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Impact of Lower Body Muscle and Joint Flexibility on the Skating Speed of 12–13-Year-Old Junior Ice Hockey Players

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THESIS
ABSTRACT

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Impact of Lower Body Muscle and Joint Flexibility on the Skating Speed of 12–13-Year-Old Junior Ice Hockey Players

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This is an intervention study with 16 junior hockey players between ages 12–13. The purpose of this study was to investigate how training flexibility intensively for six weeks affected lower body flexibility and skating speed development.

The topic was introduced in cooperation with Kajaanin Junnu Hokki 68 ry because players' skating and flexibility levels were considered problematic. This study should therefore have practical application possibilities in the field of youth coaching in order to develop the skating and flexibility levels of youth and junior hockey players.

A quantitative method was used in this research. The SPSS - program was used when the data and the results were interpreted. The focus was on a quantitative comparison of possible changes in flexibility levels and skating speed that have occurred during the six-week intervention study.
The data regarding flexibility was collected through a set of flexibility tests. The players' maximum skating speed was measured by a 30-meter skating test where the players performed an approximately a 10-meter initial acceleration before the first photoelectric sensor.

According to the results, the lower body flexibility levels have been increased significantly with the exception of thigh muscles. The maximal 30-meter skating speed did not increased significantly.

The most essential observation was that significant improvements in lower body flexibility levels, did not affect skating speed. It was an important discovery that the skating time had improved for ten players out of sixteen. However, the improvement was not significant enough to conclude that the skating speed would have been improved. The skating speed did not decreased during this intensive flexibility training period.

Despite the initial lack of certainty regarding the generalizability of the results, conducting flexibility training properly even during competitive season seems to be potentially useful and definitely worth further investigation.

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1 INTRODUCTION

Exercise response and the development of physical performance of children and youth are based on different organ systems and their performance ability and efficiency. These factors are highly affected by three phenomena of developmental biology: physical growth, biological maturation and physiological development. Physical growth means the growth of the structures and dimensions of a human body. Biological maturation refers to the maturation of the body system toward adult maturity. Physiological development means the development of physical qualities: speed, strength, endurance, flexibility, and skills. (Hakkarainen 2009, 73 - 74.)

There are differing views on how certain forms of flexibility training (i.e. stretching) affect flexibility and how the training should be conducted, especially in field of ice hockey. Earlier research regarding the subject have not formed a clear view on what form of flexibility training would be most beneficial. Should we use dynamic flexibility training which has an activating effect on muscles or static flexibility training which relaxes and recovers the muscle to resting phase.This is a question which has not been thoroughly proven in previous studies

According to Sami Kalaja, it cannot be said, that one specific stretching technique would be more beneficial to increase the flexibility levels than other stretching techniques. However, several previous studies demonstrated that static stretching during a warm-up actually decreaces the maximum and explosive strength levels and increases the possibility of injuries. The effect mechanism of this phenomenon is still unclear but the phenomenon may be related to the reduced muscle stiffness. It seems that the static stretching methods should be avoided during a warm-up. However, the static stretching methods seem to slightly improve the performance when the stretching is conducted after exercises. The possible adverse effects of static stretching during a warm-up should not be confused with the significance of flexibility levels (Kalaja 2009, 272.) Both dynamic and static methods are used in this thesis.

The topic of this thesis is the impact of lower body muscle and joint flexibility on the skating speed of 12–13-year-old junior ice hockey players. The subject was designed in cooperation with Kajaani Junnu Hokki 68 ry with the aim to benefit practical coaching of the organization as an informative tool, because players' skating and flexibility levels had been considered problematic. This thesis should, therefore, have practical application possibilities in the field of youth coaching in order to develop the skating and flexibility levels of hockey players.

We could study skating from many points of view, but in this thesis, the purpose and aims was to narrow the subject down to investigating how the possible improvements in lower body flexibility levels affect skating speed and whether a correlation can be found between skating speed and flexibility. The objective of this thesis was to find out more information about the phenomenon.This phenomenon is also interesting because the connection between flexibility and skating (instead of, for example, the more often researched connection between force production and skating) can easily be considered unimportant, as can be seen from an interview with a professional coach Teijo Raatesalmi in 2013: According to him, "flexibility is primarily connected with relaxation and recovery but not directly with skating speed or technique. When players have learned some skating technique, even if it is not correct, the player cannot utilize the increased lower body flexibility levels to improve his skating performance. To improve his skating performance, the player must be highly motivated to correct his skating technique with the help of a person who is specialized in teaching skating technique." (Raatesalmi 2013.) Whether this assumption is correct or not, it will be discussed in this thesis. The study results will have practical implications on how flexibility training should be conducted in junior coaching.

2 PHYSICAL SKILLS AND PHYSIOLOGICAL DEMANDS OF ICE HOCKEY

2.1 Skating

The most significant skill of ice hockey is skating, as skillful skaters develop the ability to move fast and economically on the surface of the ice. Therefore, knowledge regarding the physics and mechanics of skating helps coaches and skaters to develop their skating technique. (Haché 2003, 60.) Uneconomical biomechanics of skating will lead to a worse skating technique. For example, if a player is not able to adequately extend his leg backwards during a skating kick, the already existing problems in flexibility are likely to get worse, thus confusing the biomechanics of skating even further. (Huovinen 2009, 15.)

Basically, skating is a complex series of motions located in a voluntary muscular system, and this series of motions is coordinated by the central and peripheral nervous system. (Toivola 2008, 21.) This series of motions is repeated regularly, and each leg pushes the skater in the desired direction during every cycle of motion (Haché 2003, 69).

The player must be able to use his good and versatile skating skills according to the demands of game situations. Motor skills required in skating include the correct timing of leg muscles, static and dynamic balance, and leg muscle force. (Pesola 2009, 17.) The success of skating performance is determined by the correct direction of a skating kick, the location of the center of gravity of the player as illustrated in figure 1 (Haché 2003, 75), as well as the correct ankle mechanics. The range of movement of a skating kick influences skating speed tremendously. It is difficult to increase skating speed to its maximum limits if the range of movement is short. (Paananen & Räty 2002, 17.)

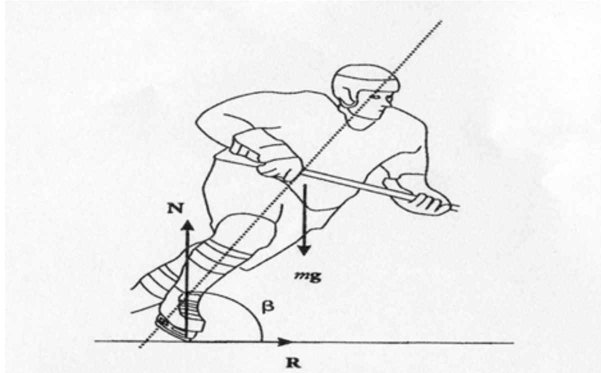

Figure 1.

Figure 1 represents the player's center of gravity.

Different forms of skating (forward skating, backward skating, and crossover skating) differ from each other because the level and direction of force production alters: the muscles used in the series of motions are activated in a different order and with slightly different intensity. (Toivola 2008, 21.) As illustrated in figure 2 (Haché 2003, 71), four parts of the limb and three significant joints of the skeletal system participate in this heavy movement. The majority of skating motions is created by extending the three major joints: ankle, knee and hip. Foot, leg, thigh, and upper limb are the four main body parts participating in the movement (Haché 2003, 69 - 71.)

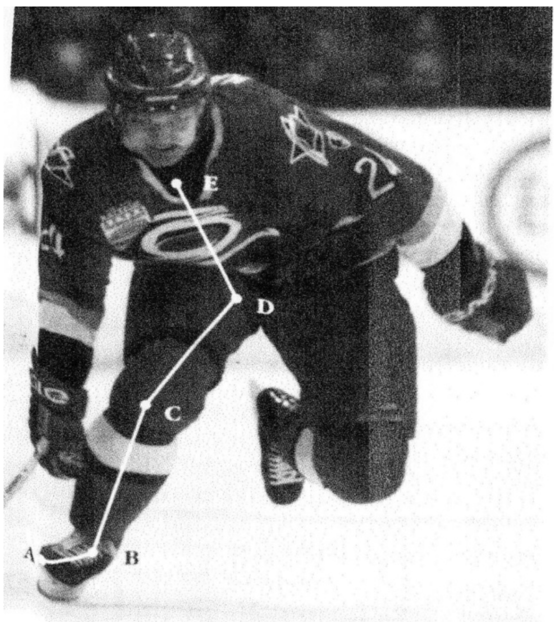

Figure 2.

Figure 2 shows the three significant joints of the skeletal system and the four body parts participating in the skating performance.

Because the coefficient of friction of the ice is near zero, the skating speed cannot be increased through pointing the feet directly forward. In this case the legs have no propulsion. According to Haché, Isaac Newton expressed this phenomenon by claiming that action and reaction always have an equal level of force, but towards opposite directions. Thus it is impossible to cause an action without the friction caused by its reaction. Because of this, a skater has to push himself forward as illustrated in figure 3 (Haché 2003, 73) by pointing the series of movement slightly sideways. (Haché 2003, 72.)

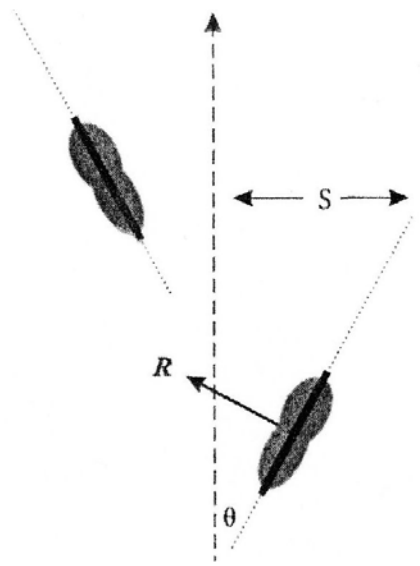

Figure 3.

Figure 3 shows the direction in which the skating kick should be directed during a skating performance.

2.2 Phases of Skating

Technically, skating can be categorized into three main phases: sliding phase, pushing phase and recovery phase as illustrated in figure 4 (Toivola 2008, 21), and each phase is important in a correct skating performance. (Toivola 2008, 22.) The ability to slide is an essential part of skillful skating. A player, who is able to slide skillfully on the ice, is capable of moving economically. Under these circumstances player can maintain energy for the game itself. (Paananen & Räty 2002, 31.) Sliding refers to the phase during which the skate slides on the surface of the ice. At the beginning of the sliding phase the center of gravity of a player is on the lower limb, which is sliding. When the sliding phase goes further, the center of gravity of the player is balanced between both legs. The sliding phase ends when the sliding leg is lifted above the surface of the ice. (Toivola 2008, 22.)

Pushing is caused by an order given by the central nervous system which activates muscles and causes the force production to begin (Toivola 2008, 22). The third phase of skating is called the recovery phase. The recovery phase has come to an end when the skate has returned back to the side of the other skate from maximal extension. Now the series of motion is changed back to the pushing phase. (Toivola 2008, 22.)

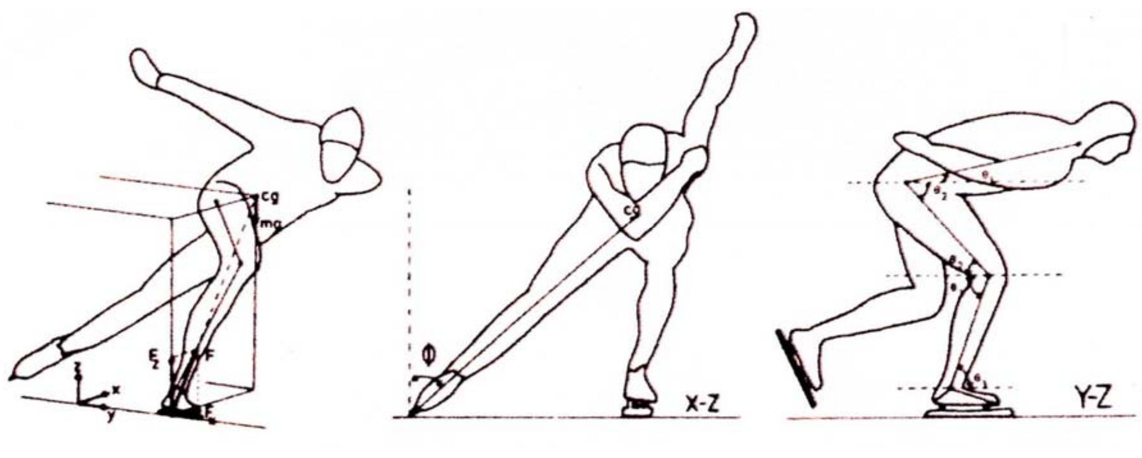

Figure 4.

Figure 4 shows the three phases of skating. Sliding phase, pushing phase and recovery phase.

2.3 Physiological Demands

The physiological demands of ice hockey have changed over decades. Because of developed equipment and professional training, the game has become faster and more demanding. (Huovinen 2009, 6.) Ice hockey is a unique game from the point of view of energy metabolism. It is physically demanding and requires highly trained aerobic and anaerobic energy systems. For the anaerobic energy system to work efficiently, good aerobic qualities are required as well. (Laaksonen 2011, 25.)

During a single shift, the intensity and the duration of the shift determine the amount of aerobic and anaerobic energy production. Accelerations with high intensity require good force production, power and anaerobic endurance from a player. Good aerobic endurance is required in order to maintain high physical performance level and to recover quickly. During a game, the amount of anaerobic energy production is approximately 69% and that of aerobic energy production is 31%. (Pesola 2009, 10.)

Muscle force is important for a hockey player because a player must have a good strength level on upper and lower limbs. The strength level of a player's lower limb has significant effect on skating speed and rhythm changes. (Pesola 2009, 11.) Muscle force is an essential factor of speediness, which is an important physical quality for a hockey player (Laaksonen 2011, 28). Speediness in ice hockey consists of many factors. Because ice hockey is a game of fast direction changes, a player is required to have good reaction abilities and good skating skills in forms of fast stops, acceleration and turns. (Pesola 2009, 13.) Agility and reaction speed are essential skills in a game situation. In order to accelerate and maintain his speed, a player must have good physical qualities of speediness. (Laaksonen 2011, 30.)

In ice hockey, like in many high intensity sports, power is an essential factor rather than force. For an ice hockey player, power is a combination of strength and speed. By its definition, power represents the amount of work in a certain time unit and it indicates how quickly the work is done. This is why power is dependent on the speed of the moving object. If there is no speed or force, power cannot exist. (Haché 2003, 87 - 88.)

In ice hockey, it is important to develop power in several ways. Power is needed in skating, shooting the puck and in contact situations. Power development is affected by the level of aerobic and anaerobic energy production as well as the level of force. (Laaksonen 2011, 27 - 28.)

Physiologically an efficient muscle is strong, i.e. it has plenty of muscle fibers and it can burn energy quickly. When the muscle contracts, it causes pulling force and the force is dependent on the contraction time of a muscle. (Haché 2003, 87 - 88.)

Flexibility is an important physical quality for an ice hockey player. In a good skating kick, the kicking leg extends completely straight from the hip. The lack of maximum extension at the end of the kick is usually the consequence of bad muscle flexibility in the lower limb (hamstrings, groins, hip flexors). A good flexibility level in these muscle groups improves skating and leg movement. (Laaksonen 2011, 32.)

A player cannot obtain the best possible skating speed and skating power if he or she cannot extend the kicking leg to its maximum during a skating movement. Flexibility training prevents injuries and improves the capability to utilize skills. (Huovinen 2009, 12 - 13.)

3 STRUCTURE AND FUNCTION OF THE NEUROMUSCULAR SYSTEM

3.1 Nervous Tissue, Synapse and Neuromuscular Junction

Nervous tissue is characterized by irritability, conductivity and ability to modify nerve impulses in neuromuscular junctions. The task of a nervous tissue is to process and transmit messages, i.e. nerve impulses. Messages are transmitted inside or between nerve cells and these connections form a neural network. A message of an action is transmitted to several places in the central and peripheral nervous system level. (Kauranen & Nurkka 2010, 55.) Nerve cells form the nervous tissue and some specialized cells are only found in the nervous system. The brain, spinal cord and peripheral nerves are all formed by nervous tissue. (Scanlon & Sanders 1997, 66 - 67.) Even though nervous tissue is complex, there are two principal types of cells of which nervous tissue is made up – neuroglia and neurons (Marieb 1988, 117). Neurons transmit information and are involved on coordination and regulations of function of the cells (Bjålie et al.1999, 20).

In addition to neurons, there are glial cells in the nervous tissue. In the brains, there are ten times more glial cells than there the neurons (Nienstedt et al. 2004, 68). Glial cells form a protective support network around the neurons of the central nervous system. One task of glial cells is to keep the composition of the interstitial fluid of the surrounding neurons as stable as possible. (Haug et al. 1994, 104.) Furthermore, these different types of cells have special functions (Marieb 1988, 117). The neuroglia cells are divided into ependymal cells, microglia cells, astrocytes, oligodendrocytes and Schwann cells (Kauranen & Nurkka 2010, 56).

A neuron is connected to other cells by neurotransmitters (Nienstedt et al. 2004, 64). Neurons are the functional and information processing units of the nervous tissue, and one neuron consists of a cell body (soma), dendrite and axon (Kauranen & Nurkka 2010, 57). The task of a dendrite is to receive information. Signals and impulses are received by the dendrites and information is passed to the body cell. The axon is the transmitter of a neuron and its task is to conduct impulses away from the cell body. (Tyldesley & Grieve 1989, 21.)

The connection of two cells, where an electric impulse is transmitted from one cell to other, is called a synapse. In a synapse, the impulse is transmitted in one direction only, and the nerve impulse transmission starts when action potential arrives to an axon terminal and presynaptic membrane. (Kauranen & Nurkka 2010, 63 - 65.) The ability of the brain to process information and guide muscle functions is based on synapses. Memory and learning are based on long term synaptic changes. (Haug et al. 1994, 106.) Neurons which transmit impulses down from the brains to the spinal cord and then away from the spinal cord to all parts of the body are called motor neurons. Respectively, neurons which transmit impulses towards the central nervous system and up from the spinal cord to the brain are called sensory neurons. (Tyldesley & Grieve 1989, 22.)

One form of a synapse is when an electric impulse is transmitted from a nerve cell to a muscle cell, and this event is called the neuromuscular junction. The junctions between motor neurons and skeletal muscles are the best researched synapses. One nerve cell forms junctions between several muscle cells, but one muscle cell has a connection with one nerve cell only. (Haug et al. 1994, 108.) Action potential spreads inner parts of muscle cell through the T-pipes in a neuromuscular junction. When this happens, it releases calcium ions which start the muscle contraction. (Hiltunen et al. 2005, 189.)

3.2 Central Nervous System

The central nervous system consists of the brain and the spinal cord, and the neuron works as a basic unit in the central nervous system. The spinal cord is the center of many reflex functions, and it combines sense stimulus and motor commands with the help of mediator neuron. The spinal cord also has a central role in regulating the power of different reflexes. (Kauranen & Nurkka 2010, 66; 87.) In cortical brain level, human is processing and recording information and human intellectual capacity and its function center is located in brain (Mero & al. 1997, 51).

The central nervous system is the essential collector and handler of sensory information and it guides all functions of human body. The brain is inevitable for nerve functions which need the specific accuracy, and the accurate sensations, information interpretation, conscious thinking and voluntary movements are possible because of the brain. (Hiltunen et al. 2005, 334.) Functionally, the brain can be divided into three parts. The sensory area receives and processes the sensations which are coming from inside and outside the body. The motor area sends commands to the muscles and glands. The motivation areas are guiding behavior through the emotional and intellectual consideration. (Haug et al. 1994, 113.)

The spinal cord and brain nerves together connect the brain to the peripheral nervous system. The spinal cord is about the same size as a little finger and its location is inside the spinal column canal, and spinal cord is the center of reflex senses. (Haug et al. 1994, 118.) The spinal cord is a part of the central nervous system and it is specialized on transmitting information. The falling peripheral nerves of the skeletal muscles start in the spinal cord, and the nerves from sense organs, sensory nerves and muscle spindles bring information back to the spinal cord. There are two important parts in the spinal cord. The higher part is located on the same height as cervical spine and it is responsible of the innervation of the upper limb. The lower one in located at the same height as the lumbar spine, taking care of the lower limb innervations. (Kauranen & Nurkka 2010, 85.)

A spinal reflex action involves the stimulation of receptors where impulses are passed into spinal cord in sensory neurons and then transmitted to motor neurons to produce a response. The stretch reflex is one example of a spinal reflex. When several muscle groups are active to receive a response, the impulses are spreading to several spinal segments, and now the intersegmental track of the spinal cord is involved. The spinal cord alone is responsible for basic movement responses to external stimuli. When higher activity centers in the nervous system develop, these basic movements are modified and more complex movements become possible. (Tyldesley & Grieve 1989, 81.)

Several motor and sensory nerve pathways pass in the spinal cord. They are responsible for transmitting the nerve impulses between the brain, spinal cord and spinal nerves. The falling nerve pathways travel through the ventral track, and these nerve pathways pass the motor nerve impulses from the brain to the spinal cord and from the spinal cord to the muscles and muscle spindles. (Kauranen & Nurkka 2010, 92.) The regulation of muscle and gland functions happen most of the time automatically or unconsciously. Sensory cells transmit nerve impulses through the sensory nerve fibers to the spinal cord or the brainstem. There, they connect with motor neurons and transmit signals to the muscles or glands. (Bjålie & al. 1999, 73.) When the sensory impulse is received, it evokes a response through a motor neuron, and the impulses which are conducted by the motor neuron control the movements of skeletal muscles (Wilmore & Costill 1994, 59).

3.3 Peripheral Nervous System

The information is transmitted from the central nervous system to the muscles through the movement nerves. Most of the human voluntary muscle movements get the innervations from the spinal cord through the spinal nerves. Only a small amount of muscles get the innervations directly from the cranial nerves. (Mero et al. 2004, 39.) The peripheral nervous system is formed by those nerve structures which do not belong to the central nervous system. The peripheral nervous system consists of cranial nerves, spinal nerves and autonomic nerves. (Hiltunen et al. 2005, 328.) All information that goes through or originates from the central nervous system travels through the cranial and spinal nerves. There are 12 pairs of cranial nerves and 31 pairs of spinal nerves. The peripheral nervous system consists of the sensory part, which transmits information to the central nervous from the body, and the motor part, which transmits the messages from the central nervous system to muscles and glands. (Haug et al. 1994, 132.)

The combination of the ventral and dorsal roots of the spinal cord together form the spinal nerves – all 31 pairs of them. In a quick span, the spinal nerve divides into dorsal and ventral rami, thus giving each spinal nerve the approximated length of only 1–1.5 cm. Like the spinal nerves, the rami contain both motor and sensory fibers. Plexuses, which are complex networks of nerves that serve the motor and sensory needs of the limbs, are formed by the ventral rami of all other spinal nerves. (Marieb 1988, 143 - 144.)

The spinal cord serves an important task for the nervous system and the entire human body. It is the integrating center for spinal cord reflexes while transmitting impulses to and from the brain. The 31 pairs of spinal nerves – which emerge from the spinal cord – are named according to their respective vertebrae: eight cervical pairs (innervating back of the head, neck, shoulders and arms), 12 thoracic pairs (innervating arms and – mainly – supply the trunk of the body), 5 lumbar pairs and 5 sacral pairs (which supply hips, pelvic cavity, and legs) and one very small coccygeal pair. The two roots – dorsal and ventral – are responsible of carrying impulses. The dorsal root, which is made of sensory neurons, carries impulses into the spinal cord. The ventral root is the motor root, and it is made of motor neurons. The motor neurons carry impulses from the spinal cord to the muscles and glands. (Scanlon & Sanders 1997, 136 - 138.)

The components of cranial nerves are the same as those of spinal nerves because they contain sensory, motor and autonomic fibers. All the fibers of one cranial nerve emerge together from the brain, either as a single bundle or as a row of filaments. Together, they join in brain stem. The cranial nerves have some specific functions. They convey information from senses to the brain for integration and eventual interpretation in consciousness. The cranial nerves provide the pathways for brain stem reflexes and for the essential movements of eyes, nose etc. The cranial nerves also carry activity in autonomic fibers, which control the size of the pupil of the eyes, the muscles of the heart and the activity of the digestive organs. (Tyldesley & Grieve 1989, 90 - 91.)

12 pair of cranial nerves start at the bottom of the brain. The first cranial nerve is the olfactory nerve and there are twenty sections in both sides of the head. The second cranial nerve is the optic nerve. In the optic nerves there are nerve fibers which carry impulses toward the central nervous system. The third, fourth and sixth cranial nerves are responsible of eye muscle innervations. (Nienstedt et al. 2004, 524 - 525.) The fifth cranial nerve is a triple nerve, which has motor and sensory tasks. The facial nerve is the seventh cranial nerve. This is responsible for motor innervations of face muscles and it gets sensory messages from tongue. The eighth of the cranial nerves is the acoustic nerve. This nerve only has sensory tasks and transmits hearing and balance information from ears to the brain stem. The glossopharyngeal nerve is the ninth of the cranial nerves. It does not have motor tasks but is responsible for sensory sensation of the pharynx and the back side of tongue. (Kauranen & Nurkka 2010, 96 - 97.)

4 STRUCTURE AND FUNCTIONS OF SKELETAL MUSCLES

4.1 Structure of Skeletal Muscles

There are over 600 muscles in the skeletal muscle system. Each of these muscles is formed by muscle tissue, connective tissue, blood vessels, and nerves. (Haug et al. 1994, 234.) These muscles perform muscle contractions under the guidance of the nervous system and thus the movement which follows the contraction (Kauranen & Nurkka 2010, 113).

How exactly does this contraction cause the movement? Each skeletal muscle is attached to at least two different bones, and while contracting, these muscles bring the bones closer to each other, thus causing movement to occur. The two attachment points of the muscle are called the origo and the insertio of the muscle. There are three sections in the skeletal muscle: the starting point of the origo called the "head", the central part called the "body", and the side of the attachment point itself, which is called the "tail". (Kauranen & Nurkka 2010, 113.) Both ends of the muscle are never attached to the same bone. Usually, while connecting from one bone to another, a muscle also surpasses a joint. Some muscles can surpass even two joints, thus being able to bend one joint and extend another. (Nienstedt et al. 2004, 143.)

There is always either a membrane tendon or a tendon at both ends of muscle tissue, thus the tissue is not attached directly to the bone (Kauranen & Nurkka 2010, 113). The function of a tendon is to transmit contraction power from the muscle to the movement of bones and joints as well as to resist stretching force during a muscle contraction. The border area of a muscle and a tendon is under great mechanical strain while the contraction power is transmitted from the muscle to the tendon. The tendon, meanwhile, is not only resistant to stretching but is also very flexible, so it can direct itself according to the traction. The muscle itself is also capable of such flexibility. (Peltokallio 2003, 227.)

The part of the muscle where the muscle fibers are located is called muscle body. Both ends of the muscle body always include a tendon part which transmits muscle movement to its surroundings. Singular muscle fibers are attached either to these tendons or to the connective tissue of the muscle. (Nienstedt et al. 2004, 143.) The specialized function of muscle fibers is to contract shortened and produced movement. A skeletal muscle is made of thousands of muscle fibers. Different movements demand different amounts of muscle fibers to contract in a muscle. (Scanlon & Sanders 1997, 126.)

In addition to muscle tissue itself, connective tissue is also an important part of a muscle. The muscle – like most other organs – is surrounded by a fascia, i.e. a membrane formed by connective tissue. Connective tissue also surrounds single muscle fibers and muscle fiber bundles. Connective tissue prevents muscle tissue from tearing under heavy stretching. (Nienstedt et al. 2004, 143.) Connective tissue forms the elastic component of the muscle, which allows the muscle to have tremendous muscle stress endurance and can store elastic energy momentarily to the muscle. Muscles receive part of their rest tone from connective tissue. (Vuori 1988, 262.) Both muscle and connective tissue adapt themselves to physical exercise by enlarging the muscle mass and by increasing the maximal stretch force of the muscle (Peltokallio 2003, 230).

4.2 Functions of Skeletal Muscles

When a human moves, a single muscle rarely acts independently from other muscles. Instead, several muscles participate in the movement with roles of action often varying greatly during the motion of even a single muscle. The role of a muscle can even change while performing a certain movement pathway. During motion, a muscle can be either a performer a.k.a. agonist, a counter-performer a.k.a. antagonist, a helper synergist, a neutralizer, or a fixator, which keeps the movement together. (Kauranen & Nurkka 2010, 138.) The agonists, or prime movers, are primarily responsible for the movement. Antagonists, on the other hand, oppose the prime movers in forms of, for example, relaxation; and synergists assist the prime movers. (Wilmore & Costill 1994, 38.)

Different types of muscle efforts are divided into dynamic and static categories, depending on whether the muscle movement includes external changes in muscle length. During dynamic muscle work a muscle either shortens or lengthens. During static muscle work the length of the muscle remains the same. (Kauranen & Nurkka 2010, 139.) The type of the muscle contraction affects the developing muscle force significantly. The contraction types mentioned above can be classified in a following way: static muscle work is classified as isometric when movement does not occur at all, while dynamic muscle work is classified either as concentric, in which case the muscle shortens, or eccentric, in which case the activated muscle stretches.

(Sandström & Ahonen 2011, 123.) During isometric contraction the external length of the muscle remains intact, although the contracting component within the muscle shortens. The connective tissue which has connected next to the contracting component or the elastic component is forced to stretch during this event. The muscle does not work in a physical sense, although physiological labor can be presented as the outcome of muscle force and contraction time. A muscle can perform physical work by contracting either concentrically or eccentrically: thus walking uphill requires more energy than walking downhill with the same speed. (Vuori 1988, 265.) A muscle produces the highest maximum strength in an eccentric activity, the second highest in an isometric activity, and the smallest in a concentric activity. Sport performances are usually a combination of dynamic and static activity. (Mero 1997, 61.)

The contraction power of a muscle is dependent primarily on how many motoric units are active. Only small units with just a few dozen muscle fibers are activated during weak contractions, while larger units are activated during more powerful contractions. Movement velocity as well as muscle fiber length and quality also affect muscle force. (Nienstedt et al. 2004, 144.)

4.3 Motor Unit

Guyton and Hall have pointed out that "each motor neuron that leaves the spinal cord innervates many different muscle fibers, the number depending on the type of muscle. All the muscle fibers innervated by a single motor nerve fiber are called a motor unit." (Guyton & Hall 1996, 82.)

A motor unit is the smallest entity in the neuromuscular system that regulates and controls functional force. Their anatomic and physiological qualities vary greatly depending on the type of muscle unit. The contraction time of motor units varies between 20 and 140 milliseconds, and the units are categorized as fast and slow units based on their contraction and relaxation times. Motor units are categorized as fast units if they can produce their maximal strength and relax this force quickly. If the units can in turn maintain their strength level for long periods of time and muscle fatigue happens slowly, they are categorized as slow units. (Kauranen & Nurkka 2010, 129 - 131.)

Momsher and Mommaerts have written on the subject of how motor units function. "Each unit reacts on the all-or-none principle, since an action potential passing down an axon will maximally activate all the fibers in the unit. Muscles that exert very fine control have small motor units in relatively large number so as to allow accurate gradation of developed force by recruiting additional small units. However, a hundred or so units will give all the gradation needed, so that, when large forces have to be developed, this is usually achieved by having very large units." (Homsher & Mommaerts 1982, 97 - 98.)

5 ENERGY METABOLISM OF SKELETAL MUSCLES

5.1 On Energy Metabolism in General

The producing of energy and the use of energy sources during exercise depend on the quality, duration and frequency of the strain. It is essential that the body can produce quickly and economically enough the high-energetic adenosine triphosphate (ATP) which is essential for muscle work. (Rehunen 1997, 58.)

The basic process of energy production is the degrading of adenosine triphosphate (ATP). The constant appeasement of the energy intake requires that ATP is being formed as fast as it is being consumed. Using the stored phosphocreatine (PCr) is the quickest route to this. (Vuori 1994, 244.)

The essential energy sources of muscle contraction are ATP, phosphocreatine (PCr), carbohydrates, fats and proteins (Rehunen 1997, 60). To contract, muscle needs energy, and it receives it in the form of free energy bonded to ATP. All of the chemical energy travels via ATP. (Nummela 2004, 97.)

During a physical exercise, the energy intake of muscles is increased tremendously. The power and length of the exercise in question – as well as the physical condition of the individual – determine the variation of energy sources and productive methods. The muscles have to produce a large amount of energy quickly during short-term and high-intensity exercises (i.e. sprint running, weight lifting). In these kinds of exercises the energy is almost exclusively received from adenosinetriphosfate (ATP) and phosphocreatine (PCr). Together with ATP and PCr, the fat tissue as well as the glycogen of muscles and liver forms the most important energy storages of the body. (Rauramaa & Rankinen 1999, 30 - 31.)

The individual ability to take advantage of the energy stored in nutrients during a muscle contraction has a high effect on the physical performance level. The power and capacity of different energy production systems affect the performance level of the individual tremendously. From the point of view of energy production, the speed of anaerobic energy production (anaerobic power) as well as the ability to maximize anaerobic energy production (anaerobic capacity) is vital in short-term performances. In long-term performances, however, the good physical ability demands high aerobic power (VO2 max), and the importance of the size of energy storages increases as the duration of the performance lengthens. (Nummela 1997, 107.)

5.2 Immediate, Short-Term, and Long-Term Energy Systems

5.2.1 Immediate

The most fundamental process of energy production is the dissolution of ATP. In order to satisfy the constant need for energy, ATP must be generated according to the level of consumption. This is accomplished most efficiently through the use of stored PCr. Although this reaction might be a fast and efficient way to produce energy, the amount of energy produced at a time – i.e. the reaction capacity – is small. (Vuori 1994, 244.)

This energy system is needed in very short-term, only a few seconds lasting physical performances. In these situations, the required ATP is received from another immediate energy source, phosphocreatine PCr. The amount of ATP in the muscle itself is low, which means that the muscle can work for a maximum of one second. The phosphocreatine–ATP system is so efficient that the ATP level of the muscle remains relatively stable for as long as there is phosphocreatine. (Rehunen 1997, 58.)

5.2.2 Short-Term

In exhausting power exercises that last from ten seconds to two minutes, such as running 400–800 meters or swimming 100–200 meters, most of the energy is produced in the anaerobic way. This means that the energy which is produced with the help of phosphocreatine and oxygen is not enough, and oxygen debt is required. In anaerobic energy production the lactic acid or lactate is stored into the muscles, and the pH value of the muscle becomes lowered and the contraction of the muscle is disturbed. (Rehunen 1997, 59 - 60.)

This method of producing energy causes carbohydrates in the body – i.e. stored glycogen and the glucose which is received from the blood – to degrade quickly or anaerobically, and the creation of lactic acid is a product of that. The accumulation of lactic acid into a functioning tissue and its transition into the blood limits the capacity of the reaction in maximal and nearly maximal exercises (Vuori 1988, 283). The most important energy source of the energy metabolism with lactic acid is sugar, which is laid down to the muscle in the form of glycogen. (Rehunen 1997, 60.)

Although lactate is mainly produced within muscle cells, muscle cells also participate in the removal of lactate from the circulation. The fast muscle cells (IIa and IIb type cells) specialize in anaerobic energy production and are therefore largely responsible for the production of lactate. (Nummela 2004, 98.) Although lactate is moved from circulation into muscles as well, most of the lactate is moved into the heart muscle and the liver, where it is used either directly in energy production or in the forming of glucose (Nummela 1997, 108).

In a short-term exercise the production of lactic acid is directly proportional to the mass of the working muscles and the intensity of the exercise (Nummela 1997, 107). The level of lactic acid in blood rises visibly when the stress reaches about 60% of the maximal oxygen consumption. As the level of lactic acid increases, so does ventilation. This phase is referred to as anaerobic threshold. (Vuori 1994, 246.)

5.2.3 Long-Term

When the physical stress lasts for over two minutes but under two hours, most of the energy is produced with the help of oxygen. If the stress level is high, as in for example skiing, running or cycling near the upper limit of the individual's own capacity, the primary source of energy is the glycogen stored within muscles. However, if the stress is light, in addition to the muscle glycogen other energy sources are used; namely sugar stored in the liver and the fats of the system. (Rehunen 1997, 60.)

The intensity of the exercise regulates the use of carbohydrates and fats in energy production. Energy is produced almost solely from the stored fats if the intensity of the exercise is under 30% of VO2 max. At higher stress levels the significance of carbohydrates in energy production is increased. This means that in almost all sports, carbohydrates are a primary energy source. (Nummela 2004, 107.) The role of fats as an energy source is emphasized the calmer and longer-term the exercise and the more experienced the person is. By using fats, the limited reserves of sugar glycogen are conserved for highly stressful short-term performances. (Rehunen 1997, 60.)

Carbohydrates and fats are consumed during long-term performances in succession in such a way that after the glycogen reserves have run out, the fat storage starts being used. Both reserves are being consumed simultaneously, but it is in such a way that the use of fats in energy production becomes increased as the performance progresses and the glycogen reserves diminish. (Nummela 2004, 107.)

5.3 Definition of Speed

Speed is known to be a highly inherent physical quality from the point of view of neuromuscular system. Achieving changes in biological structure is easiest during early childhood. Because the basic development of coordination occurs during childhood, it is obvious that training speediness during childhood has a crucial role. (Mero 1997, 168.) Speed training is practically a sport-related practice, and for this reason the technical performance, force production and relaxation improve in that certain sport. All these qualities can be developed by training, but heredity affects the force production of fast motor units and this will determine how fast individual can become. (Mero 2004, 296.)

The categories of speediness are reaction speed, explosive speed, and movement speed. Reaction speed means the capability to react quickly to a certain stimulus. It is usually measured by reaction time, meaning the duration of time from receiving the stimulus to the beginning of movement (for example shot and reaction from starting blocks in sprint running). Reaction time can also be measured as reaction to auditory, visual or tactile stimuli. Reaction speed is needed in different decision making situations of nearly all ball sports. (Mero 1997, 167.) The development of reaction speed is highly emphasized in improving reaction time, meaning the capability of the nervous system to process and transfer a message, which improves greatly during childhood. The reaction time is categorized into pre-motor and motor time. Pre-motor time means the time which passes from receiving the stimulus to the beginning of muscle activity in the muscle conducting the performance. Motor time means the time which passes from the beginning of muscle activity to the beginning of force production. However, the development of reaction speed requires a high variety of speed training and long periods of time. (Mero 2004, 294.)

Explosive speed means a single short-term movement performance, conducted as quickly as possible. Good examples of this are strikes, throws, punches, shots, kicks and jumps. Movement speed means the quick transition from one location to another. Movement speed can refer to speed in acceleration phase, stable speed phase or speed reduction phase. (Mero 1997, 167.)

6 DEFINITION OF FLEXIBILITY

6.1 Flexibility in General

Flexibility refers to the range of motion in joints, and its significance is major in sports and in normal life. The flexibility is partially an inherited physical quality but the level of flexibility can be increased by training. (Kalaja 2009, 263.) Flexibility is one of the major physical qualities, and the impaired flexibility or muscle tension is unfavorable for performance because the impaired flexibility inhibits the movement and that increases the amount of energy needed to keep the technique as economical as possible (Seppänen et al. 2010, 103). The joint flexibility and muscle and tendon elasticity are individual qualities and there are different factors affecting maintenance, development or regression of these qualities (age, sex, heredity, exercise habits, body structure) (Saari et al. 2009, 37).

Flexibility can also be understood as a motor feature when it means the ability to gain the required range of movement needed during a motion. Flexibility differs from other components of physical performance abilities because it comprises the structural, force production-related and coordinative dimensions. (Kalaja 2009, 263.) Good flexibility does not only mean muscle elasticity. In addition to muscle elasticity, the range of joint motion is determined by tendons, connective tissue and partly by peripheral nervous system. The effects of stretching do not focus only on muscles but also on supporting tissues and neuromuscular system. (Seppänen et al. 2010, 106.)

Anatomically, the limiting factors for the range of motion are the impaired flexibility of muscles, tendons and ligaments. Physiologically, the limiting factors for the range of motion are body temperature, the amount of the immediate source of energy (ATP) for muscles in muscle cells, and the over activation of stretch reflexes due to, for example, too fast-paced stretching (muscle contraction). (Koistinen 1994, 30.)

6.2 Flexibility Functions and Limitations

Flexibility is related to coordination ability which means the correct contraction and relaxation of muscles (requiring the work of agonist, antagonist, and synergist muscles). Flexibility has at least the following functions: the economy of motions increases, motor learning process speeds up, motor regulation ability increases, the aesthetics and elegance of motions are increased, the tolerance to muscle fatigue increases, the risk of injuries decreases and muscle stability increases. (Kalaja 2009, 264.)

Many motion performances are not possible without adequate flexibility. In several sports, the adequate flexibility means "local hyper mobility", meaning the kind of range of motion which stretches above the normal range of motion of a person who does not exercise sports (Kalaja 2009, 264). A high level of muscle elasticity for a stretching muscle is not functionally useful if the performance of the antagonist muscle does not correspond with the demands of the stretching muscle group. For example, if one were to move one foot straight towards the shoulders while standing straight, this movement requiring hamstring stretching would be impossible to perform if the antagonist muscles of hamstring muscles were not strong enough to overcome the stretch resistance and thus lift the limb up. Even good passive flexibility is not useful in a sport performance or pre-emptive injury resistance if muscle pairs are not able to synchronize their function together. (Seppänen et al. 2010, 107.)

Flexibility limitations are defined as the limitation for motion caused by tension of muscles, muscle–tendon connections, membrane structures or joint support structures. An incorrect exercise load can cause motion limitations for a healthy body as the body is strained too much, too little, or in an unbalanced way. (Saari et al. 2009, 38.) Several structures of the skeletal system limit flexibility and its development. In addition to the tension of muscle, tendon and joint areas, limiting factors for flexibility can include structural or trauma-related problems of the nervous system. (Seppänen et al. 2010, 107.) Flexibility exercises can also have limiting effects if they are conducted in an unbalanced way, concentrating stretching to muscles already in a good shape and thus ignoring the stability between agonist and antagonist muscles (Saari et al. 2009, 37).

6.3 Flexibility Training During Ages 12–13

During puberty, flexibility levels will develop if flexibility-improving practice has been performed, and the differences between individuals are notable. The development of flexibility is also joint-specific, which means that flexibility develops in the joints at which the stretching has been targeted. Within this age group, the flexibility will develop in a differentiated manner, which means that the flexibility levels improve in some joints and get worse in others. The growth development is not necessarily connected with the changes of flexibility, but strong growth development inevitably influences flexibility. Because of the accelerated hormone production, the growth of muscle mass is typical for this age group, not unlike growth development. The changed body dimensions require restructuring different movement performances. During puberty, plenty of active flexibility training should be done. (Kalaja 2009, 265 - 277.)

6.4 Flexibility Types and Exercise

The normal physiological joint motion ranges are used as the standard starting point for creating sport-specific flexibility. Requirements for general flexibility are not as demanding as the requirements of sport-specific flexibility, so in sports, flexibility has to be trained in a sport-specific way just like any other physical quality. When sport-specific movement is adequate, the sport-specific performance becomes economical, in which case extra energy is not needed in order to conduct the movement, and the excess energy can be focused on control and fine-motor tasks instead of using it to struggle with flexibility limitations. (Seppänen et al. 2010, 109.)

Flexibility can be categorized as active, passive, or anatomic flexibility. As illustrated in figure 5 and 6 (Kalaja 2009, 267), active flexibility equals to joint range of motion acquired by the muscle work of the performer, while passive flexibility refers to the joint range of motion acquired by an external force, which can mean, for example, the gravity or the muscle force of another person. Passive flexibility has always more force than active flexibility. (Kalaja 2009, 266 - 268.) Therefore, it can be especially useful for athletes who need extreme flexibility in their sports or need to increase their flexibility level (Seppänen et al. 2010, 111).

Figure 5.

Split jump presents active flexibility.

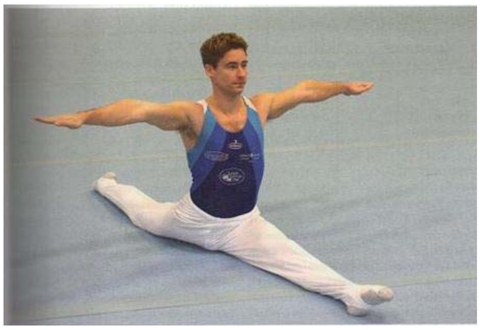

Figure 6.

Split stretch on the ground presents passive flexibility.

7 MOTOR LEARNING, SKILL DEFINITION AND HUMAN PERFORMANCE

7.1 Definition of Motor and Skill Learning

According to terms, motor learning can be defined as a group of internal processes caused by exercise and experience and which lead to permanent changes in motor ability and skill-demanding performances (Kauranen 2011, 291). The motor functions of a human are regulated by the central nervous system, which has a special learning unit, i.e. the brain. The processing and learning of information always involve both conscious and subconscious centers. (Eloranta 2002, 86.)

Motor learning is associated particularly with skill-demanding performances and transformations in the coordination and cognitive functions of movements. Motor learning causes permanent structural changes in the neural connections of the central nervous system, whereby it leaves permanent marks in the motor functions and the motor performance. Motor learning is divided into explicit (conscious learning) and implicit (unconscious learning). The share of implicit learning is over a half of the learning, and therefore, motor skills are primarily learned unconsciously during practice. (Kauranen 2011, 291.)

Motor learning is required while acquiring completely new motor skills and relearning earlier mastered skills. Motor learning can mean improving a practiced performance, standardizing performance or transferring a learned performance into a new environment. (Kauranen 2011, 291.) To learn the movement activity is the primary objective of motor learning situations. The study of motor learning is also the study of how the skill is acquired, what influences its attainment and perhaps how it is retained over time. (Singer 1982, 81.)

Learning a skill means a process within one's body that is caused by practice. During a learning process, several parallel things happen within the body. They are based on neurology (nervous system), cognition (thinking) and our feelings. Learning occurs as a result of practice and not, for example, maturation or the increase of strength. (Jaakkola, 2009, 237.)

The word skill by itself might imply an art in writing, memorizing, acting, and painting, talking or playing. To delineate the term, the muscular movement or motion of the body required for the successful execution of a desired act is termed motor skill. (Singer 1975, 35.) Learning a skill was earlier considered a very mechanical event. Not much attention was paid to the learner as an individual nor the learning environment or the characteristics of the task that is being learned. According to the current model, learning develops as a joint effect of three factors: learner, learning environment and the task that is being learned. (Jaakkola 2009, 238.)

The characteristics of the learner affect the progress of the learning process. Traits and attributes of a person include their motivation, their earlier experiences of the task that is being learned, the properties and proportions of their body, their innate abilities and their physical condition. (Jaakkola 2009, 238.) The results of motor learning are usually considerably more permanent than the effects of practice on the other physical properties of the person. This underlines teaching and learning work and movement performances correctly during the first exercises. If the motor movements required in the action are learned incorrectly, unlearning these motion models afterwards is extremely difficult and arduous and demands a lot more practice than simply learning and internalizing a new movement model. (Kauranen 2011, 291.)

Feedback refers to all the information that a person employs to steer their performance towards a goal. Feedback tells what stage of the performance one is in and how the performance must be corrected. On the other hand, feedback is an absolute requirement of learning. (Keskinen 1995, 71.) The feedback an individual gets out of a motor performance is considered the single most important factor in the learning of new motor performances. The feedback that is given usually involves qualitative aspects that have to do with velocity, timing, rhythm, softness, mechanical efficiency and the aesthetic nature. (Kauranen 2011, 382 - 383.)

7.2 Skills Classification

Both colloquial language and sciences talk of skillful performances and masters. A skillful person can be distinguished of an unskilled one when the results of both performances are seen. (Keskinen 1995, 70.) Skill and technique are the most important factors of a sports performance and must therefore be emphasized in training ever since childhood (Mero 2004, 241). Skill is a slowly developing attribute, and adopting it often requires tens of thousands of repetitions (Seppänen et al. 2010, 35).

Psychologist E.R. Guthrie (1952) has provided a definition that captures most of the critical features of skills. Skill consists of the ability to bring about some end result with maximum certainty and minimum outlay of energy, or of time and energy. This definition has several important features to consider. Firstly, performing skills implies some desired environmental goal. Second, to be skilled implies meeting this performance goal (end result) with maximum certainty. Third, a major feature in many skills is the minimization, and thus conservation of the energy required for performance. (Schmidt 1991, 4.) An essential characteristic of skill is retaining a high level in a performance, even in difficult conditions. A skillful performance is a result of long-term learning, and the nature of a developed skill also involves anticipation which allows a master to prepare for actions in good time before they must be performed. This results in confidence in and an unhurriedness of the performance. (Keskinen 1995, 71.)

The types of skills are basic skills and sport-specific skills. Basic skills refer to the ability to learn and master different skills not involved in a sport but also skills of particular sports. Sport-specific skills refer to the appropriate employment of the technique of the sport according to the situation, the ability to repair flawed techniques that manifest themselves and the ability to learn a new technique quickly. (Mero 1997, 141.)

7.3 Stages of Learning

In 1967, two American psychology researchers, Paul Fitts and Michael Posner developed a theory on motor learning which was based on three different phases. Fitts and Posner call the first phase of learning a new motor skill "the cognitive phase" because it involves a number of different cognitive functions. They labeled the second phase of motor learning as "the associative phase" and the third phase as "the autonomous phase". (Kauranen 2011, 291.) During the early stages of learning, in the cognitive phase, connections form a flimsy and rough idea of the skill (Eloranta 2002, 87).

The cognitive stage is characterized by the leaner trying to figure out what exactly needs to be done. Considerable cognitive activity is typically required at this stage, in which movements are controlled in a relatively conscious manner. During this phase, learners often experiment with different strategies to find out which ones work in bringing them closer to the movement goal and which do not. (Wulf 2007, 3.) Therefore, it involves understanding the task and clarifying its demands. The purpose of this phase is to allow the learner to follow through the action using conscious control. (Keskinen 1995, 84.)

In the associative phase the idea of the task is clear to the learner, and therefore the learning is objective-oriented and the development of skill is accelerating. This is the phase where the learner actually learns the task. (Eloranta 2002, 87.) In the associative phase the learner has solved most of the strategic and cognitive problems of the performance and is aware of how the motor task must be performed (Kauranen 2011, 307).

This phase is characterized by more subtle movement adjustments. The movement outcome is more reliable, and movements are more consistent from trial to trial. After extensive practice, the performer reaches the autonomous phase. (Wulf 2007, 3.) At the end of the autonomous phase the skill is more or less acquired and the significance of conscious control is low and a high performance level is retained even in difficult conditions (Keskinen 1995, 84). After the autonomous phase resources are released for the voluntary part of the brain, which allows it to focus on the applied development of skill (Eloranta 2002, 88).

8 RESEARCH PROBLEMS

Research problems are based on the purposes and objectives of the study. Research problems can be designed in the form of claims or questions. (Kankkunen & Vehviläinen-Julkunen 2013, 99.) Hypotheses are also used in a quantitative research, and they are expressed in the form of claims. The hypotheses can be expressed in two ways: indicating a direction or statistical hypotheses. The so called null-hypothesis (H^0) is a statistical hypothesis which suggests that there is no relationship between two phenomena or that no differences can be found between two phenomena during an experimental treatment. An alternative hypothesis (H^1) presents the researcher's expectations of the results (Hirsjärvi 2009, 158 - 159).

The purpose of this study was to investigate how training flexibility intensively for six weeks affects lower body flexibility and skating speed development. The objective of this thesis is to find out more information about this phenomenon. This cropping has been chosen with practical implications in mind: the thesis should be able to be used in junior coaching without turning the research problem too wide to handle.

1. How the development of lower body flexibility levels affects skating speed?

2. How training flexibility intensively for six weeks affects lower body flexibility and skating speed development?

- H_0: The mean of flexibility tests remains the same
- H_1 : The mean of flexibility test has changed significantly

- H_0 : The mean of 30-meter skating test remains the same
- H_1 : The mean of 30-meter skating test has changed significantly

9 RESEARCH METHODS

This is an intervention study with 16 junior hockey players between ages 12–13. Sixteen players were chosen together with a Kajaani Junnu Hokki 68 ry coaching manager. It is obvious that risks always exist in contact sports such as ice hockey; therefore, the total number of players can decrease during this research period. All players are from the same team. The six-week intervention study was conducted during a competitive season, from February to April.

The purpose of the research is to investigate how the possible changes in flexibility levels affect skating speed and whether a correlation can be found between skating speed and flexibility. Skating and flexibility tests are conducted during a competitive season over a timespan of six weeks, and the players are given a flexibility exercise program in order to investigate whether or not this program causes changes in the flexibility level of a player. The flexibility exercise program is executed under supervision.

A quantitative method is used while conducting the research. SPSS - program is used when the data and the results are interpreted. The focus is on a quantitative comparison of possible changes in flexibility levels and skating speed. The data regarding flexibility is collected through four flexibility tests: Sit and reach test measures the lower-body flexibility of muscles and joints. The squat test is a flexibility test used by the Finnish Ice Hockey Association. Modified Thomas test hip-extension angle measures the flexibility in hip flexor muscles. Modified Thomas test knee-flexion angle measures the flexibility of thigh muscles. The flexibility training, which includes the dynamic and static flexibility exercises, is conducted for the subject group under supervision during the research period.

A 30-meter maximal skating performance is used to measure the skating speed. The skating agility test is used by the Finnish Ice Hockey Association and this test measures skating skill levels. The countermovement jump is used to measure the possible changes in leg strength levels during this research. All the tests are standard test, and tests are conducted in a consistent way at the same time at the beginning of the research and at the end of it. The average change between the first and second measurements has been calculated mathematically and the result is expressed in percentages.

9.1 Quantitative Research

A quantitative research is often used in social sciences. Conclusions on previous researches, former theories, placing the hypothesis, defining concepts, collecting data, using tables and statistic data and making conclusions based on the statistical analysis are included in the most central segments of quantitative research. (Hirsjärvi 2007, 135 - 136.)

Firstly, a theoretical framework should be written out. After placing the research problems, the research ought to be directed towards a certain theoretical outlook, and central concepts and hypothesis ought to be defined. (Hirsjärvi 2007, 136.)

It is often stated that the goal of a scientific research is to produce a theory or at least aspire to do so. Forming theories is even considered to be irreplaceable because theories have some basic functions: a theory offers a shortcut for communication and organizes ideas and reveals hidden assumptions. Theory creates new ideas and may reveal the complexity of the problem and create explanations and predictions. Theory can even point out similarity in seemingly different kinds of problems. (Hirsjärvi 2007, 136 - 138.)

A hypothesis can also be used in quantitative research. Solutions or explanations can be anticipated by estimating possible differences and causal relationships, and these estimations are called a hypothesis. They are presented in the form of claims. Scientific research expects this kind of hypothesis to be well-grounded. Usually justifications are found in theories, theoretical models or previous researches. A hypothesis can be presented in two ways: either as a hypothesis indicating a direction or as a statistical hypothesis. A hypothesis indicating a direction presents a positive or a negative dependency between different phenomena which are studied. Statistical hypothesis supposes that there is no relationship between phenomena which are studied, or that such a relationship is not to be found in experimental research. (Hirsjärvi 2007, 136 - 138.)

One characteristic of a quantitative research is the evaluation of a statistical significance. The investigator must determine the level of statistical significance, the so-called p-value (probability). The most commonly used p-value is under 0.05, which means that investigator has a five-percent margin of error when he or she generalizes the results to the target group. (Kankkunen & Vehviläinen-Julkunen 2009, 45.)

9.2 Implementation of the Research

The nature of this thesis and research problems led to a quantitative intervention study. A quantitative intervention study examines how some specific methods affect the target group in question (Kankkunen & Vehviläinen-Julkunen 2009, 44).

A pervious research was made by Maukonen, Piekkola and Taira in Savonia University of Applied Sciences in 2010. The purpose of their study was to find out if the functional flexibility training performed twice a week during the six week period would affect the range of motion changes of a hip joint and back as well as a skating speed of 16 -18-year-old ice hockey players. After their research period, there were significant improvements in a flexibility and skating speed. The results of the previous study and this thesis have been compaired against each other in the discussion.

9.3 Target Group

The subject persons are 12–13-year-old junior ice hockey players playing for the Kajaanin Junnu Hokki 68 ry organization. 16 players were chosen together with Kajaanin Junnu Hokki 68 ry coaching manager. The team started their ice training season at end of July, and for the first few months the off-ice training program focused on coordination and basic skills. In November, their training program focused systematically on speed, dynamic flexibility and speed strength. The training program for these exercises was conducted from November to the end of January. When this research experiment started in February, the team did not train anything else but flexibility exercises. There were two dynamic flexibility exercises which were conducted before the ice practices. Two static flexibility exercises were also conducted on a day when there was no ice practice.

9.4 Flexibility Tests

As illustrated in figure 7 (Harvey & Mansfield 2000, 110), a modified Thomas test was conducted to measure the flexibility levels in hip flexors and thigh muscles. The test was measured by goniometer. The hip flexor flexibility is expressed in degrees and the the result is either positive or negative number. The number can be obtained in a way that the measured result is subtracted from the zero point which is 180º. The greater negative value represents a better flexibility. The proposed result for a hip flexion angle is −7º. (Harvey & Mansfield 2000, 110). The thigh muscle flexibility is expressed in degrees in a way that the measured result is subtracted from 180º. The proposed result for a thigh muscles is 45º and test is illustrated in figure 8 (Harvey & Mansfield 2000, 111).

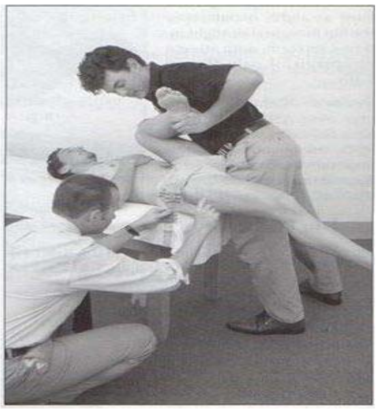

Figure 7. Hip Extension Angle

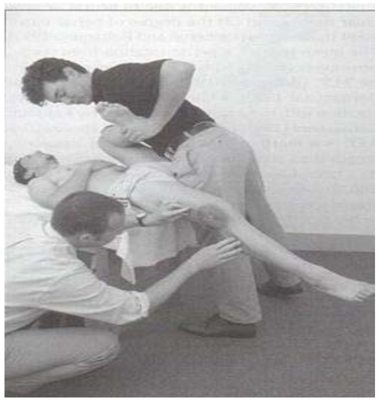

Figure 8. Knee Flexion Angle

The sit and reach test was conducted to measure the flexibility levels in lower body muscles and joints. This test requires mostly a good flexibility in groins, thigh adductors and hamstrings. The test is conducted in a way that the athlete is sitting towards the carpet on which there is tape measure in the middle. As illustrated in figure 9 (Kasva urheilijaksi testit), the athlete then starts to bend over as far as possible while keeping both hands on the carpet during the performance. The athlete must stay still a few seconds at the point of the maximal extension. The result is expressed in centimeters.

Figure 9. Sit and Reach Test

As illustrated in figure 10 (Hockey Centre - Pohjolaleiri testit), the squat test is conducted to measure comprehensively the flexibility levels of the body. The result is expressed at a scale of 1 to 3, and three body parts are measured separately. Those body parts are shoulders, back and ankle. The Finnish Ice Hockey Association has criteria for how each body parts are assessed. The person who supervises the test must be familiar with the criteria.

Figure 10. Squat Test

9.5 Skating Speed Tests

A 30-meter skating test was conducted using an electronic timing device. The players' maximum skating speed was measured by a 30-meter skating test where the players performed approximately 10-meter initial acceleration before the first photoelectric sensor. When the player passes the first photoelectric sensor, the time starts and when the player passes the second sensor the time stops automatically.

Figure 11. Photoelectric Sensors.

As illustrated in figure 12 (Hockey Centre - Pohjolaleiri Testit), a skating agility test measures the skating diversity and this test is used by the Finnish Ice Hockey Association. The four phases of the test are shown in the picture, where a straight line represents forward skating and a curved line presents backward skating.

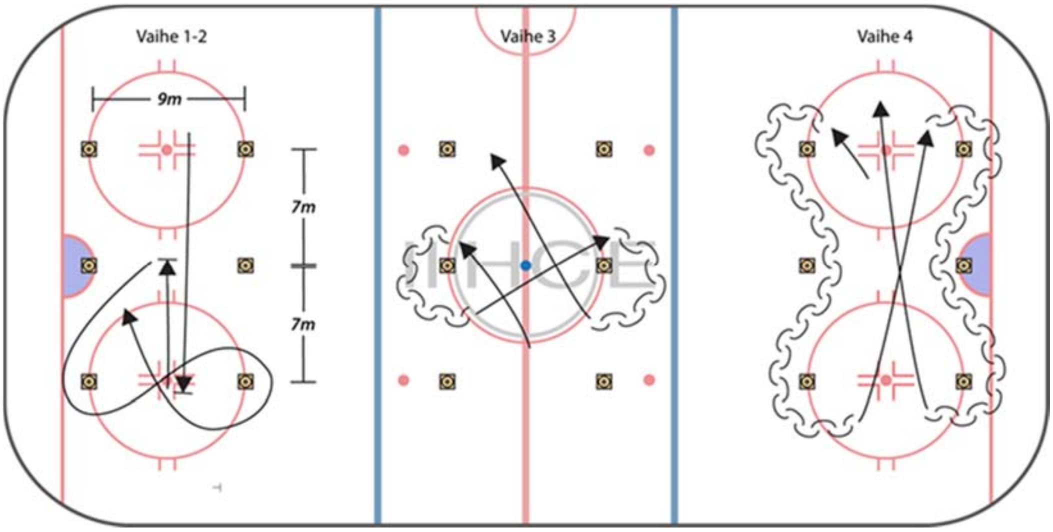

Figure 12. Skating Agility Test.

9.6 Countermovement Jump Test

The countermovement jump test was conducted to observe the possible changes in the force production levels of the players' legs during this research time. The test was conducted by contact carpet and the result is expressed in milliseconds. As illustrated in figure 13 (Fager-holm 2004, 153), at starting point, the athlete is standing straight on the carpet with his hands on his hips. Then, he performs a quick jump upwards, in a way that he performs a small squat movement downwards before the jump.

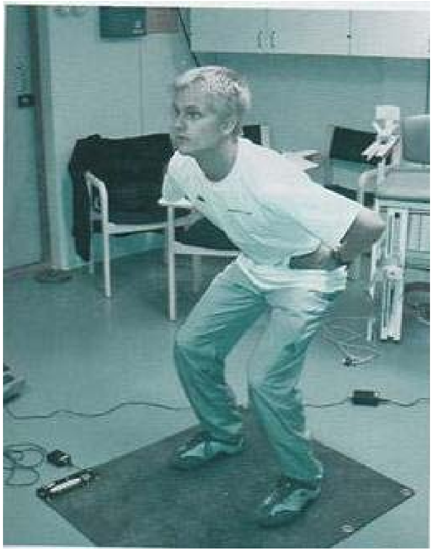

Figure 13. Countermovement Jump

9.7 Normality Test

Normality tests are used to find out how likely random variables are to be normally distributed. The test of normality was conducted to ensure that the data is reliable. According to Kankkunen & Vehviläinen-Julkunen, “normal distribution is continuous and symmetrical which means it is identical on both sides of the average. The result is interpreted as using p-value. If p-value is under 0.05 it means that normal distribution is diagonal.” (Kankkunen & Vehviläinen-Julkunen 2009, 107.) This means that, if the p-value is greater than 0.05 the data are normally distributed.

9.8 Dynamic Flexibility Exercises

During the six-week research period, the target group performed twice a week an approximately 60-minute-long dynamic flexibility exercise before ice practice. The dynamic flexibility movements focused on the muscle groups which are the most essential from the point of view of skating biomechanics. These dynamic flexibility movements were: swinging the leg to side, hurdle walks, “can-can” jumps, calves and hamstrings by “stretch-step-stretch”, hip flexors by step-body rotation backwards and body rotations to sides.

9.9 Static Flexibility Exercises

During this experiment the target group performed twice a week an approximately 90-minute-long static flexibility exercise under supervision. This exercise was conducted every time as its own practice, and the team had no other exercises during that day. The static flexibility movements focused on the muscle groups which are the most essential from the point of view of skating biomechanics. The static flexibility exercises were conducted in the circuit style, and a single stretch duration was 90–120 seconds per muscle. The stretching circuit rounds were repeated two times during the exercise, and in second round small improvements to the range of motions were attempted. A constant stretching order was kept in this static flexibility exercise.

10 RESULTS

10.1 Test of Normality

All tests are normally distributed excluding the parts of the squat test. Tests are shown in pairs with both measurement samples. Shoulder, back and ankle tests are the parts of a squat test. The squat test is evaluated on a scale 1 to 3 which means that the data are categorical (qualitative data). Qualitative data are not normally distributed. These results are illustrated in table 1.

Table 1. Test of Normality

Kolmogorov-Smirnov	Sig.	Shapiro-Wilk	Sig.
Shoulder1	0	Shoulder1	0,001
Shoulder2	0	Shoulder2	0
Back1	0,068	Back1	0,006
Back2	0	Back2	0
Ankle1	0	Ankle1	0
Ankle2	0	Ankle2	0,001
SR1	,200*	SR1	0,301
SR2	,200*	SR2	0,382
Hip1	0,161	Hip1	0,036
Hip2	,200*	Hip2	0,849
Thigh1	,200*	Thigh1	0,713
Thigh2	,200*	Thigh2	0,856
Countermovement1	0,16	Countermovement1	0,293
Countermovement2	,200*	Countermovement2	0,136
Speed301	,200*	Speed301	0,174
Speed302	,200*	Speed302	0,264
Agility1	,200*	Agility1	0,656
Agility2	,200*	Agility2	0,529

10.2 Paired Sample Statistics

Measuring shoulder flexibility levels in a scale of 1 to 3, the mean of the group in the first measurement was 2.1875 and in the second measurement 2.3750. These results are illustrated in table 2. Two players of sixteen had improved their shoulder flexibility after the experiment. The other fourteen players showed no changes between the tests. The average change between the first and second measurements was 0.1875 and the flexibility level had increased by 8.57 %.

Measuring back flexibility levels in a scale of 1 to 3, the mean of the group in the first measurement was 1.8750 and in the second measurement 2.7500. These results are illustrated in table 2. Twelve players of sixteen had improved their back flexibility after the experiment. The four other players showed no changes between the tests. The average change between the first and second measurement was 0.875 which is almost one step of the scale and the flexibility level had increased 46.66 %.

Measuring ankle flexibility levels in a scale of 1 to 3, the mean of the group in the first measurement was 1.5000 and in the second measurement 2.3125. These results are illustrated in table 2. Twelve players of sixteen had improved their ankle flexibility after the experiment. The four other players showed no changes between the tests because they got the best possible grade in both measurements. The average change between the first and second measurement was 0.8125 which is almost one step of the scale and the flexibility level had increased 54.16 %.

In the sit and reach test, the mean of the group in the first measurement was 46.63 centimeters and in the second measurement 56.31 centimeters. These results are illustrated in table 2. Between measurements, fifteen players of sixteen had improved the result of their sit and reach flexibility test. Only one player got a worse result in the second measurement. The average change between the first and second measurements was 9.69 centimeters. The flexibility level had increased by 20.78 %.

Measuring flexibility levels in hip flexors, the mean of the group in the first measurement was 179.94 degrees and in the second measurement 174.13 degrees. These results are illustrated in table 2. Between measurements, thirteen players of sixteen had improved their hip flexor flexibility and three players got a worse result in the second measurement. The average change between the first and second measurements was 5.82 degrees.

Measuring flexibility levels in thigh muscles, the mean of the group in the first measurement was 120.50 degrees and in second measurement 116.62 degrees. These results are illustrated in table 2. Between measurements, nine players of sixteen had improved the flexibility of their thigh muscles and six players got a worse result in the second measurement. The average change between the first and second measurement was 3.875 degrees.

Countermovement jump test was conducted to observe the possible changes in the force production levels of the players' legs during this research time. The mean of the group in the first measurement was 468.37 milliseconds and in the second measurement 474.31 milliseconds. These results are illustrated in table 2. Between measurements, ten players of sixteen had improved their countermovement jump result and four players got a worse result in the second measurement. One player got the same result in both measurements. The average change between the first and second measurements was 5.93 milliseconds. Countermovement jump had improved by 1.26 %.

The players' maximum skating speed was measured by a 30-meter skating test where the players performed approximately 10-meter initial acceleration before the first photoelectric sensor. The mean of the group in the first skating test was 4.22 seconds and in second skating test the time was 4.19 seconds. These results are illustrated in table 2. Ten players of sixteen had improved their skating time. Two players got the same result in both skating tests and four players got a worse result in the second skating test. Two players of sixteen had improved their skating time over 0.10 seconds and only one player had worsened the skating time over 0.10 seconds. The average change between the first and the second skating test was 0.03 seconds. The skating time had improved by 0.71 %.

A skating agility test measures the skating diversity and this test is used by the Finnish Ice Hockey Association. The mean of the group in the first skating test was 40.31 seconds and in the second skating test the time was 40.05 seconds. These results are illustrated in table 2. Ten players of fifteen had improved the time in this test. Five players had worsened their skating time in the second skating test. One player was not able to participate in the first test and for this reason there are only fifteen subjects in this test. The average change between the first and the second skating test was 0.26 seconds. Skating time had improved by 0.64 %.

Table 2. Paired Sample Statistics.

It shows the first and second measurements, their means, and the number of subject persons (N). Pairs 1, 2 and 3 are parts of a squat test.

Paired Samples Statistics		Mean	N
Pair 1	Shoulder	2,1875	16
	Shoulder2	2,375	16
Pair 2	Back1	1,875	16
	Back2	2,75	16
Pair 3	Ankle1	1,5	16
	Ankle2	2,3125	16
Pair 4	SR1	46,63	16
	SR2	56,31	16
Pair 5	Hip1	179,94	16
	Hip2	174,13	16
Pair 6	Thigh1	120,5	16
	Thigh2	116,625	16
Pair 7	Countermovement1	468,375	16
	Countermovement2	474,3125	16
Pair 8	Speed301	4,2225	16
	Speed302	4,1925	16
Pair 9	Agility1	40,316	15
	Agility2	40,0567	15

10.3 Paired Samples T-Test.

Paired t-test can be used when comparing the test averages of the observation group (Kankkunen & Vehviläinen-Julkunen 2009, 110). Table 3 shows each test in pairs and there can be detected the average change between measurements and the p-value (sig), which means the significance of the change. The findings contain stronger evidence against the null hypothesis (H^0) if the p-value is lower than .050. In that case the 5% level of risk is not exceeded and the results can be held reliable with over 95% certainty. Therefore, the results can be considered statistically reliable.

Paired sample test shows that sit and reach, hip flexors and two parts of the squat test (back, ankle) have improved significantly after this flexibility training. P-value is under 0.05, and therefore null hypothesis (H^0) can be rejected and alternative hypothesis (H^1) be applied. There are no significant improvements in other tests, which means that the null hypothesis (H^0) is accepted. Paired sample test results are illustrated in table 3.

Table 3. Paired Samples T-Test

Paired Samples Test		Sig. (2-tailed)
Pair 1	Shoulder - Shoulder2	0,083
Pair 2	Back1 - Back2	0
Pair 3	Ankle1 - Ankle2	0
Pair 4	SR1 - SR2	0
Pair 5	Hip1 - Hip2	0,024
Pair 6	Thigh1 - Thigh2	0,132
Pair 7	Countermovement1 - Countermovement2	0,313
Pair 8	Speed301 - Speed302	0,231
Pair 9	Agility1 - Agility2	0,486

10.4 Correlation Test

This correlation test shows that there are no noticeable correlation between skating speed and flexibility. The p-value and the correlation coefficient show that none of the flexibility and skating tests together have a p-value below 0.05. This indicates that there are no correlations. It should be noted that the skating times have not improved significantly, and therefore it cannot be expected that a correlation would be found. Correlation results are illustrated in table 4.

Table 4 Correlations

Correlations		Skating	Correlations		Skating
SR21	Pearson Correlation	0,095	Shoulder	Pearson Correlation	0,31
	Sig. (2-tailed)	0,727		Sig. (2-tailed)	0,243
	N	16		N	16
Hip21	Pearson Correlation	-0,064	Back	Pearson Correlation	0,258
	Sig. (2-tailed)	0,813		Sig. (2-tailed)	0,335
	N	16		N	16
Thigh	Pearson Correlation	0,147	Ankle	Pearson Correlation	-0,204
	Sig. (2-tailed)	0,587		Sig. (2-tailed)	0,448
	N	16		N	16
Countermovement	Pearson Correlation	-0,172	Agility	Pearson Correlation	0,014
	Sig. (2-tailed)	0,523		Sig. (2-tailed)	0,959
	N	16		N	15

11 DISCUSSION

11.1 Interpretation of the Results

The reliability of the research must be estimated from the point of view of the results. In this case, the internal and external validity of the results are under a supervision. The internal validity refers that the results are caused by the set-up, not by other distracting factors. The external validity refers to the generalization of the results. (Kankkunen & Vehviläinen-Julkunen 2013, 190 - 195.) One priority in a quantitative research is the relationship between the sample and the population. The population indicates the target group to which the results are intended to be generalized. (Kankkunen & Vehviläinen-Julkunen 2013, 104.)

According to the results, the lower body flexibility levels had increased significantly with the exception of thigh muscles. However, the maximal 30-meter skating speed had not increased significantly, and the same applies to skating agility. Based on these results, it can be said that the flexibility training had not brought any improvements on the skating speed of the target group. And the correlation study also verifies this phenomenon. It is important to notice, however, that the increased lower body flexibility levels have not affected the skating speed negatively either.

The squat test which is used by the Finnish Ice Hockey Association was employed in this research. The weakness of this test is that parts of it (shoulder, back, ankle) are not measured by any accurate measuring device to determine the scale 1, 2 or 3. The measurements are much more accurate in all other tests, because those tests were conducted with accurate equipment which is designed for those tests and produces accurate measuring results. Therefore, the squat test is not based on any accurate measurement but, instead, it is based on a visual assessment. The scale is given to an athlete by the person who supervises the test, and the test supervisor uses the criteria of the Finnish Ice Hockey Association to determine the grade. Under these circumstances, the results or data (1, 2 or 3) of the squat test are categorical (qualitative data). For this reason, the normal distribution cannot be detected and SPSS-program verifies this. The data was usable in other SPSS-program tests which were used in this research.

The problem of subjected feature of visual assessment not considering that, it is possible and highly probable that different test supervisors could end up with different results even if the same group is being tested. In this research, the supervisor of the squat test was one and the same person at both times of measurement. Nonetheless of the lack of visual assessment, the squat test is a good test for comprehensively describing the flexibility levels of a body. Of course, the reliability of the results would be much higher if it's possible to develop the squat test in a way that shoulder, back and ankle could be measured accurately and the measurements would determine the scale 1, 2 or 3. The parts measured with the squat test which were improved significantly with the exception of shoulders. The flexibility training was focused on increasing the lower body flexibility levels and this could be probable explanation why there are no improvements in shoulder flexibility.

After this flexibility training period, there were significant improvements in hip flexors. Harvey and Mansfield have pointed out the interpretation for hip flexor flexibility in the book of Physiological Tests for Elite Athletes. According to Harvey and Mansfield, the result of hip flexors is expressed as a positive or negative value from 180 degrees, and the percentage change between measurements can be calculated by using the proposed result (-7). The value of the group in the first measurement was 0, 06 and in the second measurement - 5, 88. The average had improved by 83.14 % of the proposed result (-7) between measurements.

The validity and reliability of this research results were ensured by collecting the data with proper measurement equipment in similar ways and similar circumstances in both measurements: both measurements are conducted at the same location at the same time after a week of practice, which had been similar in both cases. This was done to ensure that these factors do not affect the outcome of the measurements. An official instruction was followed in both tests, and those were supervised by an expert. The players need to be in a recovered state in order to achieve the maximal performance in every test, and they need to be in as similar mental and physical states as possible during all tests. They also need to be aware of how the tests will be conducted.

The target group size of this research was small (N=16), the results cannot reliably be generalized to all players in the same age group. In addition, the athletes who were chosen in this research were children, the results of adult athletes could be different from the results presented in this research. Despite this, the research findings suggest that it is possible to increase the flexibility levels and range of motions significantly in a short timespan without negatively affecting skating speed.

11.2 Comparison of Results to the Previous Study

The aim of this research was to minimize the effects of external exercises (fast running, skating and jumps) outside of this thesis. A previous research was mabe by (Maukonen et al. 2010). In their study, flexibility training was conducted at the same time (from late January to March), and their target group was also training and developing other physical qualities during the research time. There was no measurement made to monitor the possible changes in leg force production levels between the first and the second flexibility and skating tests. The team which was the target group in this previous research was training speed and strength intensively for the entire autumn and early winter until the end of January. After January, the training intensity became physically lighter. In this previous research, the skating speed of the target group had significantly increased during the six-week research period.

It is possible and probable that the team's intensive speed and strength training during several months began to affect more effectively on speediness when the training intensity had been decreased. Speediness is a slow evolving physical quality which needs structural changes in the human body, and these structural changes begin to appear many months after the training had been completed. Therefore, it is possible that something had happened on the structural and neuromuscular level during that time, and this would be a more probable reason for the increased speediness, rather than the functional flexibility training performed twice a week during six weeks.

There were some key differences between previous study and this one. First of all, the ages of the two target groups were different, which could lead to different results. Secondly, in this study the team was training only flexibility exercises during research period. The exercise program of the team was designed in such a way that exercises known to develop speed and force production (such as fast running, skating and all kind jumps) were deliberately left out. In contrast, (Maukonen et al. 2010) conducted flexibility training at the same time when their target group was also training and developing other physical qualities. Thirdly, in Maukonen, Piekkola and Taira's study the players did not perform a 10-meter initial acceleration, before the first photoelectric sensor when a 30-meter skating tests were conducted.

11.3 Reliability and Ethics

In a quantitative research, the reliability of the research can be examined from the points of view of validity and reliability. Validity means that the research measures exactly what it is intended to measure. (Kankkunen & Vehviläinen-Julkunen 2009, 152.) By contrast, reliability refers to the repeatability of the measured results. In other words, reliability means the ability to provide non-random results. (Hirsjärvi 2007, 226.)

The results of the research are as reliable as the used indicators. The indicators must be accurate enough that they limit the concept of the examination. (Paunonen & Vehviläinen-Julkunen 1997, 206.) It is advisable to use standard and existing indicators, because the stability of the indicator refers to its ability to produce the same result at different times of measurement (Kankkunen & Vehviläinen-Julkunen 2013, 190-195).

The ethics of the research are the core of any scientific action. The principle of research ethics and research legitimacy is based on its usefulness. Participation in the study must be based on consent, which means that the target person is fully aware of the nature of the experiment. Anonymity is a key factor to note in research, which means that the research information is not shared with anyone outside of the research process. (Kankkunen & Vehviläinen-Julkunen 2013, 211-221.)

Regarding ethical questions, this thesis had been developed to benefit the players' physical and personal growth and well-being. The players had been informed of all the objectives and practical purposes of this thesis, and a written consent had been presented by the players' guardians where they submit a written permission to use the results for these purposes. The test results had been handled confidentially, and the identities of the players cannot be identified from the thesis.

11.4 Professional Development

Conducting a study is always a great challenge and a learning process and one cannot ignore the importance of good writing skills. From the point of view of my professional development, these specific qualities developed tremendously during the thesis process. At the beginning of my thesis process, I had a clear vision that I wanted my thesis to concern ice hockey and especially skating because of my own hockey background, originally as a player and today as a coach. I had a basic idea for my thesis but I needed to narrow it down more and to find the thread of my argument. I finally settled on one, and at that point my thesis idea was ready, and I ended up with the idea that this study would study the impact of lower body flexibility on skating speed.

I knew that the theoretical part would be large and challenging to write because the topic would include difficult language. For this reason, I started to seek a lot of references at an early stage and started to find suitable chapters in the books which I would use when I would start the writing process. This was very useful for me, and after I had written few pages, I discovered that it would be quite practical if I started by forming a complete structured paper by directly using the reference books and then begun to write that using my own words. This helped the text to become more fluent to read and also more academic. I studied the SPSS - program quite a bit because otherwise I would not have been able to use proper methods while interpreting the data. During this time, all the pieces started to find their places and fluent conclusions could be written out.

The thesis process developed my coaching philosophy tremendously and it gave me much new and significant information about skating itself and how important good flexibility levels are in sports and in normal life. Because of my thesis process, I am now a better coach for the athletes whom I coach and I have become a better sports instructor.

12 CONCLUSIONS

The thesis was designed to investigate only the phenomenon of range of motion changes caused by flexibility training, and the effect these changes had on skating speed. For this reason, the exercise program of the team was designed in such a way that exercises known to develop speed and force production (such as fast running, skating and all kind of jumps) were deliberately left out. Therefore, a countermovement jump test, which measures the changes in force production levels of legs during this research time, was conducted at the beginning and the end of this research. A paired sample test shows that the levels of leg force production have not increased significantly between the measurements (p-value .313).

Correct skating performance requires a sufficient range of motions because a skating kick is directed to the back and side at the same time. For this reason, the aim was to increase the levels of lower body muscle and joint range of motions by using dynamic and static flexibility training. The primary focus of lower body muscle and joint flexibility training was that stretching movements target the essential muscle groups which affect a skating kick during a skating performance. These muscle groups are: groins, hip flexors, hamstrings, thigh muscles, calves, buttocks and the thigh adductors. Thigh muscles were the muscle group at which less dynamic and static stretching repetitions were directed. Because the skating posture is static, the thigh muscles are under constant tension. For this reason, the skating posture itself may cause muscle tension on thigh muscles, and therefore more stretching repetitions for thigh muscles should have been done. If more stretching would have been performed, there might have been better improvements in flexibility levels of thigh muscles.

The purpose of this study was to examine only the changes in lower body flexibility levels and how they affect skating speed. In ice hockey, however, skating speed and skating performance consist of several components. Essentially, skating is affected by force production, skating kick frequency, skating power, flexibility levels and skill. In short distances, skating is affected by the player's ability to produce force in a short time, which means that a player who has a worse skating technique but a good ability to produce force in a short timespan can be faster in short distance skating than a player who has a better skating technique. In ice hockey, a player needs to be fast in short distance skating because the game situations change quickly. Skating power, on the other hand, is connected with skating economy, where the players' skill level, correct skating technique and sufficient range of motions are particularly emphasized.

The most essential discovery of this research and the answer to my research problems was that six-week intensive flexibility training conducted during a competitive season, while bringing significant improvements in lower body flexibility levels, did not affect skating speed. Important discovery was that the skating time had improved for ten players out of sixteen. However, the improvement was not significant enough to conclude that the skating speed would have been improved. The paired sample test verifies this phenomenon because the p-value of the skating test changes was .231. It is particularly important to notice that the skating speed had not decresed during this intensive flexibility training period. Based on the results of this thesis, particular phenomenon suggests that at some point during a competitive season, the training can be coordinated in a way that an approximately one-month-long intensive flexibility training period can be executed. During this period it seems possible to increase players' flexibility levels significantly without affecting skating speed negatively.

Speed is a slowly evolving physical quality and, therefore, it cannot be expected that speediness could improve a lot during a six-week research period. The players' lower body flexibility levels had improved significantly during this research period, but it is possible that players were not able to utilize their increased lower body range of motions during skating performance when the second 30-meter skating test was conducted. This assumption is supported by an interview with Teijo Raatesalmi a professional coach, who said: "Flexibility is primarily connected with relaxation and recovery but not directly with skating speed or technique. When a player has learned some skating technique, even if it is not correct, the player cannot utilize the increased lower body flexibility levels to improve his skating performance. To improve his skating performance, the player must be highly motivated to correct his skating technique with the help of a person who is specialized in teaching skating technique." (Raatesalmi 2013.) It is important to notice that it is only an assumption that players were not able to utilize their increased range of motions in skating performance. Without the biomechanical motion analysis it is impossible to say with certainty whether any changes have happened in the players' skating performance.

Skating technique and force production in skating performance were not included in the topics of this research. However, from the point of view of coaching and skill learning, it is important to notice that utilizing the increased range of motions during skating performance and skating technique requires a sufficient amount of force production in legs and a sufficient amount of skating repetitions. For this to work, it requires correct teaching and especially the player's own motivation and desire to develop as a hockey player. The coach's role is highly important because he or she should be able to give correct feedback on the performance and also be able to correct mistakes in players' skating performance. Especially in junior coaching, the role of the coach is significant because movement mechanisms should not strengthen to a wrong direction. Correcting the wrong movement mechanism is much harder at an older age. In practice, it is difficult to give sufficient amount of personal coaching and guidance in team sports like ice hockey when the number of athletes is large.

It is important to understand that a significant part of good flexibility is not only about players becoming faster or technically better skaters. Above all, flexibility training is conducted to prevent sport injuries. In high intensity sports such as ice hockey, lower body muscles and joints are under a constant pressure, and therefore the importance of good personal flexibility levels and systematic flexibility training should not be understated.

The subject persons in this research had not been given any previous instructions on how flexibility training should be performed and they had not previously conducted any flexibility training under supervision either. All the considerations presented above lead us to the final conclusion that despite the initial lack of certainty regarding the generalizability of the results, conducting flexibility training properly even during competitive seasons seems to be potentially useful and definitely worth further investigation: while this method seems to affect flexibility levels positively, it does not appear to be harmful for other aspects of physical development, such as the development of skating speed. Hopefully the observations, findings and flexibility training methods will encourage the ice hockey organization Kajaanin Junnu Hokki 68 ry, who commissioned this thesis, to conduct flexibility training more systematically, and hopefully flexibility training will get more emphasis in the future.

13 FURTHER RESEARCH PROPOSITIONS

More research should be conducted on this subject and it would useful to investigate players of different ages and of different genders. In addition, control groups should be used in such a way that one group is conducting the research with the same principles being used in this research and the other does not change its training program consciously to develop flexibility levels. It would also be interesting to add a third control group in the research and this third group would consciously try to improve its speediness and force production levels during six-week research period. It would be a good research topic to investigate how the increased lower body flexibility and range of motions affect skating performance and skating technique?

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APPENDICES

Suostumus osallistumisesta opinnäytetyötutkimukseen

Olen liikunta-alan opiskelija Kajaanin ammattikorkeakoulusta. Teen opinnäytetyötä Kajaanin Junnu Hokki 68 ry:lle aiheesta ”Lihasten ja nivelten liikkuvuuden vaikutus luistelunopeuteen 12 – 13 vuotiailla jääkiekkoilijoilla”. Opinnäytetyön tavoitteena on parantaa tietämystä liikkuvuuden merkityksestä jääkiekossa.

Koska lapsenne on alaikäinen, tarvitsen huoltajan kirjallisen suostumuksen, jotta voin käyttää hänen testituloksiaan opinnäytetyössäni. Testituloksia käsitellään ja säilytetään luottamuksellisesti eikä yksittäistä henkilöä voi tunnistaa.

Allekirjoitus:

Nimenselvennys:

Päivämäärä ja paikka:

Mikäli teillä on kysyttävää, minuun voi ottaa yhteyttä sähköpostitse:

SPO9SAnttiO@kajak.fi

Kiittäen,

Liikunnanohjaajaopiskelija

Antti Ovaska

Liikkuvuusharjoitusohjelma
D-juniorit / Antti Ovaska

Dynaaminen liikkuvuus + Jääharjoitus
1) verryttely 2) sivuloikka 2 x 40m per puoli 3) sivuttain juoksu 2 x 40m 4) jalan heiluttelu sivulle 3 x 15 per jalka 5) jalan heiluttelu eteen 3 x 15 per jalka 6) jalan heiluttelu taakse 3 x 15 per jalka 7) pohkeet väli askeleella 2 x 30m + joka askeleella 2 x 20m 8) takareidet väliaskelella 3 x 30m 9) vartalon taivutus sivulle 2 x 10 per puoli

Staattinen liikkuvuus

15min alkuverryttely lenkki ennen harjoitusta

kierros 1
1) pohkeet - 90s
2) takareidet - 90s
3) lonkankoukistajat - 90s
4) etureidet - 90s
5) nivuset - 90s
6) pakarat tyyli 1 - 90s
7) reiden lähentäjät - 90s
8) pakarat tyyli 2 - 90s

kierros 2
1) pohkeet - 2 x 90s
2) takareidet - 2 x 120s
3) lonkankoukistajat - 2 x 90s
4) etureidet - 120s
5) nivuset - 2 x 120s
6) pakarat tyyli 1 - 90s
7) reiden lähentäjät - 2 x 120s
8) pakarat tyyli 2 - 90s

Dynaaminen liikkuvuus + Jääharjoitus
1) verryttely 2) sivuloikka 2 x 40m per puoli 3) sivuttain juoksu 2 x 40m 4) jalan heiluttelu sivulle ja eteen 3 x 15 per jalka 5) lonkankoukistaja venytys + vartalontaivutus taakse 2 x 40m 6) aitakävelyt 8 aitaa: kävely suoraan yli 3x, ”8” kävely 3x 7) ”can-can” hyppely 3x per puoli 8) selän venytys - vartalon taivutus ja jalalla kosketus maahan

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Shoulder1	,373	15	,000	,734	15	,001
Shoulder2	,385	15	,000	,630	15	,000
Back1	,212	15	,068	,817	15	,006
Back2	,485	15	,000	,499	15	,000
Ankle1	,350	15	,000	,643	15	,000
Ankle2	,326	15	,000	,755	15	,001
SR1	,163	15	,200*	,933	15	,301
SR2	,151	15	,200*	,940	15	,382
Hip1	,188	15	,161	,872	15	,036
Hip2	,160	15	,200*	,969	15	,849
Thigh1	,132	15	,200*	,961	15	,713
Thigh2	,140	15	,200*	,970	15	,856
Countermovement1	,188	15	,160	,932	15	,293
Countermovement2	,173	15	,200*	,910	15	,136
Speed301	,164	15	,200*	,917	15	,174
Speed302	,143	15	,200*	,929	15	,264
Agility1	,165	15	,200*	,958	15	,656
Agility2	,109	15	,200*	,950	15	,529

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Shoulder	2,1875	16	,54391	,13598
	Shoulder2	2,3750	16	,50000	,12500
Pair 2	Back1	1,8750	16	,80623	,20156
	Back2	2,7500	16	,44721	,11180
Pair 3	Ankle1	1,5000	16	,51640	,12910
	Ankle2	2,3125	16	,79320	,19830
Pair 4	SR1	46,63	16	19,366	4,842
	SR2	56,31	16	21,121	5,280
Pair 5	Hip1	179,94	16	7,920	1,980
	Hip2	174,13	16	7,491	1,873
Pair 6	Thigh1	120,5000	16	10,62073	2,65518
	Thigh2	116,6250	16	10,16448	2,54112
Pair 7	Countermovement1	468,3750	16	29,42080	7,35520
	Countermovement2	474,3125	16	33,62879	8,40720
Pair 8	Speed301	4,2225	16	,22711	,05678
	Speed302	4,1925	16	,25940	,06485
Pair 9	Agility1	40,3160	15	1,91694	,49495
	Agility2	40,0567	15	2,15214	,55568

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Shoulder - Shoulder2	-,18750	,40311	,10078	-,40230	,02730	-1,861	15	,083
Pair 2	Back1 - Back2	-,87500	,61914	,15478	-1,20492	-,54508	-5,653	15	,000
Pair 3	Ankle1 - Ankle2	-,81250	,54391	,13598	-1,10233	-,52267	-5,975	15	,000
Pair 4	SR1 - SR2	-9,688	5,199	1,300	-12,458	-6,917	-7,453	15	,000
Pair 5	Hip1 - Hip2	5,813	9,268	2,317	,874	10,751	2,509	15	,024
Pair 6	Thigh1 - Thigh2	3,87500	9,72882	2,43221	-1,30912	9,05912	1,593	15	,132
Pair 7	Countermovement1 - Countermovement2	-5,93750	22,75220	5,68805	-18,06129	6,18629	-1,044	15	,313
Pair 8	Speed301 - Speed302	,03000	,09606	,02401	-,02118	,08118	1,249	15	,231
Pair 9	Agility1 - Agility2	,25933	1,40421	,36256	-,51829	1,03696	,715	14	,486

Correlations

		SR21	Hip21	Thigh	Countermovement	Shoulder	Back	Ankle	Agility	Skating
SR21	Pearson Correlation	1	,010	-,223	-,081	-,097	-,386	,143	-,105	,095
	Sig. (2-tailed)		,972	,406	,766	,720	,140	,597	,710	,727
	N	16	16	16	16	16	16	16	15	16
Hip21	Pearson Correlation	,010	1	-,173	-,143	-,081	-,158	,034	-,135	-,064
	Sig. (2-tailed)	,972		,523	,598	,764	,558	,901	,632	,813
	N	16	16	16	16	16	16	16	15	16
Thigh	Pearson Correlation	-,223	-,173	1	,056	,368	,069	,055	-,199	,147
	Sig. (2-tailed)	,406	,523		,836	,161	,799	,839	,476	,587
	N	16	16	16	16	16	16	16	15	16
Countermovement	Pearson Correlation	-,081	-,143	,056	1	,052	-,720**	-,233	,023	-,172
	Sig. (2-tailed)	,766	,598	,836		,848	,002	,386	,935	,523
	N	16	16	16	16	16	16	16	15	16
Shoulder	Pearson Correlation	-,097	-,081	,368	,052	1	-,167	-,437	-,366	,310
	Sig. (2-tailed)	,720	,764	,161	,848		,537	,090	,179	,243
	N	16	16	16	16	16	16	16	15	16
Back	Pearson Correlation	-,386	-,158	,069	-,720**	-,167	1	,124	,329	,258
	Sig. (2-tailed)	,140	,558	,799	,002	,537		,648	,231	,335
	N	16	16	16	16	16	16	16	15	16

Ankle	Pearson Correlation	,143	,034	,055	-,233	-,437	,124	1	,013	-,204
	Sig. (2-tailed)	,597	,901	,839	,386	,090	,648		,964	,448
	N	16	16	16	16	16	16	16	15	16
Agility	Pearson Correlation	-,105	-,135	-,199	,023	-,366	,329	,013	1	,014
	Sig. (2-tailed)	,710	,632	,476	,935	,179	,231	,964		,959
	N	15	15	15	15	15	15	15	15	15
Skating	Pearson Correlation	,095	-,064	,147	-,172	,310	,258	-,204	,014	1
	Sig. (2-tailed)	,727	,813	,587	,523	,243	,335	,448	,959	
	N	16	16	16	16	16	16	16	15	16

**. Correlation is significant at the 0.01 level (2-tailed).

Squat

		Shoulder	Shoulder2
1		2,00	2,00
2		2,00	2,00
3		3,00	3,00
4		2,00	2,00
5		2,00	2,00
6		3,00	3,00
7		2,00	2,00
8		2,00	3,00
9		3,00	3,00
10		1,00	2,00
11		2,00	2,00
12		2,00	2,00
13		2,00	2,00
14		2,00	2,00
15		3,00	3,00
16		2,00	3,00
Total	N	16	16
	Mean	2,1875	2,3750

Squat

		Back1	Back2
1		2,00	3,00
2		1,00	3,00
3		3,00	3,00
4		2,00	3,00
5		2,00	3,00
6		3,00	3,00
7		1,00	2,00
8		3,00	3,00
9		3,00	3,00
10		2,00	3,00
11		1,00	3,00
12		2,00	3,00
13		1,00	2,00
14		1,00	2,00
15		2,00	3,00
16		1,00	2,00
Total	N	16	16
	Mean	1,8750	2,7500

Squat

		Ankle 1	Ankle 2
1		2,00	3,00
2		1,00	3,00
3		2,00	3,00
4		2,00	3,00
5		1,00	2,00
6		2,00	3,00
7		1,00	1,00
8		2,00	3,00
9		2,00	3,00
10		2,00	2,00
11		1,00	2,00
12		2,00	3,00
13		1,00	2,00
14		1,00	1,00
15		1,00	2,00
16		1,00	1,00
Total	N	16	16
	Mean	1,5000	2,3125

Sit And Reach

		SR1	SR2
1		55	61
2		43	50
3		62	77
4		21	28
5		25	33
6		81	100
7		51	50
8		71	75
9		74	91
10		44	52
11		32	42
12		50	56
13		22	36
14		31	40
15		58	70
16		26	40
Total	N	16	16
	Mean	46,62	56,31

Thigh

		Thigh1	Thigh2
1		123,00	110,00
2		105,00	115,00
3		122,00	120,00
4		113,00	105,00
5		112,00	100,00
6		119,00	120,00
7		125,00	128,00
8		115,00	116,00
9		116,00	112,00
10		100,00	116,00
11		138,00	138,00
12		122,00	125,00
13		135,00	118,00
14		126,00	108,00
15		120,00	105,00
16		137,00	130,00
Total	N	16	16
	Mean	120,5000	116,6250

Countermovement jump

		Countermovement1	Countermovement2
1		512,00	510,00
2		476,00	457,00
3		478,00	515,00
4		488,00	510,00
5		488,00	488,00
6		485,00	509,00
7		455,00	473,00
8		491,00	523,00
9		464,00	478,00
10		485,00	486,00
11		504,00	466,00
12		438,00	457,00
13		459,00	425,00
14		404,00	435,00
15		429,00	427,00
16		438,00	430,00
Total	N	16	16
	Mean	468,3750	474,3125

30m skating

		Speed301	Speed302
1		3,92	3,85
2		3,92	3,92
3		3,95	3,92
4		3,99	4,00
5		4,00	4,01
6		4,09	4,02
7		4,19	4,15
8		4,23	4,09
9		4,25	4,20
10		4,25	4,21
11		4,35	4,35
12		4,38	4,39
13		4,40	4,24
14		4,49	4,37
15		4,57	4,51
16		4,58	4,85
Total	N	16	16
	Mean	4,2225	4,1925

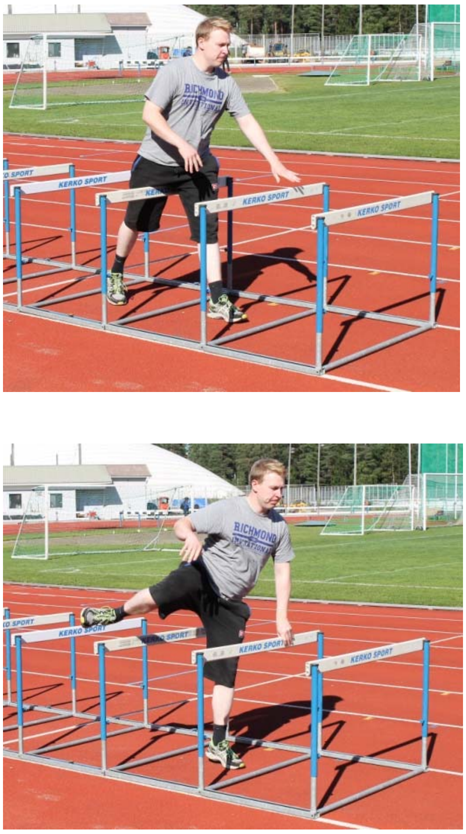
Skating agility

		Agility1	Agility2
1		39,01	39,35
2		38,75	39,25
3		37,28	37,42
4		38,27	36,96
5		42,08	39,84
6		38,46	37,78
7		39,32	38,24
8		42,83	41,56
9		41,30	38,74
10		39,54	40,81
11		39,67	41,32
12		41,32	40,35
13		41,38	43,91
14		44,16	44,07
15		41,37	41,25
Total	N	15	15
	Mean	40,3160	40,0567

Swinging legs to side

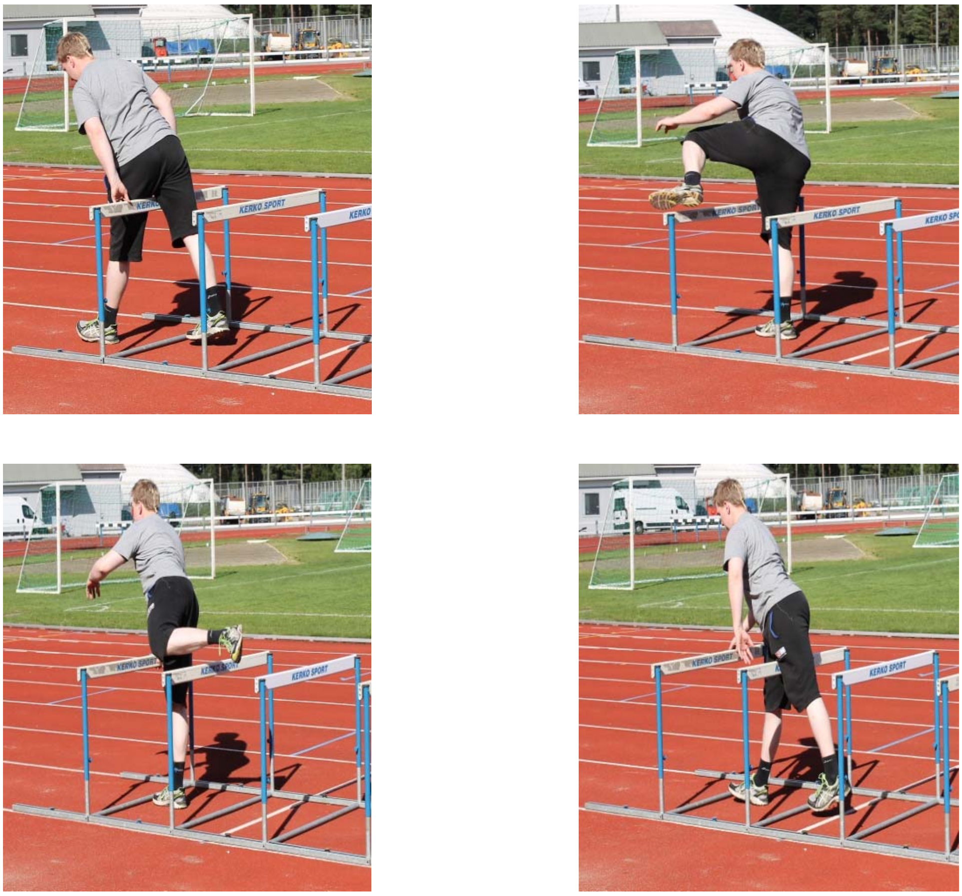
Swinging legs backwards

Hurdle walking



Hurdle walking “8“

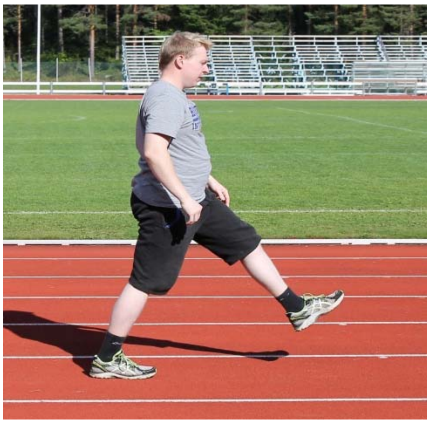
Hurdle walking backwards



"Can-can jumps"

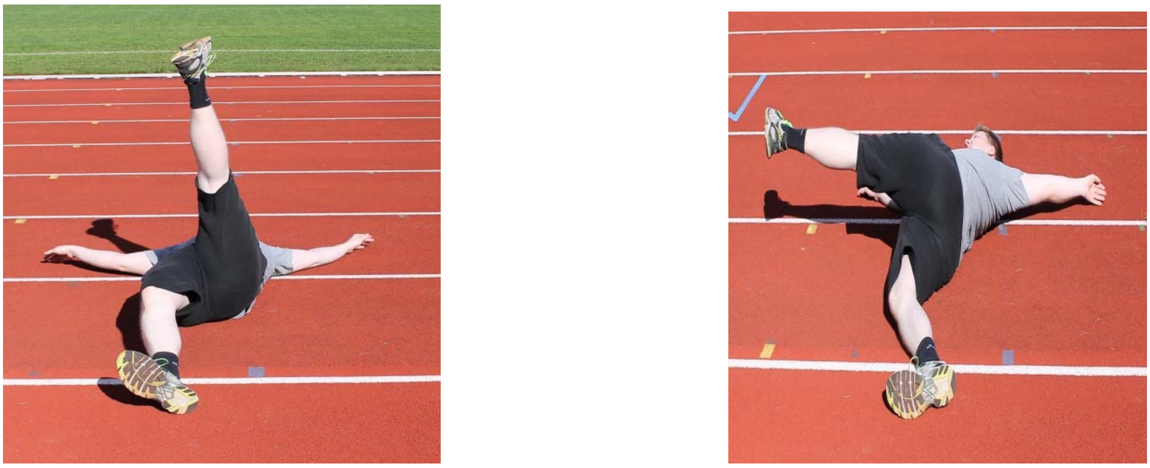
Calves and Hamstrings - “step - stretch - step”

Hip flexors



Body rotation

Back rotation

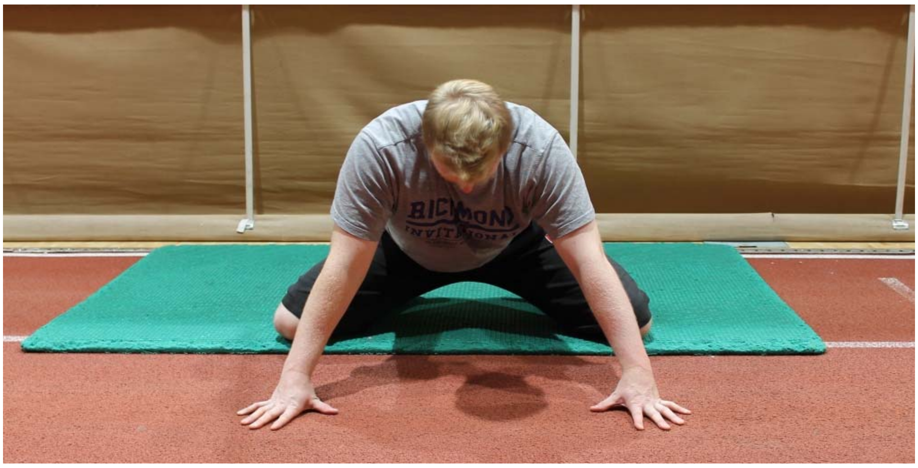


Hip flexors

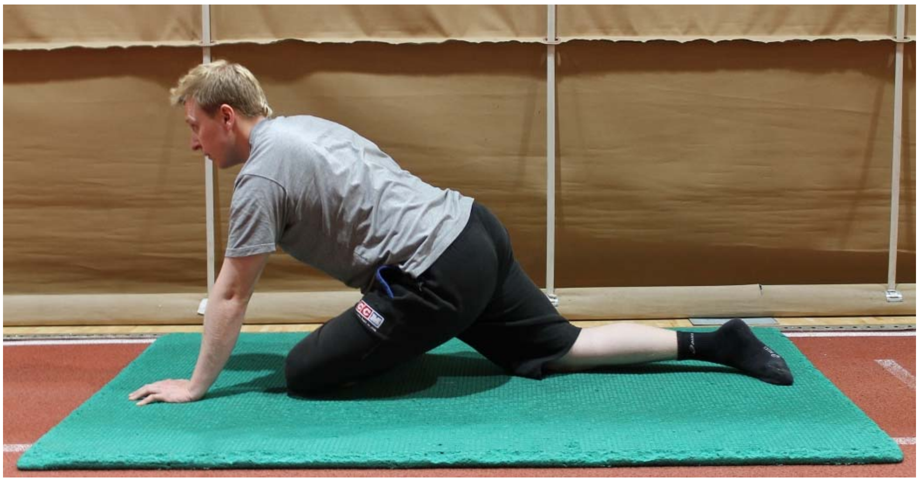
Calves

Hamstrings

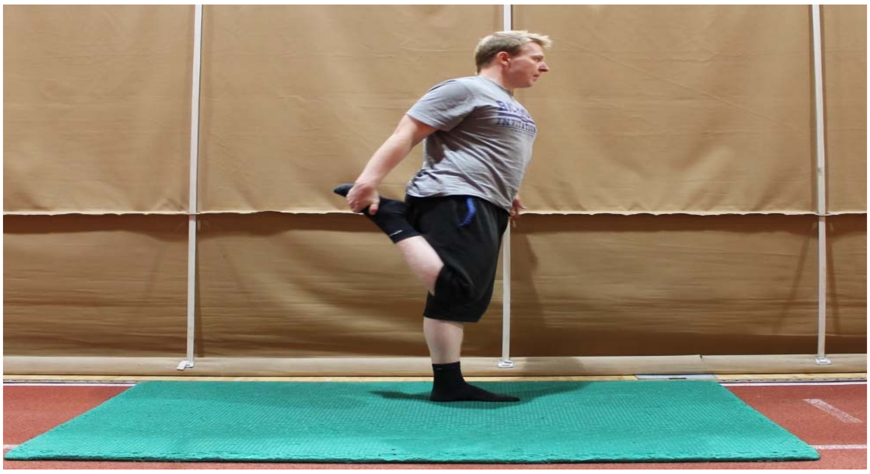
Groins

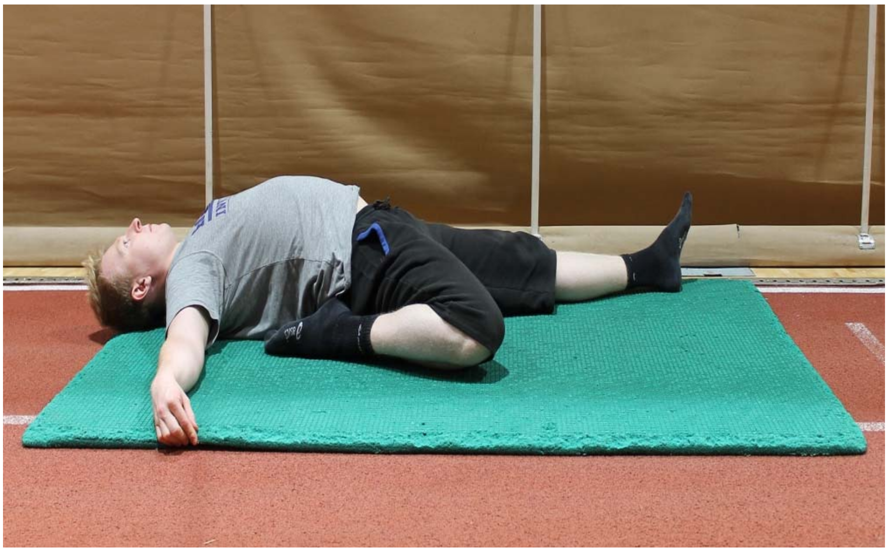


Buttocks



Thigh muscle





Thigh adductors