a particular type of training which includes balance training, dynamic joint stability training, perturbation training, and plyometric training. NMT describes training programs that include some or all of these components. The basic concept behind these training methods is that repetitively challenging an individual's ability to maintain static or dynamic control of his or her knee joint results in improved neuromuscular control and subsequently, improved joint stability.

The definition of the four neuromuscular components according to Risberg and Myklebust:

Balance: state of body equilibrium or the ability to maintain the center of body mass over the base of support without falling

Dynamic joint stabilization: balance exercise where the patient is to maintain body position while moving an extremity in space

Perturbation training; an unexpected physical event that changes the movement or movement goal

Plyometric training: a quick, powerful movement involving pre-stretching the muscle and activating the strengthening-shortening cycle to produce a subsequently stronger concentric contraction.

In the past, rehabilitation programs focused primarily on strengthening and paid little attention to the neuromuscular-proprioceptive training of the knee joint [1]. Neuromuscular training is not only thought to be important in conservative management but also in the rehabilitation after a reconstruction.

Anatomy of the Knee

The knee joint is the junction of three bones – the femur, the tibia and the patella. The tibiofemoral is a hinge joint with two degrees of freedom; flexion, extension, and axial, rotation. The condyles of the femur are convex and the tibial surface is mutually concave. However, this does not make the articular surface completely congruent, which enables the two bones to move in different amounts guided by ligaments and muscles. The two bones have full congruency in full extension and are therefore most stable in this position. The patella-femoral joint is a modified plane joint. During flexion and extension different parts of the patella articulate with the femoral condyles. One of the functions of the patella is to increase the efficiency of extension by holding the quadriceps away from the axis of movement. The ends of the three bones are covered with articular cartilage. This is a tough, elastic material that helps absorb shock and allows the knee joint to move smoothly. The menisci are separating the bones of the knee. These are pads of connective tissue, which are divided into two crescent-shaped discs positioned between the tibia and the femur. This structure aids in lubrication and nutrition of the joint [2]. It also acts as a shock absorber makes the joint surfaces more congruent, reduces friction during movement, and aids the ligaments and capsule in preventing hyperextension

Static Stabilisers

Static stabilization of the knee is mainly provided by the ligamentous structures and to a lesser extent the joint capsule, the bony architecture, and the meniscus. The essential ligaments of the knee are; Medial Collateral Ligament (MCL), Lateral Collateral Ligament (LCL), Anterior Cruciate Ligament (ACL,) and Posterior Cruciate Ligament (PCL). The medial and lateral collateral ligaments are positioned on the sides of the knee joint. These ligaments prevent valgus and varus movements of the joint. The ACL is situated in the anterior part of the joint and prevents the tibia from sliding anteriorly on the femur. In opposition, the PCL prevents posterior translation of the tibia on the femur. Additionally, both the ACL and PCL serve to reduce rotation of the femur on the tibia. The cruciate ligaments are tense in all positions, but increase their tension in the extremes of flexion and extension [3]. The cruciate ligaments are so intimately related to the capsule that they can be considered as actual thickenings of the capsule.

Dynamic Stabilisers

Dynamic support of the knee is achieved through preparatory and reflexive neuromuscular control. The primary active stabilizers of the knee are the quadriceps, hamstrings, and gastrocnemius. These per articular muscles contribute to the defense of the knee joint by contracting in a perfectly synchronized manner. Particular movements are preconditioned by the cerebral cortex and prevent mechanical distortions of the joint. Due to this preconditioning, they are indispensable for the ligaments, which only react passively [4].

Risk Factors and Incidence of Anterior Cruciate Ligament Injuries

Sports presenting the greatest risk for ACL injury are "cutting sports". These are sports including fast running and quick lateral movements. Examples are football, handball, skiing, basketball, and, soccer. The reason for this is the high frequency of jumping, running, and pivoting movements with the rapid deceleration of the body in a fixed foot position occurring in these sports. Other causes can be a direct blow to the leg from the front, such as a low tackle, or a twisting injury. The major symptom of an ACL injury is a sudden loss of control of the injured joint in a weight-bearing position [5].

Nervous System

The sensory signals provided by the mechanoreceptors are mediated in the nervous system. The time for the motor response to occur depends on which level of the CNS the sensory information is being delivered. The CNS can be divided into three levels according to the type of motor response.

The spinal level produces spinal reflexes and is characterized by gross, quick movements that require no cortical input or sensory feedback. The output is generally stereotypical and modified by the intensity of the afferent signals. Simple reflex processed on the spinal level is the quickest neuromuscular response. The most basic spinal reflexes occur with a latency of 30-50 m s. This generating of fast reflex responses is important for joint stabilization and can be trained by using perturbation training/ local stimuli.

The brain stem level produces semiautomatic movements (rhythmic behavior) usually requiring supra spinal initiation and termination, but proceeds automatically in terms of neural control (e.g. walking, chewing). These motions are intermediated between reflex and voluntary activity. Motor responses mediated in the brain stem are typically referred to as long-loop reflexes and the latency of their responses is 50-80ms longer than those of segmental spinal reflexes. Because these reflexes are processed at a higher level they are more flexible than the spinal reflexes. Improving function at this level can be achieved by performing balance and postural activities.

The cortical level consists of the motor cortex, basal ganglia, and cerebellum. Voluntary activity is affected by attention and motivation. They are learned and require practice for perfection. Once learned, complicated voluntary movements can be used to form a motor program by which complex tasks are accomplished without thinking about each step. The latency of these responses is usually greater than 120 m s. These motor responses are highly flexible due to the complex processing occurring at this level. The highest level provides cognitive awareness of body position and movement that are repeated and stored as central commands to be performed without continuous reference to consciousness [5].

The Neuromuscular Control System

Neuromuscular control is the efferent (motor) response to sensory information, also referred to as the ability to produce controlled movement through coordinated muscle activity [6].

Neuromuscular control results from the complex interaction between the nervous system and the musculoskeletal system.

In a very basic model, the neuromuscular system can be divided into three components; receptors, the nervous system and muscle response [6].

The receptors transmit afferent (sensory) information to the central nervous system (CNS), which provides a motor response. A control system is required when processing afferent signals into efferent responses for dynamic joint stabilization. This complex control strategy incorporates feed-forward and feedback mechanisms.

Feed-forward neuromuscular control involves planning movements based on sensory information from experience. This requires building a program depicting the expected conditions with all of the known task parameters. This mechanism pre-activates the muscle tension in anticipation of movements and joint loads.

Feedback is a process that uses information from joint and muscle receptors to continuously regulate ongoing muscle activity. The feed-forward mechanism is responsible for preparatory muscle activity, while feedback processes are associated with reactive muscle acivity [7].

Sensory Receptors

Sensory receptors are specialized to respond to energetic stimuli like sound, mechanical stimuli, light, etc. [7]. Important for neuromuscular function are the mechanoreceptors, found in the skin, muscle, and joints as well as ligaments and tendons. The mechanoreceptors provide the CNS with sensory information, referred to as proprioception, the conscious and the unconscious appreciation of joint position, and kinaesthesia, the sensation of joint motion or acceleration. Mechanoreceptors in the joint are triggered by the deformation and loading of the soft tissue that composes the joint. These receptors are sensitive to pressure changes resulting from as little as 2° of changes in the joint position [8]. Four types of joint receptors have been identified in the soft tissue of the knee; Ruffini endings, Pacinian corpuscles, Golgi tendon organ-like receptors, and free nerve endings.

Neuromuscular Training and Proprioception

Neuromuscular training and proprioception is the key to joint stability. Neuromuscular control is an unconscious response to joint motions that occurs without awareness. It is how a runner adjusts to uneven pavement or shifts his weight to stay balanced on inclines. Proprioceptive information includes an ability to detect joint position, movement, direction, amplitude and speed of motion. In theory, a joint that possesses a high level of neuromuscular control and a highly sensitive proprioceptive feedback system can respond appropriately to variations in forces placed upon it during activity and decrease the risk of injury. Therefore, the goal of proprioceptive exercises is to train joint proprioceptors to adapt to stimuli received either during or before the initiation of a deleterious movement.

Sample Lower Body neuromuscular Exercises

The following exercises can be used to rehab the lower extremity.

1. One-leg Balance. Try to stand on one leg for 10-30 seconds
2. One-leg Balance with Eyes Closed.
3. Balance Board Ball Toss. While balancing on a wobble board, balance board, or Bosu Ball catch

and toss a small (5-pound) medicine ball with a partner.

4. Balance Board with Half-squats. While balancing on a wobble board, perform 10 slow, controlled half-squats.
5. Step up onto Balance Board. Place a balance board (or soft pillow or foam pad) 6-8 inches higher than your starting point. Step up 10 times.
6. Step down onto Balance Board. Place a balance board (or soft pillow or foam pad) 6-8 inches lower than your starting point. Step down 10 times.
7. Lateral Plyometrics. Perform a lateral (sideways) step-down and then step-up.
8. Single Leg Hops. Hop forward and concentrate on "sticking" the landing.
9. Single Leg Spot Jumps. Hop from spot to spot on the floor.
10. Reactive Spot Jumps. Place numbered pieces of tape on the floor and as a partner calls out a number, hop to that number [9].

Prevention programs:

This prevention program consists of a warm-up, stretching, strengthening, plyometrics, and sport-specific agilities to address potential deficits in the strength and coordination of the stabilizing muscles around the knee joint. The coaches and trainers need to emphasize correct posture, straight up and down jumps without excessive side-to-side movement, and reinforce soft landings. This program should be completed 3 times a week.

Warm-up

Warming up and cooling down is a critical part of a training program. The purpose of the warm-up section is to allow the athlete to prepare for the activity. By warming up your muscles first, you greatly reduce the risk of injury. Ex. Jog line to line (cone to cone): Elapsed Time: 0.5 minute, Shuttle Run (side to side) Elapsed Time: .5to1 minute,

Strengthening

This portion of the program focuses on increasing leg strength. Walking Lunges (1 minute), Elapsed Time: 1.5 –2.5min, Russian Hamstring (1 minute), Elapsed Time: 2.5 –3.5 min, Single Toe Raises (1 minute) Elapsed Time: 3.5 –4.5min.

Plyometrics

These exercises are explosive and help to build power, strength, and speed. The most important element when considering performance technique is the landing. It must be soft when one lands from a jump, and softly accept the weight on the balls of your feet slowly rolling back to the heel with a bent knee and a bent hip. Ex. Lateral Hops over Cone (30 seconds), Forward/Backward Hops over cone (30sec), Single Leg hops over cone (30 seconds), Vertical Jumps with headers (30 seconds), Scissors Jump (30 seconds) Elapsed Time: 6.5 –7min.

Agilities

Increase dynamic stability of the ankle/knee/hip complex Ex. Forward run with 3-step deceleration, Lateral Diagonal runs (3passes), and Bounding run (4 yards).

Stretching

It is important to incorporate a short warm-up before stretching and should never stretch a “cold muscle”. By performing these stretches, one can improve and maintain a wide range of motion, reduce stiffness in the joints, reduce the risk of injury and improve overall mobility and performance. Ex. Calf stretch, Quadriceps stretch, Hamstring stretch, Inner Thigh Stretch, and Hip Flexor Stretch [10].

Conclusion and Recommendations

An ACL injury affects the stability of the knee joint and has an impact on both mechanical and static functions. Mechanoreceptors are found in the ACL and injury to this ligament causes disturbances of the reflex pathways influencing knee instability. Research states that there are no changes in passive knee laxity after rehabilitation, though functional improvement has been reported. This indicates that neuromuscular function appears to compensate for mechanical instability. There is a correlation between hamstring reflex latency and functional ability, but no correlation is found between muscle strength and functional stability. This implies that traditional strengthening exercises are insufficient in knee rehabilitation. Neuromuscular training is found to decrease the hamstring reaction time, which is essential in maintaining dynamic joint stability. NMT has shown a positive effect on improving knee function after an ACL injury concerning the aspects of balance, dynamic joint stability, coordination and returns to sports activity.

Recommendations for clinical practice

Current literature suggests that a training program focusing on neuromuscular control should be applied for conservatively treated patients in rehabilitation after an ACL injury. The aim of the rehabilitation program should be to reach the pre-injury level. The physiotherapist should take advantage of the possibility to include the training principles for NMT, so the rehabilitation results reach an optimal level.

References

[1] Lutz GE, Stuart MJ, Sim FH. *Rehabilitative techniques for athletes after reconstruction of the anterior cruciate ligament*. *Mayo Clin. Proc*. 1990, 65:1322-1329.

[2] Magee DJ. *Orthopedic Physical Assessment, third edition. Montreal*: 1987-1997.

[3] Jenkins DB*, Hollinshead's Functional Anatomy of the Limbs and Back. Harcourt Brace & Company*. Philadelphia: 1991

[4] Kapandji IA. *The physiology of the joints. Volum two, lower limb.* Fifth edition. Churchill Livingstone. 1987.

[5] Zatterstroem R, Friden T, Lindstrand A. *The effect of physiotherapy on standing balance in chronic anterior cruciate ligament insufficiency*. *Am. J. Orthop. Sports Med.* 1994, 22(4):531-536.

[6] Williams GN, Chmielewski t, Rudolph KS, Buchanan TS, Snyder-Mackler L. *Dynamic knee stability: Current theory and implications for clinicians and scientists*. *J. Orthop. Sports Phys. Ther.* 2001, 31:546-566.

[7] Swanik CB, Lephart SM, Giannantonio FP, Fu FH. *Reestablishing proprioception and neuromuscular control in the ACL-injured athlete. J. Sports Rehab.* 1997, 6(3):182-206.

[8] Kreighbaum E, Barthels KM. *Biomechanics: A qualitative approach for studying human movement*. Boston: Allyn and Bacon. 1996.

[9] Beard DJ, Dodd CAF, Trundle HR, Simpson AHRW. *Proprioception enhancement for anterior cruciate ligament deficiency*. *J. Bone Joint Surg*. 1994, 76B: 654-659.

[10] Cohen LA, Cohen ML. *Arthrokinetic reflex of the knee. Am. J Physiol.* 1954, 184:433-437.