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JUNIOR ICE HOCKEY PLAYER'S MOBILITY TRAINING –
TUTORIAL GUIDE ABOUT MOBILITY EXERCISES FOR
JUNIOR PLAYERS AND THEIR COACHES

Degree Programme in Physiotherapy

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The purpose of this thesis was to produce a tutorial guide about mobility exercises for junior ice hockey players and their coaches. Mobility training is an integral part of any sports conditioning plan and mobility can be considered as a physical attribute where in particular young athletes should pay attention to. Nevertheless, instructed mobility training is rarely included in the training regimen in children's sports. This thesis is aimed to increase junior ice hockey players and their coaches' knowledge about mobility training and to provide a practical tool that assists the coaches to develop off-ice mobility training and to support players' independent training. The thesis was carried out in co-operation with TPS junior ice hockey.

Based on sport analysis of ice hockey, exercise physiology, and physiotherapeutic knowledge, the most significant musculoskeletal stress factors and the type of mobility and movement patterns required in ice hockey were determined. Paediatric exercise physiology was utilized in determining the type and the amount of mobility training that children and adolescents should perform during the different phases of growth.

Based on acquired knowledge a tutorial guide consisting of theoretical information about children and adolescents mobility training and examples of static stretching exercises and hockey-specific active mobility exercises was assembled. In total, the guide contains 45 mobility exercises illustrated with photos and accompanying text. The guide was provided as a PDF file (Portable Document Format) for the use of TPS junior ice hockey. In the future, the guide can be developed by adding new exercises into it or by creating a computer based program where exercises are demonstrated on video.

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1 INTRODUCTION

Mobility is one of the basic elements which constitute a person's physical performance along with strength, speed, endurance and coordination (Spring et al. 1993, 10). It is a physical attribute that improves efficiency of movement and has a positive effect on force production, endurance and speed. During puberty, body proportions change rapidly and the development of mobility slows down. Period of rapid skeletal growth may also increase muscle- tendon tightness about the joints and lead to loss of flexibility, muscular control and coordination due to the bones growing much faster than the muscles grow and stretch. If mobility training is neglected during the childhood and adolescence, it might be difficult in the adulthood to reach the optimal level of mobility required in a sport. Therefore, mobility can be considered as a physical attribute in which particularly young athletes should pay attention to. (Alter 1996, 9,141; Hakkarainen & Nikander 2009, 142; Kalaja 2009, 277; Seppänen, Aalto & Tapio 2010, 103).

In the year 2006 the Young Finland Association (Nuori Suomi ry), the Finnish Olympic committee and the association of Finnish coaches (Suomen Valmentajat ry) established a work group in collaboration with 13 sports associations. One of these was the Finnish ice hockey association. The work group conducted a study to find out how much a young Finnish athlete moves and trains in total, is the training one-sided or comprehensive, and how the training should be developed in the future. According to the study results training mobility is rare in all sports and only half of the mobility training is instructed. Warm ups and cool downs are also rarely included in the training regimen. In ice hockey, a lack of instructed warm-ups and cool downs was found to be a problem in all age groups. (Hakkarainen 2008, 22; Hakkarainen et al. 2008, 5, 44-45).

This bachelor's thesis is done in collaboration with TPS junior ice hockey. The purpose of this thesis and its end product, a tutorial guide about mobility exercises

for junior players and coaches, is to provide information and practical examples for the coaches and players throughout the organization of TPS regarding the type of mobility exercises a young hockey player should perform during the different phases of growth. TPS junior ice hockey includes almost 40 teams, age groups from 7 year olds to young adults. Totally TPS has almost 900 junior players, 100 coaches and instructors and 150 team leaders and equipment managers. (Website of TPS junior ice hockey).

Frequently, terms mobility training and stretching are understood as the same. In this thesis, mobility training refers to exercises that are dynamic in nature and combine strength and stretching exercises. The main purpose of these exercises is to improve one's potential degree of active mobility and to prepare the body for the activity. Stretching in this thesis is considered more or less as a passive procedure that can be utilized to maintain or to increase passive range of motion about joints, to recover tightened muscles to their rest length and to prevent body's asymmetry.

2 THE PURPOSE AND AIM OF THE THESIS

The purpose of this bachelor's thesis is to produce a tutorial guide for junior ice hockey players and their coaches about mobility exercises. The aim of the tutorial guide is to increase the pool of knowledge regarding mobility and how it can be developed during the different phases of growth. The tutorial guide is aimed to serve as a practical tool to help the coaches to develop off-ice mobility training and to support players' independent training.

3 ICE HOCKEY

Ice hockey is an intensive, interval type of collision sport characterized by fast, explosive skating, rapid and sudden changes in direction, and physical contact. It is a team sport that requires aerobic and anaerobic conditioning, speed, agility, reaction skills, balance, muscular strength and endurance, whole-body power, rotatory power and dynamic flexibility. (Twist & Rhodes 1993, 68-70; Twist 2007, xiv).

A game of hockey is played between two teams on an ice surface known as a rink. The rink in Europe is approximately 60 meters long and 30 meters wide. (Website of the International Ice Hockey Federation). Both teams have 6 players on ice: a goalkeeper, two defensemen and three forwards. A game lasts 3 times 20 minutes with a 15 minutes break between the periods. The team that scores more goals during the periods wins. A typical player performs 15 to 20 minutes of a 60 minute game and each shift lasts from 30 to 80 seconds with 4 to 5 minutes of recover between the shifts. The intensity and duration of a particular shift determines the extend of the contribution from aerobic and anaerobic energy systems. A typical shift involves short bursts of high intensity skating followed by longer periods of coasting. During a typical shift heart rate exceeds the anaerobic threshold in most players and lactate

accumulates in the blood. (Montgomery 1988, 99, 110; Airaksinen 2002, 456 Harari & Ominsky 2002, 2, 21). In juniors, the length of a game varies. In Finland 13 to 14 year old and older juniors play full length games. In younger age groups, a game lasts either 2 times 25 minutes or 3 times 15 minutes. Slap shots and bodychecking is prohibited in younger age groups (Finnish Ice hockey association 2010).

Ultimately, hockey is about the skill to win one-on-one situations. According to Twist (2007, 1) the five principal on-ice skills are skating, puckhandling, bodychecking, shooting, and passing. From these, the most important skill is believed to be skating (Bracko 2004, 47). Hockey skating, also referred to as power skating, involves several complex motor skills like starts, stops, moving laterally, skating while being checked, backward skating, turning, pivoting and skating in different velocities. A technically solid skater is mechanically efficient, so that he utilizes less energy and delays fatigue. A poor skater utilizes much more energy and fatigues more quickly. Acquiring proper skating technique requires a base of strength, flexibility, speed, quickness, and agility. Asymmetrical strength imbalances inhibit skating technique, and lack of joint mobility and movement skills interferes with complex skating patterns. (Twist 2007, xiv). Regular mobility training improves coordination, body fitness, posture, and symmetry (Alter 2004, 14; Kalaja 2008, 264, 268). Targeting mobility exercises especially in hip, groin, quadriceps and hamstrings may help skating technique, improve foot work and reduce the risk of injuries. Excessive joint mobility in a hockey player may counteract efforts to improve strength and power. While selecting and instructing mobility exercises, special care should be demonstrated with young hockey players because some of them may already be excessively flexible and therefore predisposed to injury. (Twist & Rhodes 1993, 70; Twist 2007, xiv, 29-30).

3.1 Skating position and motion

In a balanced skating position, the skates are positioned slightly wider than shoulder width apart and the weight is on the ball of the feet. Ankles are dorsiflexed, knees are slightly flexed, trunk is flexed from the hips, and pelvis is tilted forward. The head is kept up and the hockey stick close to the ice or on the ice. In practice, each of the

other skating characteristics is derived from this two-foot balance position that enables quick starts in all directions. (Paananen & Rätty 2002, 29; Bracko 2004, 47).

Forward ice skating includes three phases: propulsion, glide and recovery. Effective force production requires that the skating motion begins from the core muscles and proceeds downwards all the way to the minor muscles of the foot. (Toivola 2008, 21-22, 24). To push off, the skate is directed to the side. This requires free hip external rotation and pronation of the ankle. During the propulsion phase the hip is abducted and extended, knee is extended, and at the end of the propulsion the ankle is extended. During the recovery phase, the hip is flexed and adducted to return the leg towards the midline of the body. Fast skating requires wide strides, quick recovery after propulsion, deep knee flexion prior to propulsion, and significant forward lean. Back is kept straight and stiffened during the skating actions and proper movement of the shoulders is rhythmic, smooth and coordinated abduction and adduction as an opposite reaction to the hip abduction and adduction. (Paananen & Rätty 2002, 17, 30; Bracko 2004, 50, 52; Martinmäki 2010, 22-23).

3.2 Loading of the musculoskeletal system

The musculoskeletal system is an integrated system formed by the bones, muscles and joints. Optimal function of the musculoskeletal system requires muscle coordination, muscle strength and joint mobility. An adult human has 206 bones and almost 700 muscles. Joints are points at which two or more bones connect, the connections are primarily performed by ligaments and assisted by muscles and tendons (Ahonen & Lahtinen 1993, 152; Alter 1998, 2; Tortora & Derrickson 2006, 195, 259, 326). The hip, knee and ankle joints participate in the production of the skating force and are thus, highly stressed in ice hockey (Paananen & Rätty 2002, 25). Prolonged repetitive loading or overloading of a joint may cause restrictions in joint range of motion and muscular imbalance, especially if preventive mobility training is neglected (Ylinen 2002, 11; Saari, Lumio, Asmussen & Montag 2009, 38).

3.2.1 Muscle balance

Muscle balance refers to the ability of muscles to activate in right order and time to produce smooth, purposeful and coordinated movements efficiently. Good muscle balance is a prerequisite for an optimal performance in sports. It enables efficient training and decreases the risk of injuries (Ahonen & Lahtinen 1988, 281, 284; Spring et al. 1993, 13; Forsman & Lampinen 2008, 287). Unilateral or over-training of certain muscle groups has a negative effect on muscle balance (Spring et al. 1993, 12; Ylinen 2009, 12; Seppänen et al. 2010, 105).

In many sports, it is difficult to maintain muscle balance as the performance itself is asymmetrical (Ahonen & Lahtinen 1988, 316). Ice hockey requires performing a high volume of asymmetrical movements, often with power. Skating can cause strength and flexibility imbalance between the quadriceps and hamstrings, hip flexors and extensors, and hip abductors and adductors. Postural asymmetry and uneven flexibility can result from preferentially shooting off one side, stopping more often on one side, and loading up one leg more than the other to generate power striding forward. Leg length discrepancies and injuries which lead to compensational patterns in the body are also contributing factors. (Twist & Rhodes 1993, 70; Nicholas & Tyler 2002, 340-341; Gilmore & Karageanes 2007,544; Twist 2007, 29).

Muscles act at joints as force couples (agonists and antagonists). Agonist is the muscle contracting to cause an action or a movement while its opposing muscle, the antagonist, relaxes and stretches. (Tortora & Derrickson 2006, 330). A key to structural balance is an equal pull by the antagonist (Figure 1a). Muscle balance can be lost due to one muscle being too weak or too strong compared to its opposing muscle (Figure 1b and 1c). Basic treatment guideline for such a case is to strengthen the weak muscle and stretch the shortened muscle. (Alter 1996, 33-34).

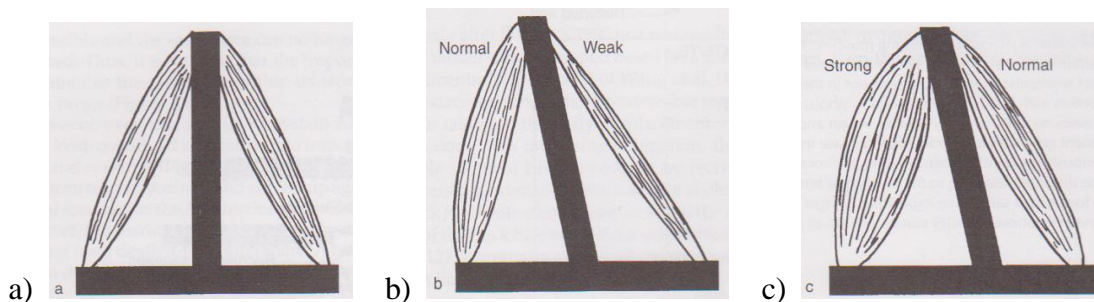


Figure 1. Structural balance and typical imbalances between agonist and antagonist muscle (Alter 1996, 34).

Unfortunately, the maintenance of muscle balance is not as simple because movements are the result of several muscles acting as a group. Therefore, an imbalance between the agonist and antagonist will also affect on so called synergist and fixator muscles which aid the movement of the agonist. Usually, when muscle imbalance is present, these muscles become overworked and lose their ability to stabilize joints and the agonist, in order to prevent unwanted movements (Tortora & Derrickson 2006, 330; Chaitow 2006, 57).

According to their function muscles can be divided into two groups: postural and phasic. Postural muscles, which are presented in figure 2, maintain upright posture and are prone to tightness when stressed. They have a tendency to become tight even without excessive loading or playing ice hockey. In proportion, phasic or moving muscles tend to become weak and inhibited. Predominantly tight or overactive muscles will reflexively inhibit their antagonists, thereby altering basic movement patterns. Consequently, an athlete will use compensational movement patterns during sport performance and predisposes himself to injuries. (Chaitow 2006, 52-55).

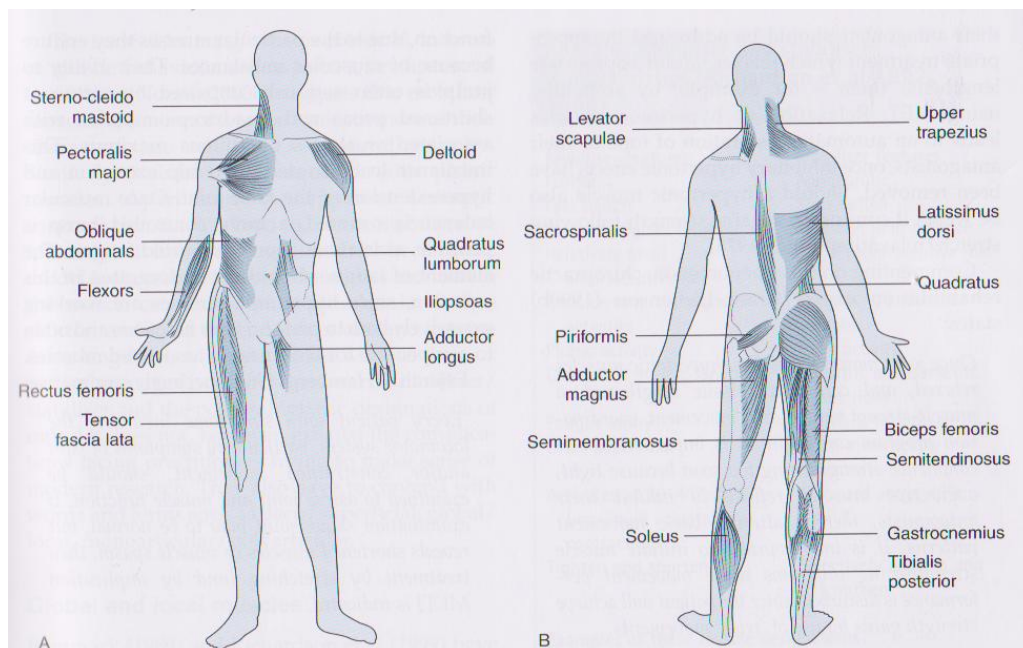


Figure 2. The major postural muscles of the anterior and posterior aspect of the body (Chaitow 2006, 53).

3.2.2 Lower back, pelvic region and hip

Ice hockey players' back is stressed due to the flexed posture in skating, which demands continual isometric contraction of the back extensors. Stressful twisting actions also load the back throughout a game. Especially shooting and sequential turns, hits and feints require forceful trunk rotations and whole body rotatory power. (Twist & Rhodes 1993, 70; Twist 2007, 78). An abnormal posture of the lumbar spine can increase the risk of lower back injury, particularly in individuals who play contact sports. Asymmetrical trunk rotation and lateral flexion range of motion has a connection to low back pain as well as lack of rotation in the thoracic spine. To avoid back problems and to improve performance on-ice, hockey players require strong, stable, symmetrical and highly reactive torso musculature (rectus abdominis, transversus abdominis, multifidus, internal and external obliques, quadratus lumborum, spinal erectors, gluteals, hamstrings and hip rotators) that transmits forces developed in the upper body, through the torso, for optimal projections through the legs to the floor and vice versa (Boyle 2004, 85; Richardson, Hodges & Hides 2005, 170; Pelham & Holt 2008, 92; McGill 2009, 13). Pelvis functions as a link between the upper and lower body. Dynamic, stable and balanced pelvis enables efficient

force production during the skating actions and prevents low back injuries. Proper function of the pelvic girdle is also important to prevent common strain injuries in hockey. The most important link between the pelvis and lower extremities is the hip joint. (Gilmore & Karageanes 2005, 543-545; Koistinen 2005, 153-155).

The hip joint is a so called ball and socket joint which means it can move in all directions. Individuals involved in sports that require repetitive explosive rotary movements of the hips, such as ice hockey, often develop limited hip rotational flexibility. Inadequate flexibility of the hips can have a significant effect on lumbopelvic posture (Richardson et al 2005, 170-171; Holt, L., Pelham & Holt 2008, 92). The majority of muscles responsible for moving the hip joint originate from the pelvis, but some originate from the spinal column. The most important muscles that pass over the hip joint are gluteal muscles, groin muscles and hip flexors. (Wirhed 1985, 36-37, 39).

The gluteal muscles (gluteus maximus, gluteus medius and gluteus minimus) work powerfully when, in forward skating, the hip is externally rotated, abducted and extended during the propulsion phase. Particularly gluteus maximus is subjected to great stress as it is able to extend the leg with a great force when the body is flexed forward at the hip. Proper function of the gluteus medius and minimus muscles is emphasized while balancing on one leg as they stabilize the hip joint and prevent the upper body from falling to the opposite side (Wirhed 1985, 39-40). According to Twist (2007, 78) hockey players balance on one leg over 80% of the time when they are on task challenging for the puck.

Small hip external rotator muscles that are located deep to the gluteus maximus (piriformis, obturator internus, obturator externus, superior gemellus, inferior gemellus and quadratus femoris) are also used a great deal in ice skating. (Wirhed 1985, 43; Tortora & Derrickson 2006, 383). Tightness in the hip external rotator muscles changes the optimal alignment of lower extremities. This increases stress on both the lumbar spine and lower extremities. (Koistinen 2005, 165-166).

The groin muscles (adductor magnus, adductor longus, adductor brevis, pectineus, gracilis) work powerfully when, in skating, the skate leaves the ice after propulsion

and begins to swing forward (Wirhed 1985, 41-42). Tightness in the groin muscles restricts hip abduction and ability to perform wide skating strides (Koistinen 2005, 164). Repetitive, forceful adduction movements, quick accelerations and decelerations, and sudden directional changes may overload the adductor muscles and cause discomfort in the groin area. Groin strain is a typical injury in ice hockey. (Airaksinen 2002, 464; Engebretsen, A., Myklebust, Holme & Engebretsen, L 2010, 2056). According to Nicholas & Tyler (2002, 339, 341), a history of groin strains and strength imbalance between the hip abductors and adductors predispose hockey players to groin strains. In their study, NHL players who sustained groin strain, the adduction strength was only 78% of abduction strength and in uninjured players the adduction strength was 95% of abduction strength. Asymmetry in abduction strength was also evident among injured players. Age and experience have also been recognized as risk factors for groin injuries. In addition, strength imbalances between the propulsive muscles and the stabilizing muscles of the hip and pelvis and between the synergistic abductors and adductors have been suggested as risk factors for groin injuries, as well as delayed contraction of the transversus abdominis as a measure of reduced core stability. (Engebretsen et al. 2010, 2056). Preventive training consists of strengthening, active muscle stretching and functional exercises aimed at increasing adductor strength and stabilizing muscular activity may help to decrease the risk of groin injuries. (Stuart & Smith 1995, 461; Airaksinen 2002, 464; Nicholas & Tyler 2002, 341; Engebretsen, A., Myklebust, Holme, Engebretsen, L. & Bahr 2008, 1056).

Hip flexor muscles pass over the hip joint on the anterior aspect of the body. In the skating position, primary hip flexor muscles psoas major and iliacus, and a secondary hip flexor muscle rectus femoris, tilt the pelvis forward and flex trunk at the hip joint. In forward skating, these muscles work powerfully together with the adductor muscles during the recovery phase. (Wirhed 1985, 43-44; Tortora & Derrickson 2002, 384, 389). Psoas major and iliacus muscles have different origins, but a common insertion point. This should be remembered when choosing strength and mobility exercises. (McGill 2009, 79). According to Montgomery (1988, 117) hip flexor muscles are well developed in hockey players in comparison to the other parts of their body. Strong but short hip flexor muscles may counteract efforts to improve skating speed and power, because passive tension in hip flexor muscles limits the

ability to perform full hip extension. If hip extension is restricted, pelvis tends to tilt forward and anterior curvature (lordosis) of the lumbar spine increases during the push offs. Increased lumbar lordosis subjects the discs between the lumbar vertebrae to great stress. Combination of weak abdominals and tight low back muscles, and possibly tight tensor fascia latae muscle, increase the lumbar lordosis further more. Strength imbalance between strong hip flexors and possibly weak muscles at the back of the thigh (hamstrings) may also lead to mild back aches. (Wirhed 1985, 44, 46; Twist & Rhodes 1993, 69; Koistinen 2005, 163).

3.2.3 Lower extremities, knee and ankle joint

The knee joint is extremely vulnerable to damage because it is mobile, weight-bearing joint and its stability depends almost entirely on its associated ligaments and muscles. (Tortora & Derrickson 2006, 282). In ice hockey, the knee joint faces extreme stress during fast, explosive skating and quick changes in direction. Most common knee injuries in ice hockey are partial rupture of medial collateral ligament and tear of medial meniscus. Total rupture of the medial collateral ligament and damage to anterior cruciate ligament are also possible. (Airaksinen 2002, 457, 460-461).

When extending the knee joint in the skating thrust, knee extensor muscles (quadriceps femoris) develop the largest contractile forces. In addition, they stabilize the knee joint during all the actions that occur on the ice. Hamstring muscles located at the back of the thigh (biceps femoris, semitendinosus and semimembranosus) function as knee flexors and hip extensors. During the skating actions the hamstring muscles assist gluteus maximus in hip extension, stabilize the knee during weight shifts and push offs, and participate in the production of backward skating motion. When the trunk is flexed forward at the hip they activate to resist gravity. (Wirhed 1985, 50, 53; Montgomery 1988, 100; Alter 1996, 245; Toivola 2008, 24; Tortora & Derrickson 2006, 388-389). According to Twist & Rhodes (1993, 69) tightness in hamstring muscles is quite common among hockey players because these muscles are not able to fully stretch during the skating stride. Lack of hamstring flexibility disturbs skating techniques and may result in a stationary hip. With a stationary hip,

a person is not able to tilt his pelvis forward and tries to compensate for this by bending forward at his lumbar spine. This may lead to back pain (Wirhed 1985, 54; Twist & Rhodes 1993, 69). Some evidence suggests that especially asymmetrical flexibility between the hamstring muscles has a connection to back pain (McGill 2008, 13).

The foot and ankle play an important role in all sports as they provide shock absorption, contact balance, and spontaneous propulsion in all motion planes (Deppen 2007, 145). In dorsiflexion, the ankle acts like a rigid structure and provides support for the entire body. In plantarflexion, it is much more mobile and acts like a flexible lever for propulsion. (Magee 2007, 844, 846). In ice hockey efficient use of the ankle joint increases skating speed, and ankle reactivity combined with whole body balance greatly influence edging and aggressive on-ice maneuvers (Paananen & Rätty 2002, 25, Twist 2007, xiv). Calf muscles (gastrocnemius and soleus) plantarflex the ankle to produce force at the end of the skating stride. Gastrocnemius also stabilizes the knee joint during weight shifts and push offs. It is able act on both the knee and ankle joint, because it origins from the condyles of thigh bone. Soleus muscle acts only on the ankle joint. Together gastrocnemius and soleus form the heel tendon (Achilles) which is inserted into the heel bone. Ankle dorsiflexion during the skating actions is primarily produced by tibialis anterior muscle. It is active particularly during the glide phase (Montgomery 1988, 100; Tortora & Derrickson 2006, 392; Toivola 2008, 24; Martinmäki 2010, 23).

3.2.4 Upper body and upper extremities

During the actions on ice, the shoulder links push, pull, and ward-off movements to deliver hits, battle for pucks in the corner, clear the slot, and absorb forces from opponents (Twist 2007, 78). Holding the stick rotates shoulders slightly inwards. Consequently pectoral muscles have to work in a shortened position and may tighten. (Alavataja & Salittu 2006, 13). Shooting, passing and stickhandling take shoulders and wrists through their full range of motion and require efficient force transmission between lower extremities, trunk and upper extremities (Liitsola 1985, 245; Neeld 2010). Particularly slap shots and wrist shots rely on a strong full range of motion.

Snap shots require power with short range of motion. This loads wrist extensors and flexors. Backhand shots and passes rely more on posterior shoulder action. (Twist 2009, 78). Scapulothoracic stabilization is important to avoid chronic overuse problems in the upper thoracic, cervical, and shoulder region. Optimal stability helps to protect the player from traumatic injuries as well (Gilmore & Karageanes 2005, 544). Latissimus dorsi is an important muscle that controls shoulder while shooting, passing or stickhandling. Because it is connected via thoracolumbar fascia to the deep core stabilizer muscle (transversus abdominis), and to the gluteal muscles and hamstrings, it is able to transmit forces developed in lower extremities to the trunk and upper extremities. (Virtapohja 2002, 134).

4 MOBILITY

Mobility describes the range of motion available in joints. Three types of mobility exist: active, passive and anatomic. Active mobility, also known as dynamic flexibility, requires neuromuscular activation and refers to the maximum joint range of motion that can be produced using own muscle strength. Passive mobility is dependent on extensibility of soft tissues and refers to the maximum joint range of motion that can be produced with the help of some external force like gravity or a training partner. Anatomic mobility is a theoretical concept that describes the joint range of motion when muscles are removed. (Kisner & Colby 2002, 2, 66; Kalaja 2009, 266, 268). One's potential degree of mobility is partly inherited, but it can be modified through training. In general, mobility can be developed at any age, but the rate of development and potential for improvement is not the same at every year. (Alter 1996, 158; Kalaja 2009, 263; Ylinen 2008, 29-30). In the literature, mobility and its different forms are described with numerous terms, the most essential terms are explained in Appendix 1.

There are a number of factors that can affect on ones potential degree of mobility. Among them are age, gender, genetics, dominant laterality, temperature, activities, and time of day. Mobility is also specific to each joint, factors that affect on joint

mobility can be divided to structural, performance and coordinative factors (Table 1). Structural factors affect in particular on passive joint range of motion. Performance and coordinative factors are important elements in active mobility (Alter 1996, 158; Ylinen 2002, 10; Kalaja 2009, 263-264; Saari & Lumio 2009, 37).

Table 1. Factors affecting on joint mobility (Kalaja 2009, 263).

Structural factors	Performance factors	Coordinative factors
-joint structure and surface anatomy of the bones	- strength of the agonist muscles	- coordination between the agonist, antagonist and synergist muscles
- elasticity of the muscles and tendons		- coordination between the agonist, antagonist and synergist muscles
- amount of muscle mass		- muscle tone
		- muscle and tendon reflexes

In sports, active mobility is by far more important than passive mobility, because in an athlete mobility describes the capacity to perform active movements over large range of motion with control (Spring et al 1993, 124; Alter 1998, 1, 14; Chaitow 2006, 323; Smith & Plowman 2007, 35; McGill 2009, 13). Adequate mobility is a requirement for an athlete, but loose joints without accurately controlled strength are unstable and predispose to injuries. (Chaitow 2006, 323; McGill 2009, 13). Good mobility will not always be primary concern in some fields of sport. A certain amount of muscle tightness helps for example in sports requiring maximum strength. Stiff muscles may also decrease the need for stabilizing muscular activity. If full range of motion is used during movements, the increased joint mobility has a positive effect on sport performance. (Ylinen 2008, 21).

5 PHYSIOLOGY OF STRETCHING AND MOBILITY TRAINING

Muscle resists a stretch both actively and passively. The total length and diameter of muscle, length and organization of muscle fibers, degree of active fibers, muscle

tone, collagen structure, joint lever system, joint angle, and speed of stretching determine the amount of resistance. By performing different kind of passive, active and dynamic mobility exercises, it is possible to either increase flexibility or to maintain it. There is no evidence that some specific stretching technique increases flexibility better than others, but there is evidence that the effects of stretching exercise on muscle performance are dependent on the type of stretching and muscular activity performed. Any type of stretching will cause mechanical changes in all tissue and increase tolerance to stretch in the muscle-tendon system by raising pain tolerance. However, only active-dynamic type of mobility exercises train the tissues from a structural and neuromuscular perspective that will affect on one's potential degree of active mobility. Therefore, more consideration regarding the stretching exercises prescription is often needed, especially among individuals participating in sports. Otherwise the stretching exercises prescription will not follow the SAID (Special Adaptations to Imposed Stress) principle and offer optimal specificity in training. (Alter 1998, 12; Ylinen 2002, 34; Smith & Plowman 2007, 35; Ylinen 2008, 36; Kalaja 2009, 272; McGill 2009, 13, 39; Saari & Lumio 2009, 41; ACSM 2010, 171). In order to understand how various stretching techniques affect on flexibility, it is important to know the basic structure and function of muscle, the function of muscle-tendon system, and the function of central nervous system and neuromuscular system.

5.1 Structure and function of muscle and muscle-tendon system

Skeletal muscle consists of thousands of muscle fibers that form muscle fiber bundles (fascicles). The entire muscle, each muscle fiber bundle and each muscle fiber is surrounded by fibrous connective tissue (epimysium, perimysium and endomysium). Single muscle fibers are attached to tendon or aponeurosis via heavily corrugated and stretch durable muscle-tendon junction. Structurally, each muscle fiber contains smaller functional units called myofibrils. These myofibrils lie parallel to the fiber's long axis and contain myofilaments that also run parallel to the myofibrils long axis. The myofilaments consist of proteins like titin, actin and myosin. Titin gives myofibrils their intrinsic extensibility and elasticity, and causes most resistance in the passive stretching of muscles. It can be hypothesized that the

quantity and quality of titin in any given muscle influence its flexibility. The actin and myosin filaments form the functional unit of the muscle, the sarcomere, and within it provide the mechanical mechanism of muscle action by overlapping each other. (Kravickas 1999, 85; Ylinen 2002, 27; McArdle, Katch, F. & Katch, V 2006, 384-386; Tortora & Derrickson 2006, 297-298; Ylinen 2008, 33). The number of sarcomeres in series and the amount of titin within the myofibrils determine the distance through which a muscle can shorten, the length at which it produces maximum force, and the point where it reaches its elastic limit (Kravickas 1999, 85; Chaitow 2006, 2). The maximum total active tension is found out at about 1.2 to 1.3 times the muscle's rest length (Alter 2004, 64; Hall 2007, 167). If the initial length of the muscle is short, the actin and myosin filaments in each sarcomere are already overlapped, limiting the maximal tension that the muscle can develop (Sahrman 2002, 24; Chaitow 2006, 2). By putting high tension along the myofibrils or muscle tendon junction the amount of sarcomeres in series can be increased (Chaitow 2006, 2). Simultaneously increases the quantity of titin (Sahrman 2002, 29). Muscle's structure will change over time as it adapts to its new functional demands. In practice, muscle grows length and its active range of motion increases. (Alter 1998, 10; Chaitow 2006, 2; Website of LiVE).

The muscle-tendon system can be divided into two functional parts. These parts represent the elastic structure of the muscle. Muscle-tendon junction together with contractile elastic components (actin and myosin filaments) and non-contractile elastic components form the serial elastic component of muscle-tendon system (SEC). The parallel elastic component of muscle-tendon system (PEC) is formed by the muscle membranes. It is passive and comes into play only at longer muscle lengths. It supplies resistance when a muscle is passively stretched. (Ylinen 2002, 27; Hall 2007, 150-151).

The serial elastic component of muscle tendon system acts as a spring to store elastic energy when a tensed muscle is stretched. When the muscle contracts, actin and myosin filaments in the serial elastic component overlap each other, increasing the number of transverse bridges between them. These transverse bridges store elastic energy. Elastic energy will be stored while stretching a relaxed muscle as well, but a tensed muscle will store noticeably more elastic energy as its serial elastic

component is rich in transverse bridges. When muscle is lengthened under load, elastic energy will be stored to its all parts. (Ylinen 2008, 33).

In sport performance, the ability of muscle-tendon system to store and release elastic energy plays an important role. It is an energy saving mechanism and essential to good performance in many fast-moving actions and in those producing high force. A muscle-tendon system with low flexibility and elasticity may predispose to tendon and muscle damage, especially in sports that require strength through large range of motion (Ylinen 2008, 32-33). Dynamic stretching with high-velocity trains the series elastic component whereas static stretching tends to focus on the passive elastic components of muscle (McGill 2009, 39). For optimal performance, it is important to improve the elastic spring characteristics of the muscle-tendon system by taking the muscles through their full range of motion under load. Athletes who employ techniques to store and recover elastic energy should never stretch beyond their competitive range of motion (Ylinen 2008, 23, 28; McGill 2009, 39-40).

5.2 Function of central nervous system and neuromuscular system

The central nervous system is crucial in the regulation of co-contraction of muscles around several joints in legs, body and arm simultaneously. Both the sensory and motor innervation of muscles are needed to make coordinated movements possible while maintaining joint stability and balance of the whole body. For adequate functioning it is essential that the central nervous system is able to rapidly analyze all the information it receives from muscles, joint capsules, ligaments, balance organ, eyes and other sensory organs. (Ylinen 2008, 43).

“The function of the neuromuscular system is to produce and control movement and maintain body posture and position of body parts while regulating muscle tone.” (Ylinen 2008, 39). Skeletal muscles have two distinct types of nerve fiber receptors. Muscle spindles are interspersed throughout the fibers of muscles. Golgi tendon organs are located in the muscle-tendon junctions and in the tendons at both ends of muscles. These nerve fiber receptors and mechanoreceptors of joints are so called proprioceptors, which refer information to the central nervous system concerning

muscle length, tension, and position and motion of joints. Proprioceptors are extremely important for muscle reflex functioning, which influences highly on muscle flexibility. (Kravickas 1999, 85; Tortora & Derrickson 2006, 553-554; Hall 2007, 131-132; Ylinen 2008, 39).

The muscle spindles have primary and secondary sensory endings which provoke reflex contraction in a stretched muscle and inhibit tension development in antagonist muscles. Primary endings measure the length plus rate or velocity of the stretch and respond to both dynamic and tonic stretch. Secondary endings measure the length of a muscle and respond only to tonic stretch. Sudden or unexpected increase in muscle's length changes the shape of muscle spindles and they will send a message to spinal cord which will fire a stretch reflex. The muscle that has been stretched will contract to resist the stretch and its antagonist will relax (reciprocal inhibition). (Alter 1998, 6; Hall 2007, 132). Through passive stretching the muscle spindle receptors will adapt to new length and the critical point at which the stretch reflex is initiated can be reset to a higher level and therefore, muscles will be able to relax farther into the stretch. During long passive stretches activity in the muscle spindle receptors decreases which results in reduced motor neuron activity and muscle's active force production capacity. (Alter 1998, 10; Ylinen 2002, 21, 34). Because the spindle reflex response to stretch is important in protecting and coordinating muscles and tendons, intensive stretching should not be done immediately prior to intense exercise or contest (Ylinen 2008, 23).

The golgi tendon organs are tiny mechanoreceptors that detect differences in muscle tension. When muscle contracts or shortens a force is applied to the muscle-tendon system and Golgi tendon organs. They relay the spinal cord a message that results in inhibition of the agonist muscle and contraction of the antagonist muscle. Therefore, the Golgi tendon reflex enhances the ability of a muscle to stretch, while the spindle stretch reflex attempts to prevent muscle elongation. The aim of a stretching exercise should be to enhance the Golgi tendon organ reflex and inhibit the stretch reflex. (Kravickas 1999, 85; McArdle & Katch 2006, 380; Ylinen 2008, 40). Ultimately, the function of Golgi tendon reflex is to protect tendons and their associated muscles from damage due to excessive loading or stretch. (Tortora & Derrickson 2006, 463, 555; Hall 2007, 131).

Several types of joint mechanoreceptors are located within and around the articular capsules of synovial joints. These joint kinesthetic receptors function to provide proprioceptive sensations which allow awareness of the location of limbs and how they move even with the eyes closed. Type I joint receptors (Ruffini corpuscles) refer information about joint movement, direction, range and speed. They sense pressure on joints, reflexively cause muscle tension to preserve posture, assist movement and decrease activity of pain pathways. These receptors are by type, both static and dynamic and activate easily to stretch irritation, even with minimal loading. Basically these mechanical receptors are always partially activated according to joint position and thus reflect information even during rest. Type II joint receptors (Lamellated Vater-Pacini corpuscles) are by type dynamic and function to relay information about movement changes like acceleration and deceleration. They are not active while joints are at rest. These receptors activate easily both with slow and fast movements of joints, but their function stops immediately with static loading and stretching. Type II receptors also respond to pressure together with free nerve endings. Articular ligaments contain receptors as well. These receptors are similar to Golgi tendon organs and adjust reflex inhibition of the adjacent muscles when excessive stress is placed on joint. (Tortora & Derrickson 2006, 553-556; Ylinen 2008, 44).

Dynamic mobility exercises that combine strength and stretching exercises must be used to condition the Golgi tendon organs, the muscle spindle receptors and the joint mechanoreceptors for their desired response. Dynamic motion will also stimulate proprioceptors in the inner ear that provide information for maintaining balance. Therefore dynamic mobility exercises will not only improve mechanical flexibility of connective tissues and other tissue properties like passive stretching, but it will also have an effect on muscle-tendon and joint reception activity in relation to sensory information. In the long term, activation of nerves through this type of training can achieve both functional and structural changes in the central nervous system, which affect muscle activation, coordination, and balance. In sport performance, improved nervous function makes the contraction and relaxation of agonist and antagonist muscles (reciprocal innervation) faster and more efficient. (Alter 1998, 5-6, 12; Tortora & Derrickson 2006, 553-554; Ylinen 2008, 44; Saari & Lumio 2009, 40).

5.3 Static stretching techniques

Passive-static stretching involves stretching to the farthest point with the help of some external force and holding the stretch (Ylinen 2008, 56). The aim of passive-static stretching is to increase the extensibility of soft tissues by causing plastic deformation so that a degree of elongation remains when the stretch force is removed (Smith & Plowman 2007, 35). More specifically, passive-static stretches are designed to elongate the contractile and non-contractile components of muscle-tendon system and structures surrounding a joint while the individual tries to relax as much as possible. (Kisner & Colby 2002, 66; Ylinen 2008, 56). Because passive-static stretches do not pay any deliberate attention to neuromuscular processes, they do not enhance coordination and have a poor effect on the dynamic range of movement required in a physical activity. (Alter 1998, 12; Siff 2005, 134). Static stretches remain important in an overall training program, because they increase passive mobility which provides a protective reserve if a joint is unexpectedly stressed beyond its normal limits. (Siff 2005, 134). To increase flexibility a static stretch should be maintained at least 20 to 30 seconds (Saari & Lumio 2009, 40). The American College of Sports Medicine (2010, 173-174) recommends at least 10 minutes of stretching for major muscle groups a minimum 2 to 3 days per week, holding each stretch for 15 to 60 seconds to the limits of mild discomfort within range of motion; 4 or more repetitions per stretch. Achieving long term effects requires stretching that is continued for enough time for the effects on tissue to last. According to Ylinen (2008, 56) effects at the tissue level require about a 2 month stretching program and regular exercise thereafter to preserve the acquired effects.

Active-static stretch is accomplished by contracting the agonist muscles. Stretch force is applied slowly or gradually and each stretch is maintained 6 to 30 seconds. Active-static stretching develops active flexibility and potentially dynamic flexibility, but the main purpose is to strengthen the agonist muscles which restrict active flexibility and simultaneously facilitate the relaxation of the antagonist muscles. Larger gains in active flexibility are associated with longer periods of isometric contraction in the active muscle group. (Alter 1996, 179-180; Alter 1998, 14, 22; Kalaja 2009, 269).

Static stretching is not a warm up activity. Good warm up raises core muscle temperature, which increases muscle elasticity, increases the rate of agonist muscle contraction, and increases the rate of antagonist muscle relaxation (Twist 2007, 31; Saari & Lumio 2009, 3-4). Sports involving explosive type of movements require a muscle-tendon system that is compliant to store and release a high amount of elastic energy. Forceful stretching before exercise may decrease the compliance temporarily. It may also impair coordination by resetting some of the organs involved in joint and muscle proprioception, and modulate the stretch receptors to inhibit subsequent performance, at least in children. Changes in viscosity after intensive stretching can also have negative effect on performance, especially in sports requiring maximum force and speed. (Ylinen 2008, 23; McGill 2009, 13, 40). Short 1 to 10 second static stretches that are repeated 3 to 6 times with low intensity (30-50%) can be included in the warm up because they facilitate neuromuscular system, increasing muscle activity and circulation in the muscles. (Saari & Lumio 2009, 40, 62).

For hockey players Twist (2007, 29, 40) recommends static stretches only as a post-ice activity. According to him static stretches are great for isolating muscles and they help a player to achieve equal range of motion throughout the body. Alter (1998, 23) defines cooling down as performing group of light exercises immediately after an activity to provide the body a period of adjustment from exercise to rest. The purpose of cool down is to facilitate muscular relaxation, promote the removal of muscular waste products, reduce muscular soreness, and allow the cardiovascular system to adjust to lowered demand (Alter 1996, 151). Stretching will improve recovery in both locomotor and nervous system. Static stretching is an important part of cool down, but not until the muscular waste products have been set in motion. Intensive and long static stretches should be avoided during cool down period because they decrease circulation in muscles and impair the removal of waste products. Intensive physical workout increases nerve activity, which will gradually increase muscle tension during the rest period after performance. Excessive loading will also activate pain receptors which, via the central nervous system increase muscle tension. Performing short static stretches (1 to 10 seconds) that are repeated 1 to 3 times with very low intensity (20-30%) help to reduce muscle tension and induce relaxation during the cool down. Light stretching will also lower intramuscular pressure and

improve the circulation in the tissues surrounding muscles. (Ylinen 2008, 24; Saari & Lumio 2009, 32). After energy storages and fluid balance have returned to normal level, semi long static stretches (5 to 30 seconds) can be performed about 90 minutes after workout with low intensity (20-30%) (Saari & Lumio 2009, 40, 62). On delayed onset muscle soreness that may appear after strenuous physical exercise, stretching does not affect (Ylinen 2002, 19).

5.4 Mobility training and dynamic stretching

The Finnish healthy athlete program LiVE (Liikuntavammojen Valtakunnallinen Ehkäisyohjelma) defines mobility training as active muscular work that causes a need in a muscle to adapt to a new functional length. In practice mobility training is light strength training where a muscle has to work in a slightly stretched position. The purpose of mobility training is to assist the recovery of the muscle to its rest length and to increase it. According to current knowledge, active muscular work is an effective way to increase muscle's growth in length and simultaneously flexibility. Light dynamic muscular work also enhances recovery after physical exertion. (Website of LiVE). According to Alter (1996, 179) strength exercises in the zone of active insufficiency reduce the passive inadequacy and increase the zone of active mobility. To develop optimum dynamic flexibility essential for all sports, dynamic stretching must be incorporated into the training regimen (Alter 1998, 12, 14).

Dynamic stretching refers to a stretch that is accomplished by contracting antagonist muscles at slow, normal or rapid speed, with control. The muscle is stretched by moving a joint in the direction that muscle will be stretched and immediately returned in the same direction. This may be repeated several times while gradually increasing the range of motion. Three to six sets with 10 to 15 repetitions are recommended for beginners. Fatigue is a sign to stop. Well-trained athletes may perform as many as 40 or more repetitions. Dynamic stretch movement can be ballistic, meaning bobbing, bouncing, rebounding, and rhythmic motion, but this type of uncontrolled motion is not recommended as it increases the risk of injury and has a weak effect on sensory receptors. Dynamic stretching requires balance and control over movements. The purpose of dynamic stretching is to improve coordination

between agonist, antagonist and synergist muscles; strengthen antagonist muscles, and increase metabolism and activity of the nervous system. Disadvantages include short time of stretch and too rapid movement may initiate stretch reflex which will contract the muscle to resist stretch. (Alter 1996, 179; Alter 1998, 12-13, 22; Ylinen 2008, 47-48; Kalaja 2009, 268-269).

Functional mobility training is dynamic stretching that consists of functional-based exercises that mimic movement patterns required in specific sport. Functional mobility training programs are developed by analyzing the movements associated with a sport activity and developing stretches to enhance flexibility and balance based on these movements. Any type of functional training can be described as purposeful training for a specific sport where athlete learns to handle own body weight in all planes of movement through kinetic chains. Kinetic chains describe interrelated groups of joints and muscles working together to perform movements. The aim of functional mobility training is to stimulate proprioceptors which activate neuromuscular system. The purpose is to prepare the body for activity, and to improve dynamic flexibility, coordination and balance. In addition, functional mobility training can be used to teach or emphasize sport-specific movements needed during practice or competition. (Hedrick 2000, 26; Boyle 2004, 2-3; Saari & Lumio 2009, 40).

5.5 Injury prevention

Preventing the first injury should be a high priority because it will keep players away from entering the vicious cycle of repeated injuries to the same body part (Engebretsen et al. 2008, 1059). Stretching has not been shown to prevent athletic injury. Thacker, Gilchrist, Stroup & Kimsey (2004, 371-378) conducted a systematic review to assess the evidence for the effectiveness of stretching as a tool to prevent injuries in sports. They searched electronic databases, such as Medline, the Cochrane library and SPORDiscus, without language limitations and limited their meta-analysis to randomized controlled trials or cohort studies for interventions that included stretching. All studies that lacked controls or did not include subjects in sporting or fitness activities were excluded. According to their findings there is not

sufficient evidence to endorse or discontinue routine stretching before or after exercises to prevent injury among competitive or recreational athletes. Weldon and Hill (2003, 141-150) conducted a similar kind of systematic review. They found one randomized controlled trial and three controlled clinical trials concluding that stretching reduced the incidence of exercises related injury. The best randomized controlled trials in quality did not show positive effects for stretching. Small, McNaughton & Matthews (2008, 213-231) conducted systematic review to find out evidence about the efficacy of static stretching as part of a warm-up for the prevention of exercise related injury. According to their findings there is moderate to strong evidence that routine application of static stretching does not reduce overall injury rates, but there is preliminary evidence that static stretching may reduce musculotendinous injuries.

According to Ylinen (2008, 29) in sports requiring good stability intensive stretching may actually increase the risk of injury by causing joint instability. It may also disturb or weaken the reflex response to stretch, which is important in protecting and coordinating muscles and tendons. Individual's passive mobility is always larger than active mobility, the greater the difference between them, the greater is the risk of injury (Alter 1996, 179; Kalaja 2009, 268). To avoid injuries, strength exercises in the zone of active inadequacy are recommended instead of stretching. They will reduce the passive inadequacy and increase the zone of active mobility. (Alter 1996, 179).

6 MOBILITY TRAINING DURING THE DIFFERENT PHASES OF GROWTH

The process of human growth and development is a complex phenomenon. Child's and adolescent's trainability is greatly influenced by physical growth, biological maturation and physiological development. (Hakkarainen 2009, 73-74). In addition, psychic development affects on trainability (Nikander 2009, 103). Physical growth in stature and weight occurs over the 15 to 20 years following birth. The growth in height usually proceeds at a slow rate until shortly before puberty, when a period of

rapid skeletal growth occurs. Biological maturation, which refers to the hormonal changes in the body during the growth, does not proceed according to the chronological age. In practice, biological maturation occurs throughout the growth, but the timeframe and speed of it varies greatly between individuals. The physiological development refers to the functional development of the body systems which is largely dependent on the physical growth and biological maturation. In addition, environmental factors and especially physical activity has a major impact to the physiological development. All children exhibit a certain potential to develop both physical attributes (strength, speed, endurance and mobility) and motor skills. The timeframe in which the development occurs, depends on genetic and environmental factors. Development of joint mobility is optimal between 11 to 14 years of age. (Hakkarainen 2009, 73-75, 94, 102).

The growth during childhood (1 to 10 years old) and adolescence (10 to 18 years old) occurs distal to proximal. Especially during childhood the length of the extremities increases, the hands and feet grow first, followed by the calves and the forearms, the hips and the chest, and lastly the shoulders. (Baxter-Jones & Sherar. 2007, 4). The cross-sectional area of muscles and muscle mass increase steadily (Hakkarainen et al. 2008, 7). Some children may experience a minor growth spurt between the ages 6 to 8, but it is not associated with the hormonal changes like the growth spurt during puberty. (Hakkarainen 2009, 77).

The growth during adolescence includes several phases. During pre-puberty the physical growth is slow until the hormonal changes associated with biological maturation launch the growth spurt that lasts about two years. The period of rapid skeletal growth is followed by years of slower growth until the final height is achieved approximately at the age of 20. In boys the growth spurt generally begins between the ages of 10 to 12. The peak in growth is between the ages 13 to 15. In girls the growth spurt begins and ends about two years earlier. (Hakkarainen 2009, 78). During the adolescence growth spurt the legs grow in length before the trunk. Thus, for a period of time, a youth will have relatively long legs and may appear a bit clumsy because their body's center of gravity has suddenly changed (Baxter-Jones & Sherar 2007, 4-5). At this stage special care should be paid to not excessively load young athlete's spine (Kalaja 2009, 277). The hormonal changes also increase

muscle mass and the cross-sectional area of muscles. Simultaneously the ability to recover and develop after a physical exercise improves. Children and pre-adolescents exhibit good aerobic and short-term anaerobic metabolism, but lactate metabolism develops during puberty. (Hakkarainen 2009, 92, 102).

Physical activities increase bone mass and strengthen articular cartilages, ligaments, tendons and joint capsules during the growth, but excessive physical exercising and loading of joints may postpone puberty and delay growth spurt. During the growth spurt high intensity plyometric and strength exercises may disturb bones growth in length and cause painful condition at so called growth plates. (Hakkarainen et al. 2008, 7-8; Hakkarainen 2009, 94). Stretching may help to reduce the amount of stress put on the growth plates and pain (Peltokallio 2003, 1041).

Significant differences in joint mobility between individuals exist throughout the childhood and adolescence. Overall children are quite flexible by nature, but after 10 years of age flexibility begins slowly to deteriorate. (Spring et al. 1993, 126; Peltokallio 2003, 1033, 1041; Kalaja 2009, 265-266, 277). Because increasing flexibility is a slow process, the aim of mobility training should be to maintain natural flexibility (Spring et al. 1993, 124; Kalaja 2009, 277). According to Alter (1996, 139) flexibility decreases during the school years until puberty, increases throughout adolescence, levels off after adolescence, and then begins to gradually decrease. To maintain natural flexibility during the years of rapid skeletal growth and to prevent muscular imbalances, mobility training should be started early in the childhood. Both active and passive mobility exercises should be done daily during the entire sport career. Before puberty, young athletes should learn basic stretching techniques and stretches which target major muscle groups and muscles prone to tightness. Dynamic mobility drills can be performed to develop motion and motor patterns in a safe way. The emphasis in training at this stage should be on handling body weight and general training through playful interaction. Maximal level of passive mobility should be achieved between the ages of 11 to 14 which is the actual sensitive period for mobility training. During puberty, a wide variety of dynamic mobility exercises should be performed. Especially during the growth spurt peak they may help to re-structure movement patterns and to maintain co-ordination skills. After growth spurt mobility can be trained intensively without limitations. At this age

mobility training can be more sport-specific and aimed to improve dynamic flexibility required in a specific sport. (Hakkarainen & Nikander 2009, 142-143; Kalaja 2009, 265-266, 277; McGill 2009, 40).

7 THE PROCESS OF THE BACHELOR'S THESIS

The thesis was started August 2010 when it was suggested to me to create a cd-rom containing stretching exercise instructions for junior ice hockey players by an ice hockey club from Pori. For practical reasons I decided to contact TPS and inquire of their interest towards this type of work. In September 2010 agreement to do the thesis in collaboration with TPS junior ice hockey was signed. At this point the exact aim and purpose of the thesis was unclear. Contact persons in TPS suggested focusing on active mobility exercises rather than on stretching, or to gather together mobility training guidelines for different age groups. The possibility of producing a tutorial guide instead of a cd-rom was also discussed. Based on this information, literature review was done during the autumn 2010 to find out theoretical background for the exercises. At the beginning the aim was find out how ice hockey loads musculoskeletal system and what type of mobility exercises children and adolescence should perform during the different phases of growth. Writing the theory part began in October 2010 and ended in February 2011. The decision to produce a tutorial guide instead of a cd-rom was made after the theoretical part was finished. The actual product of this thesis, which is a tutorial guide about mobility exercises for junior ice players and their coaches, reached its final form after the pictures about the exercises were taken. The theoretical part of the guide was written, and feedback of the initial version of the guide was received from TPS and from another local junior ice hockey club. The thesis was presented and the maturity exam was taken in March 2011. The whole process of this bachelor's thesis is presented in figure 3.

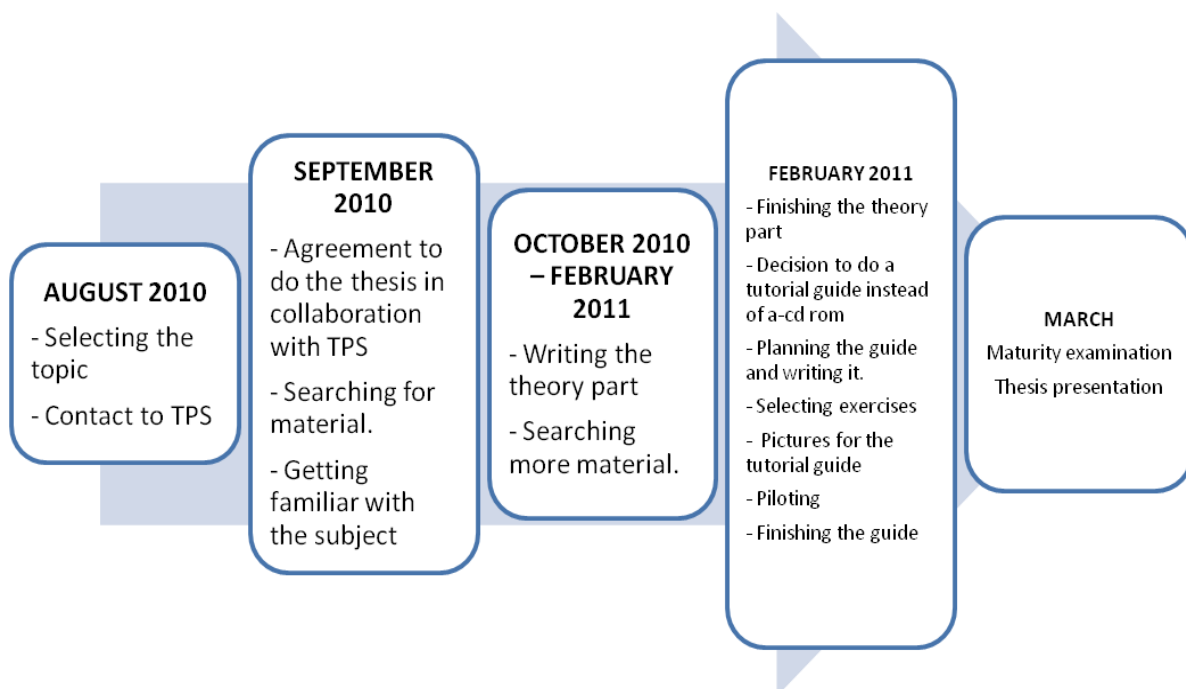


Figure 3. The process of the bachelor's thesis.

The final version of the tutorial guide contains general information about mobility, mobility training, and mobility training during the different phases of growth. Topics are discussed from ice hockey point of view and the theoretical part of the guide is aimed to act as a foreword to the exercises presented later in the movement bank part of the ´guide. The movement bank contains guidelines and practical examples about how to perform static stretches, and active and dynamic mobility exercises. In total, the guide contains 45 mobility exercises. All the exercises are demonstrated in pictures and the correct technique and movement form is explained in words. According to Singer (1980, 277) pictures, words and the knowledge about the movement form can help the learner to “get the idea” of what is supposed learn. Exercises presented in the movement bank were selected based on the knowledge which muscles are prone to tightness in ice hockey, and what movement patterns are required in the sport. Static stretches and active-dynamic mobility exercises were selected based on the knowledge that children and adolescents should perform both passive and active mobility exercises during the growth. In the theoretical part of the guide, chapter about mobility training during the different phases of growth is divided into three parts (7 to 10 year olds, 10 to 15 year olds and 15 to 18 year olds) according to the development of flexibility and the need for mobility training during the different phases of growth. Photos for the guide were taken in a gym owned by

Raisio adult education center. Model in the pictures is Pasi Palonen. He coach junior players in an ice hockey club called RNK (Raision nuorisokiekko).

8 DISCUSSION

The aim of this thesis was to produce a tutorial guide that would increase junior ice hockey players and their coaches' knowledge about mobility and mobility training. I had started to work on a bachelor's thesis about another subject with my classmate, but during the summer 2010 we decided to split up and do our own separate theses. While thinking about a new subject I was suggested to create a cd-rom containing stretching exercise guidelines for junior ice hockey players. At first I was not very excited about the idea of doing this type of thesis for hockey players, even though I am interested in sports physiotherapy. I have played ice hockey at junior level for several years and I felt a thesis about stretching would not have anything new to offer for people involved in hockey. Books and internet are already full off stretching exercise instructions and videos that are available for any one at any time. Retrospectively, I probably had the same attitude towards stretching as most hockey players have; it is something that should be done, but so boring that I rather skip it. However, after I became acquainted with the subject I was convinced that there really is a need for mobility training instructions. In particular, the recent study about children's training where I refer in the introduction part, contributed to my decision to finally carry out this thesis. Agreement to do the thesis in co-operation with TPS junior ice hockey was signed in September 2010; even though I was not able convince them about the need for this type of thesis.

Collaboration with TPS was concise. I met my contact persons only once and they gave me few suggestions concerning the outcome of this thesis. They mentioned active mobility exercises, guidelines about mobility exercises for different age groups and exercises that improve ankle stability. The exact aim and the purpose of this thesis were left for me to decide. Even though our collaboration was limited to one meeting, I got new ideas and valuable information concerning their current

mobility training. In TPS C, B and A juniors perform active-dynamic mobility exercises 2 to 3 times each week. One of the initial ideas was that I would participate in their training sessions to see what type of mobility exercises they are performing. This would have helped me a lot in the process of making this thesis, but because of my work and studies, I did not have extra time for this type of collaboration. Because co-operation with TPS was so short-lived, I was not able to the thesis exactly according to their needs. Now the product of this thesis is more “mine looking”. Particularly the lack of precise topic made the whole process of making this thesis extremely difficult and challenging. I also made a huge mistake by starting to write the theory part without having an exact aim and purpose. I had an idea about what I am going to do, but I was not quite sure what the outcome would be. Basically I changed the aim and purpose each time I gained more knowledge about the subject.

In physiotherapy literature flexibility and stretching are discussed from a therapeutic point of view. Most of my references are from physiotherapeutic literature because I had an easy access to them, and I think that is one of the weaknesses of this thesis. Because my aim was to increase knowledge about mobility training, I should have used more references from the field of sports sciences and exercise physiology. On the other hand the thesis has now a physiotherapeutic point of view in terms of mobility training and injury prevention. Without taking into consideration the injury prevention aspect, I believe this work would not have been suitable as a physiotherapy bachelor’s thesis. My other aim was to increase knowledge about mobility as a physical characteristic. In the physiotherapy literature most studies are about stretching methods that are aimed to increase passive range of motion, only little information about active mobility is available. Active mobility is rarely studied as no standardized measurement technique exists that can be used in practical settings for evaluating it. The lack of theoretical information about active mobility was by far the greatest challenge while making this thesis. Collecting together the theory behind active-dynamic mobility exercises was like building a puzzle and it might have led to some factual errors.

The product of this thesis was done in two days and that unquestionable affected on the outcome. I decided to do a tutorial guide instead of a cd-rom because I lacked time and resources for such an extensive work like making a cd-rom. To make a cd-

rom I would have needed external help from someone who knows how to film a proper video and to encode. By producing a guide with pictures I was able to do everything independently. This saved time, but the product was not what I originally planned. However, I got positive feedback concerning the outcome of the guide from the managing director of TPS, and he personally felt that a guide is easier to use in practice than what a cd-rom would have been.

Because my aim was to increase knowledge about mobility and mobility training by producing a tutorial guide, I decided to add on the guide some general theoretical information concerning mobility, mobility training and stretching, and mobility training during the different phases. While writing the guide I tried to keep the text as simple as possible, but still provide some useful and new information. My biggest concern while making the guide was that some exercises are too demanding for children. However, the initial feedback that I got from TPS and from another ice hockey club was that the theoretical part and the exercise guidelines are clear and easy to understand, and all the exercises are simple enough for children to perform. TPS is now planning to produce a paper version of the guide that would be available for everyone at the hockey rink.

I deliberately asked a friend of mine who coach junior players to model in the pictures because he was able to provide me valuable information concerning what type of exercises I should choose. By doing collaboration with him I was also able to provide my knowledge directly to someone who works with children every day and is in charge of educating other coaches. He was also an excellent model because he has all the typical hockey-specific range of motion restrictions which helped me to dismiss too demanding exercises right away. At some point I thought I have selected way too many exercises for the guide. However, I do not see that as problem because mobility training should be versatile and muscles should be stretched from various angles in order to achieve desired results. I wanted to provide examples and options; the decision which exercise is utilized depends on coach or player.

In the future the product of this thesis can be developed in various ways. More exercises can be added to the movement bank as well as other stretching techniques. In addition, the original plan can be carried out to create a computer based program

where exercises are demonstrated on video. A similar type of guide could also be made for other sports or for working aged and elderly people.

Overall thesis process was a positive learning experience even though writing in English was time-consuming and challenging. I have acquired a huge amount of knowledge concerning physiology of stretching and mobility training, and I have also been able to take advantage of this knowledge while working with neurological clients and clients with musculoskeletal problems. Hopefully people involved in junior ice hockey benefit from the product of this thesis and see this thesis as an opportunity to develop one part of training.

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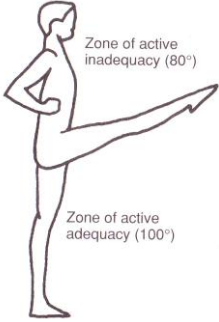
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Terms related to mobility.

Term	Explanation
Range of motion (ROM)	Full possible motion that can occur between any two bones (Kisner & Colby 2002, 43)
Functional range of motion	The ability of structures or segments of the body to move or be moved to allow the presence of range of motion for functional activities (Kisner & Colby 2002, 65).
Joint mobility	The ability of a joint to move or be moved freely (Kisner & Colby 2002, 2). Dependent on joint structure, extensibility of muscles and other soft tissues that cross or surround a joint, and function of the nervous system. In practice the same as joint flexibility. (Spring et al 1993, 124; Ylinen 2009, 6).
Functional mobility	The ability of an individual to initiate, control, or sustain active movements to perform motor skills (Kisner & Colby 2002, 65).
Flexibility	The range of motion available in a joint or group of joints that is greatly dependent on the function of the nervous system. Usually classified as active, passive, ballistic, dynamic, functional or static. (Alter 1996, 9, 179; Ylinen 2009, 6).
Zones of passive inadequacy and adequacy	 <p>(Alter 1996, 179)</p>

<p>Zones of active inadequacy and adequacy</p>	 <p>(Alter 1996, 179)</p>
<p>Flexibility deficit</p>	<p>The difference between an individual's active and passive flexibility zones. (In previous pictures 50°) The greater the flexibility deficit, the greater is the likelihood of an injury. (Alter 1996, 179).</p>
<p>General flexibility</p>	<p>The ability to perform basic motor skills and movements without restrictions. Good general flexibility is foundation for sport specific flexibility. (Seppänen, Aalto & Tapio 2010, 108).</p>
<p>Sport specific flexibility</p>	<p>Flexibility required in a certain sport. Optimal sport specific flexibility enables mechanically efficient performance. (Mero & Holopainen 2007 364; Seppänen, Aalto & Tapio 2010, 109).</p>
<p>Elasticity</p>	<p>The ability of soft tissue to return to its pre-stretch resting length directly after a short-duration stretch force has been removed (Kisner & Colby 2002, 70)</p>
<p>Stiffness</p>	<p>Decrease in joint flexibility or resistance caused by the surrounding soft tissues of a joint (Ylinen 2009, 6)</p>
<p>Hypomobility</p>	<p>Decreased mobility or restricted motion (Kisner & Colby 2002,</p>

<p>Stability</p>	<p>The ability of the neuromuscular system to hold a proximal or distal body segment in a stationary position or to control a stable base during movements. Joint stability is the maintenance of proper alignment of bony partners of a joint by means of passive components (joint surface anatomy, joint capsule and ligaments) and dynamic components (muscles). (Kisner & Colby 2002, 3; Ylinen 2009, 6).</p>
<p>Instability</p>	<p>Abnormal joint mobility due to lack of support normally supplied by the surrounding tissues to maintain the integrity of the joint; testing can reveal laxity of joint ligaments. (Ylinen 2008, 7).</p>
<p>Hypermobility</p>	<p>Exaggerated range of motion within the normal function of a joint (Ylinen 2008, 7).</p>