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Lower back pain in amateur adult ice hockey players. Pre-game hip mobility warmup guide.

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Abstract

Lower back pain is a common problem both in athletic and general population. It has been a topic of interest across various sports. More than 80% of ice hockey players experience episodes of lower back pain (LBP) during the season, which could be explained by the nature of the sport and heavy physical demand on musculoskeletal system. LBP is a multidimensional problem, and lately hip mobility has been a topic of interest in research of lower back pain.

The thesis was conducted in collaboration with an amateur ice hockey team. The aim of this thesis was to raise the players' awareness of the LBP issue and to provide a warmup-guide aimed to prepare the players for on-ice activities.

In the literature research the lower back pain in ice hockey and other similar sports was investigated. The dysfunction of the lumbo-pelvic-hip complex was the main area of concern of the research.

Based on the results of the research a comprehensive warmup guide was created aimed to improve function of the lumbo-pelvic-hip complex by addressing muscle length and strength, joint mobility, neuromuscular function.

Key words
Lower back pain, hip mobility, ice hockey, warmup

CONTENTS

1 INTRODUCTION

Lower back pain (LBP) is very common in competitive sports, and it has been widely studied across various sports. More than 80% of ice hockey players experience episodes of LBP during the season, which could be explained by the nature of the sport and heavy physical demand on musculoskeletal system, especially on the hip area as it works as a link between the upper and lower body. (Fett et al., 2017; Pearsall et al., 2000.)

Impaired hip joint range-of-motion (ROM) has been associated as one of the main contributors to LBP in athletes and general population (Sadeghisani et al., 2015). Repetitive movements and load on the musculoskeletal system while having restricted and asymmetrical hip ROM, muscle length imbalance, decreased muscle strength and endurance, faulty technique, poor biomechanics along other factors, might contribute to compensatory movement patterns and musculoskeletal adaptations, which increases the load and stress on the tissues and structures in lumbopelvic region, resulting in symptoms of LBP (Manners, 2004; Pearsall et al., 2000; Shell et al., 2017; Upjohn et al., 2008.)

Mobility training is a crucial aspect of ice hockey training. Although LBP is a multidimensional problem, mobility might be one of the key factors to manage and prevent LBP in hockey players. Neglecting mobility training can significantly affect the player’s performance and predispose one to an injury. Appropriate pre-ice routine prepares player’s mind and body for intense workout. It enables the players to be agile on the ice, effective in their plays and contribute to their team. It is common practice for the players to do a few brief warmup stretches as a part of their pre-game ritual, however the benefit of such warmup routine is questionable, therefore an appropriate warmup routine should be implemented. (Boyle et al., 2010; Twist, 2007, pp. 27–28; Twist & Rhodes, 1993, pp. 69–70.)

1.1 Aim and objectives of the thesis

The aim of this thesis is to produce a warmup guide for amateur ice hockey players suffering from lower back pain; raise the players' awareness of the LBP issue and the significance of preparation for demanding physical activities.

The objectives are to conduct research on the LBP phenomenon in ice hockey by investigating factors contributing to LBP in literature from anatomical and biomechanical perspective, with a focus on the hip area; use the findings from this research to design an evidence-based warmup exercise program targeting the lumbo-pelvic-hip complex to address LBP issue and its factors contributing.

1.2 The client

This thesis was conducted in cooperation with the Latvian amateur ice hockey team "HK Kengarags 2" competing in 8th division of the EHL (Entuziastu Hokeja Liga). Currently the team has 25 active players, with the majority having playing experience of two years or less. None of the players are professional athletes; they come from different backgrounds, they possess different physical abilities and conditioning. Ice hockey is a hobby sport for them. During on-ice training sessions the focus is on the elements of the hockey game. Strength, mobility, flexibility, and cardiovascular training are not separately addressed in the team training, and it is each of the players' own responsibility to work on these components.

After an unsuccessful season and missing the playoffs, it was determined by the team management to implement changes in the off-season preparation process, specifically addressing the physical performance of the players. The coach and the players have acknowledged the lack of structured warmup routine, and until now it was each player's own responsibility to prepare before the practice or the hockey match. As the author is a player of the mentioned team, the team management ordered the author to conduct thesis research on this topic and to produce a warm-up program for the players.

2 ICE HOCKEY

Ice hockey is a dynamic, highly skilled, and fast-paced contact sport, characterized by intermittent high-intensity bouts of skating with rapid accelerations and decelerations, frequent changes in speed and direction, stick handling, and body checking. It is a physically demanding sport and requires players to possess good physical abilities - overall muscle strength, good aerobic and anaerobic endurance, mobility, agility, and balance. (Twist & Rhodes, 1993.)

Ice hockey is a goal-oriented one-on-one sport and requires certain set of skills – skating, stickhandling, shooting, and checking. One of the main characteristics of a proficient hockey player is excellent skating skills. Skating is the primary mode of locomotion and it is the foundation for developing other hockey skills, making it the most important skill of hockey. (Buckeridge et al., 2015; Twist & Rhodes, 1993.)

2.1 Skating

In ice hockey similar movement patterns are performed as in speed and figure skating; however, the performance and tasks of the game are different. During the game, a player performs complex movement patterns that involve accelerations, deceleration, stopping, changing direction, pivoting, skating forward and backwards at different speeds in response to actions on the ice. In order for the player to perform effectively, they must possess complex set of skating skills, great mobility and core strength. (Pearsall et al., 2000; Twist & Rhodes, 1993.)

2.1.1 Hockey stance

Hockey stance (posture) is a fundamental position in ice hockey that players adopt. This low position lowers the player’s center of gravity, allowing them to maintain their balance, mobility, and the ability to engage in game action. The proper hockey stance is characterized by feet placed shoulder width apart or slightly wider, ankles in dorsiflexion, knees bent to approximately 90° angle, trunk flexed from the hips, pelvis slightly tilted anteriorly (forward), head up and looking forward, and stick held in front, on the ice. (Bracko, 2004, p. 47.)

In the study conducted by Bracko et al. (1998), the most common skating characteristics of National Hockey League (NHL) forwards were analyzed. The results indicated that the players spent majority of the time (39%) gliding on two feet, highlighting the significance of the hockey stance (Bracko et al., 1998). While this low, crouched position enhances player's stability, responsiveness and engagement in game actions, this constantly flexed posture and repetitive skating movements might put significant stress on the lower back region, potentially leading to symptoms of LBP (Twist & Rhodes, 1993, p. 70; van Hilst et al., 2015.)

2.1.2 Skating mechanics

The most common activity of skating is moving forward. The skating stride consists of support and swing (recovery) phases, where the support phase can be subdivided into gliding phase and propulsion (push off) phase. The support phase is further subdivided into single-support and double-support phases. (Pearsall et al., 2000.) The forward skating stride begins with one blade making contact with the ice for propulsion, while the other skate is lifted and moved ahead before it is placed on the ice for the gliding phase. The propulsion starts by directing the skate to the side through external rotation of the hip and pronation of the foot. The core muscles are engaged to stabilize the upper body; the hip is abducted, knee is extended, and the ankle is plantar flexed. During propulsion, the opposite leg is flexed at the hip and the knee, and the thigh is brought (abducted) away from the midline of the body. Propulsion is followed by recovery phase - the hip is flexed and adducted bringing the leg towards the midline; knee is flexed, and the ankle is dorsiflexed. During the gliding phase the weight is transferred onto the gliding leg, while the other leg performs propulsion. (Haché, 2002, pp. 39–42; Terry & Goodman, 2018, p. 2.)

A proficient skater is technically and biomechanically efficient. It enables the player to move quickly and accurately on the ice, increasing the number of goal scoring chances in the game (Upjohn et al., 2008). Buckeridge et al. (2015) and Upjohn et al.

(2008) studies investigated kinematics of ice skating in different level ice hockey players. Both studies demonstrated that the high-level skaters achieved faster skating speeds than lower-level skaters while performing similar number of strides. The high-level skaters exhibited greater ROM in hip abduction, hip extension, hip external rotation, knee flexion, and knee abduction movements, contributing to stride length. Furthermore, they exhibited greater rate of hip flexion, knee extension and plantar flexion at propulsion, contributing to higher force application at propulsion. (Buckeridge et al., 2015; Upjohn et al., 2008.) In another study, Lafontaine (2007) demonstrated that knee ROM increased with the number of strides as the skating velocity increased. These findings support de Koning's et al. (1995) idea that a larger joint ROM facilitates greater extension velocities, resulting in greater force application at propulsion, which in turn results in higher skating velocity. This highlights the significance of joint ROM. (Buckeridge et al., 2015; Upjohn et al., 2008.)

2.2 Stickhandling

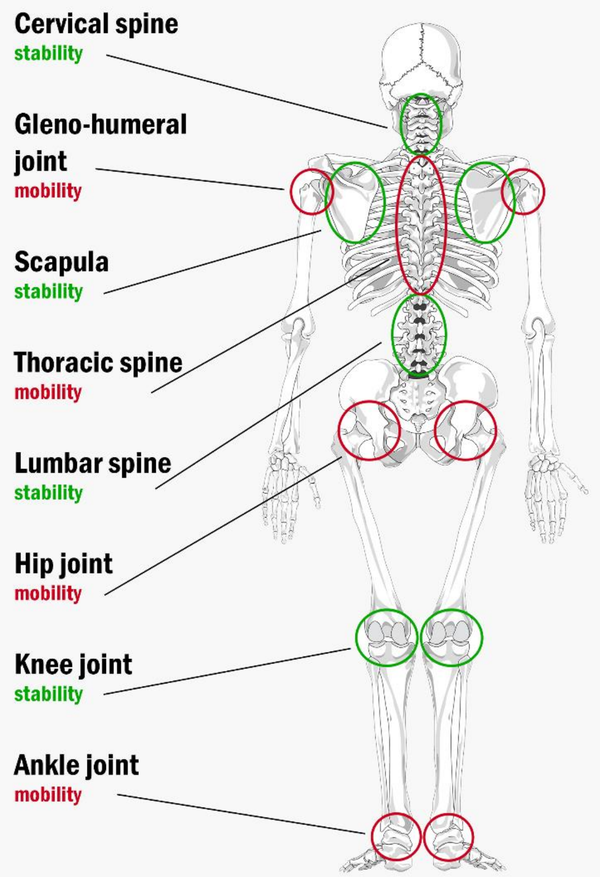
Stickhandling is another fundamental skill of ice hockey. It is the ability to control the puck and keep it in possession while skating, passing, and shooting. (Pearsall et al., 2000). Shooting and passing requires great trunk rotation ROM, hip mobility, core stability, and power generation from the core muscles. For instance, players with greater mobility will be able to open-up for more extensive wind-up, allowing for greater force and speed generation for both shooting and passing. Lack of these components hinder player’s ability to perform on-ice, and increases risk of injury. (Terry & Goodman, 2018, p. 111; Twist & Rhodes, 1993.)

3 CONSIDERATIONS FROM KINESIOLOGY PERSPECTIVE

The human body is an interconnected system, that consists of series of joints and muscles that work together to produce movement. A kinetic chain is a concept that describes interaction between these body segments. A properly functioning kinetic chain facilitates energy transfer throughout the chain, thus significantly improving athletic performance by increasing movement velocity and force production. Dysfunction of the kinetic chain significantly affects the energy transfer along the chain, leading to dysfunctional movement, increased load on distal segments, and risk of injury. (Ellenbecker & Aoki, 2020; Kibler et al., 2006; Sciascia et al., 2012, p. 19.)

3.1 Joint-by-joint approach

Each joint or series of joints has a specific function, therefore each joint has specific needs to function properly. These needs of each specific joint are described by “The Joint-by-Joint” concept conceived by Gray Cook and Michael Boyle (Picture 1). It suggests that joints must alternate between mobility and stability. However, stability does not include only static support during movements, but also dynamic support, meaning that every joint should have a certain degree of ROM. Furthermore, movement or stability at each joint affects movement or stability in joints above or below in the kinetic chain, therefore maintaining this balance within the kinetic chain is crucial. (Boyle et al., 2010; Canadian Fitness Professionals Inc., 2023; van Asten, 2022, p. 40.)



Picture 1. Kinetic chain. Posterior view. (Modified Mariana Ruiz Villarreal, 2007).

When one segment loses its function, another segment compensates for it. For instance, the hip joint must have the mobility to move in multiple motion planes, while the lumbar spine must remain stable during whole-body movements. If the hip joint has restriction in extension direction, the lacking extension ROM can be provided by lumbar spine extension followed by anterior pelvic tilt. If these compensatory patterns are prolongedly repeated, the stable segment is forced to move, thus becoming less stable. Such compensatory movements can lead to overuse injuries, muscle imbalances, and pain (in this case in the lumbar spine area) limiting one's performance. (Avman et al., 2019, p. 49; Boyle et al., 2010; Sciascia et al., 2012, p. 19; van Asten, 2022, p. 40.)

3.2 Agonist-antagonist muscle interaction

To produce movement, several skeletal muscles act together as a group. Most of the muscles work in antagonistic pairs - e.g., flexors-extensors, abductors-adductors etc.

When performing a movement, the agonist muscle, also called prime mover, contracts, and produces force needed for the movement, while the antagonist muscle relaxes and lengthens to allow for the movement at the joint. The antagonist also assists in stabilizing the joint and ensures controlled and precise movement execution. Furthermore, this agonist-antagonist interaction can be assisted by the synergist and fixator muscles. Synergist muscles assist the prime mover in performing a movement. Fixator muscles stabilize the origin of the agonist muscle allowing for more efficient movement. Coordinated, well-functioning musculoskeletal system is a prerequisite for optimal movement execution and physical performance. (Tortora & Derrickson, 2017, pp. 333–334.)

4 LUMBO-PELVIC-HIP COMPLEX

The lumbo-pelvic-hip complex (LPHC), also referred to as “core”, is the key component connecting the upper and lower body and facilitates efficient energy transfer along the kinetic chain. LPHC consists of musculoskeletal structures that are responsible for spinal and pelvic stability - the lumbar spine, pelvis, femur, and associated ligaments and muscles. The proper function of the lumbo-pelvic-hip structures enhances trunk stability, allows for efficient movements and force generation in the lower extremities, and reduces risk of injury. Dysfunction of either the upper or lower body or both can result in dysfunction of the LPHC and vice versa as they are closely related. (Chang et al., 2017; Kibler et al., 2006.)

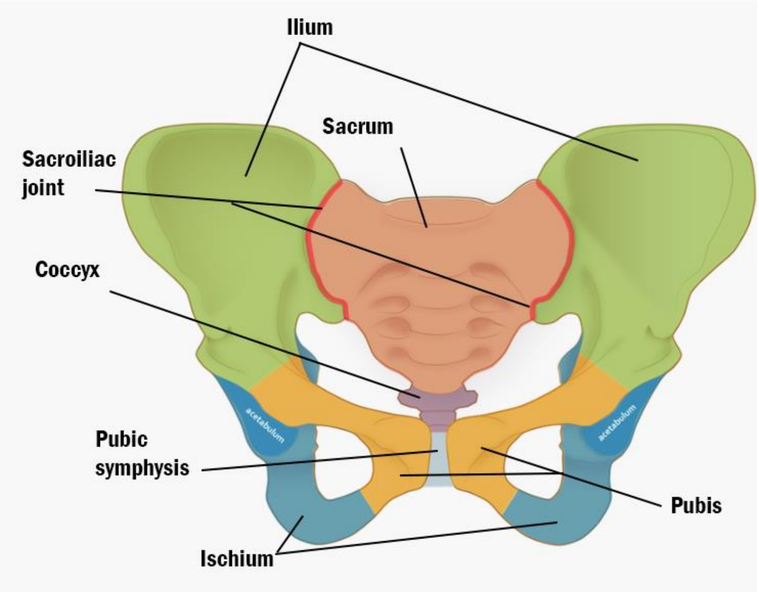
The LPHC consists (depending on the context) of at least 11 joints and 29 to 35 muscles that attach to the lumbar spine or pelvis (Cuppett & Paladino, 2001). It is a complex compound of structures, thus van Asten (2022, p. 40) suggests to focus on the movement patterns and broad muscle groups to identify their effects on pelvic positioning.

The relationship between the pelvis and the lumbar spine is described as the lumbo-pelvic rhythm (LPR). Proper rhythm facilitates larger ROM and prevents overloading of the involved and surrounding structures. For instance, forward trunk bending consists of flexion of the lumbar spine followed by anterior tilting of the pelvis. When returning to erect posture, the movement sequence is opposite – first, the pelvis is tilted posteriorly, and the lumbar spine is extended. This is achieved by balanced eccentric and concentric contractions of muscles of the LPHC. (Hasebe et al., 2014; Tojima et al., 2016.)

4.1.1 Pelvis

The pelvis is the key component of the lumbo-pelvic-hip complex primarily responsible for locomotion. It supports the weight of the upper body, serves as an attachment point for lower limb and trunk muscles, and protects internal organs in the pelvic and abdominopelvic region. (Wobser et al., 2023.)

The pelvis (Picture 2) consists of complex bone and ligament structures, and it can be divided into two anatomic parts – the pelvic girdle (anterior part) and pelvic spine (posterior part). The pelvic girdle (also known as hip bone) is composed of three fused bones: the ilium, ischium, and the pubic bone. The pelvic spine is composed of the sacrum and coccyx. These two parts are connected by forming four pelvic joints - anteriorly connected by the pubic symphysis, posteriorly articulating with the pelvic spine, two sacroiliac joints are formed, and sacrococcygeal joint – a hinge joint formed by the sacrum and the coccyx. (Tortora & Derrickson, 2017, pp. 243–245; Wobser et al., 2023.)

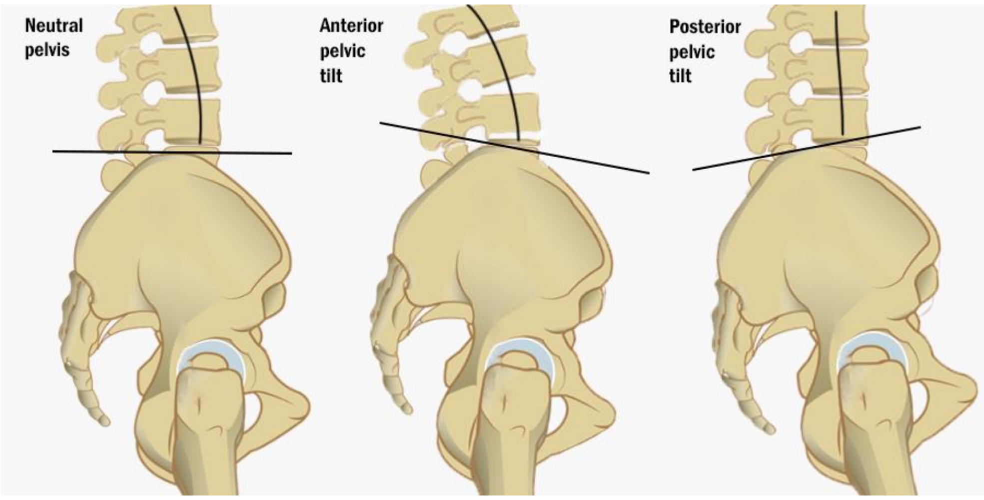


Picture 2. Anatomy of the bony pelvis. Anterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

Pelvic tilting describes the position of the pelvis that allows for certain postures and movements, regulates the alignment of the spine and the hips. The orientation of the pelvis regulates the curvature of the lumbar spine. The position of the pelvis (Picture

3) can be described as 1) Neutral pelvis, 2) Anterior pelvic tilt, 3) Posterior pelvic tilt. (Lowe, 2009, pp. 164–169; Mansfield & Neumann, 2018, p. 203.)

The neutral pelvis refers to the anatomical position, where the pelvis is in its natural, balanced alignment – slightly tilted anteriorly. Transversus abdominis muscle is one of the main contributors in stabilizing and maintaining neutral pelvis position. In the anterior pelvic tilt, the pelvis is tilted forward, and the curvature of the lumbar spine (lordosis) is increased. In the posterior pelvic tilt, the pelvis is rotated backwards, thus decreasing the lordosis of the lumbar spine. Excessively tilted and prolongedly sustained positions can put significant mechanical stress and overload the spinal structures – intervertebral discs, facet joints and spinous processes of the vertebrae; alter the spinal alignment, cause muscle imbalances, leading to discomfort and pain in the lower back, and reduced physical performance. (Lowe, 2009, pp. 164–169; Roussouly & Pinheiro-Franco, 2011.)



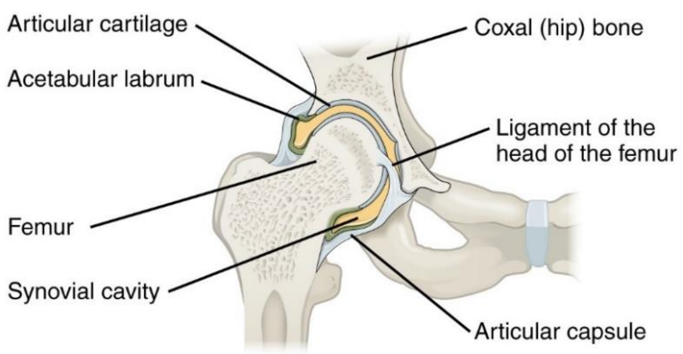
Picture 3. Position of the pelvis. Lateral view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

As discussed in the previous chapter, the hockey stance is characterized by flexed position of the trunk and lower limbs, and anterior pelvic tilt. To safely maintain this specific posture, stable and proper functioning pelvis is required, which can be achieved through appropriate conditioning – strength, mobility and flexibility training. (Terry & Goodman, 2018, pp. 1–6; Twist & Rhodes, 1993.)

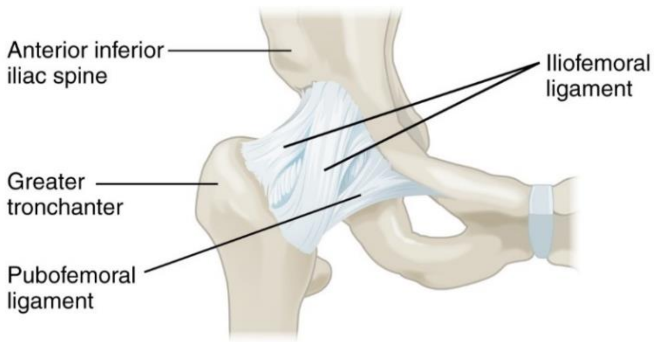
4.1.2 Hip joint

The hip joint is a ball-and-socket synovial joint that connects the thigh bone (femur) to the pelvis; and it connects the lower extremities to the axial skeleton. The joint is formed by the acetabulum (socket) of the hip bone and the head of the femur (ball) (Picture 4), and it allows for the movement in all three planes – frontal, sagittal and transverse plane. (Tortora & Derrickson, 2017, p. 282.)

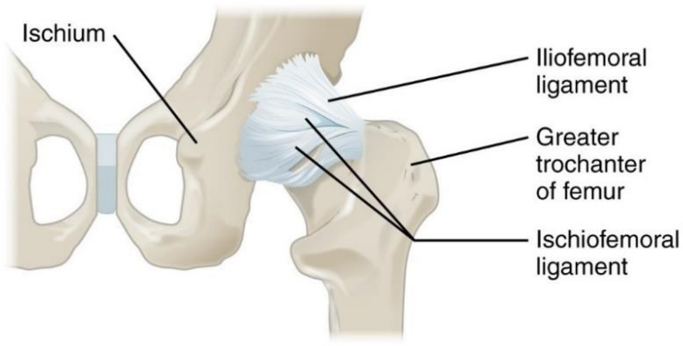
The hip joint is a weight-bearing joint, and requires stability to support the weight-bearing, gravitational and muscular forces affecting the joint from different angles. It is tremendously strong and stable due to its strong joint capsule and ligaments and muscles surrounding it. The extracapsular ligaments (Pictures 5 and 6) – ischiofemoral, pubofemoral, iliofemoral, which together prevent excessive ROM of the joint and enhance passive joint stability. The strong fibrous capsule along with the muscles surrounding the joint enhances the stability of the joint, and enables the movement of hip joint in rather large ROM. (Mansfield & Neumann, 2018, p. 274; Physiopedia contributors, 2023; Tortora & Derrickson, 2017, p. 282.)



Picture 4. Frontal section of the right hip joint (OpenStax College, 2013). CC BY 3.0.



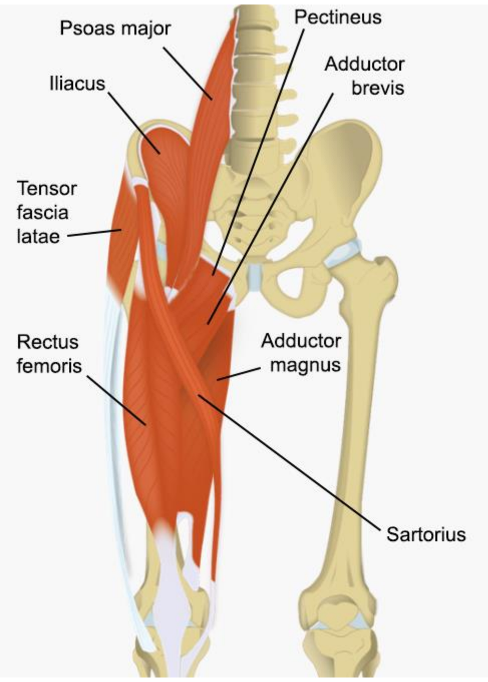
Picture 5. Anterior view of the right hip joint (OpenStax College, 2013). CC BY 3.0.



Picture 6. Posterior view of the right hip joint (OpenStax College, 2013). CC BY 3.0.

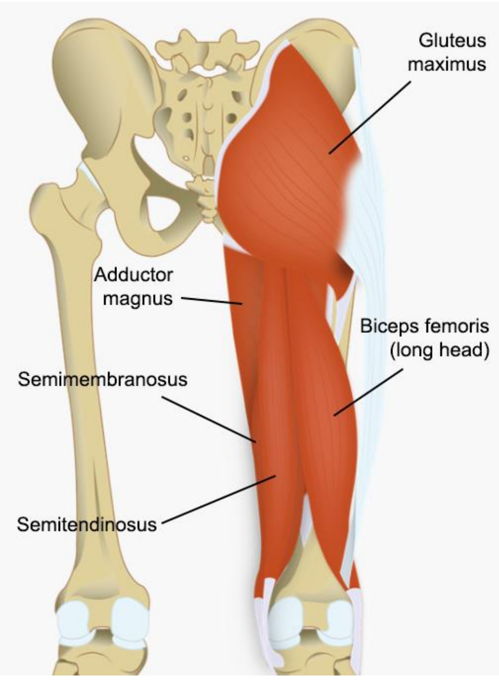
The hip joint allows for movement in flexion, extension, abduction, adduction, medial (internal) rotation, lateral (external) rotation, and circumduction (a combination of the mentioned movements) direction. This requires for joint mobility to move in rather large ROM. Large number of muscles are involved in movements of the hip joint, and they can be grouped based on their function – flexors, extensors, abductors, adductors, internal rotators, external rotators. (Physiopedia contributors, 2023; Tortora & Derrickson, 2017, p. 282.)

Muscles involved in flexion of the hip joint displayed in Picture 7. The primary movers of the hip joint are Iliacus, Psoas major, Rectus femoris, and Tensor fascia latae. The secondary movers (synergists) that assist the movement and stabilize the hip joint during the flexion movement are sartorius, pectineus, and adductors - magnus and brevis. (Mansfield & Neumann, 2018, p. 248; Tortora & Derrickson, 2017, pp. 384–385.)



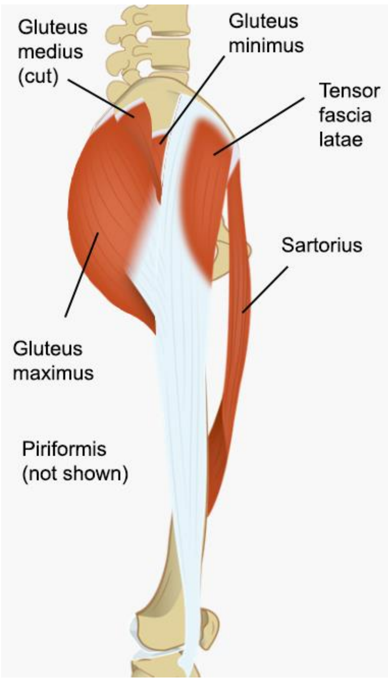
Picture 7. Flexors of the hip joint. Anterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

The primary hip extensors are the Gluteus maximus, hamstrings (Semitendinosus, Semimembranosus, Biceps femoris (long head)), and posterior head of the Adductor magnus as shown in Picture 8 (Mansfield & Neumann, 2018, p. 255; Tortora & Derrickson, 2017, pp. 384–385).



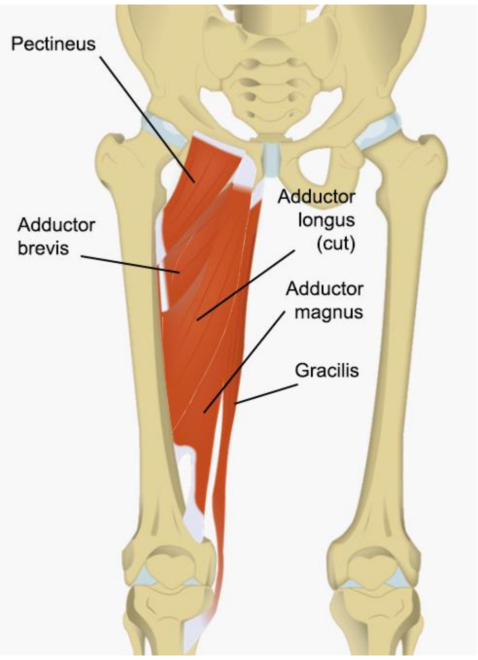
Picture 8. Extensors of the hip joint. Posterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

The primary hip abductor muscles include the Gluteus medius, Gluteus minimus, and Tensor fascia latae (TFL) along with the synergists Sartorius, Piriformis and superior fibers of the Gluteus maximus, shown in Picture 9. With the pelvis fixed in position, these muscles move the femur away from the midline. (Mansfield & Neumann, 2018, p. 260; Tortora & Derrickson, 2017, pp. 384–385.)



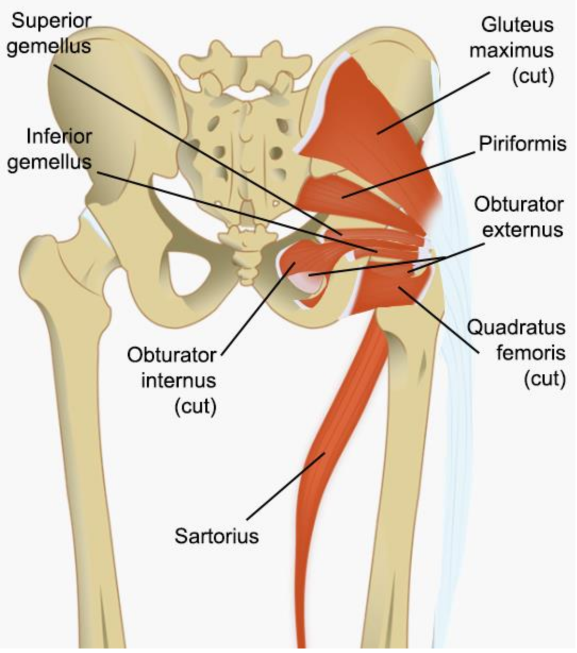
Picture 9. Abductors of the hip joint. Lateral view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

The hip adductors (also known as groin muscles) are responsible for moving the extremity towards the midline. The primary movers (shown in Picture 10) are the Adductor magnus, Adductor longus, Adductor brevis, Pectineus, and Gracilis. (Mansfield & Neumann, 2018, p. 265; Tortora & Derrickson, 2017, pp. 384–385.)



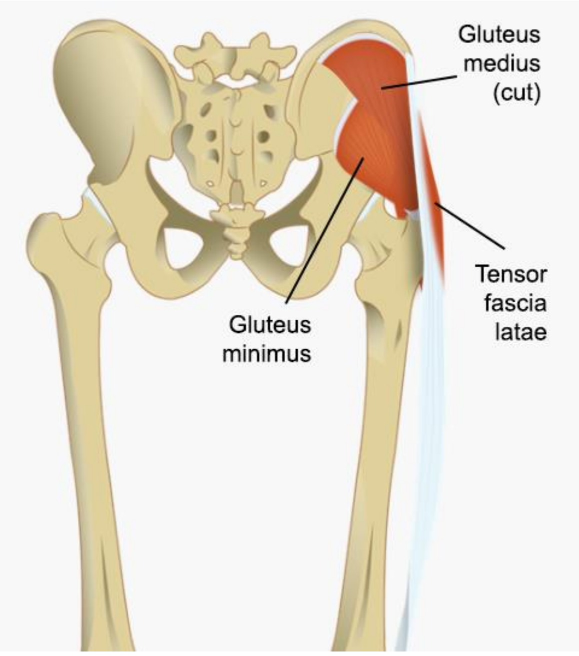
Picture 10. Adductors of the hip joint. Anterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

Hip external (lateral) rotators (Picture 11) are responsible for rotating the femur outwards away from the body. The primary movers are the Piriformis, Gemellus superior, Gemellus inferior, Obturator internus, Obturator externus, Quadratus femoris along with the synergists the Gluteus maximus, Sartorius, and Adductors – Magnus, longus, brevis. (Mansfield & Neumann, 2018, pp. 269-271; Tortora & Derrickson, 2017, pp. 384–385.)



Picture 11. External rotators of the hip joint. Posterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

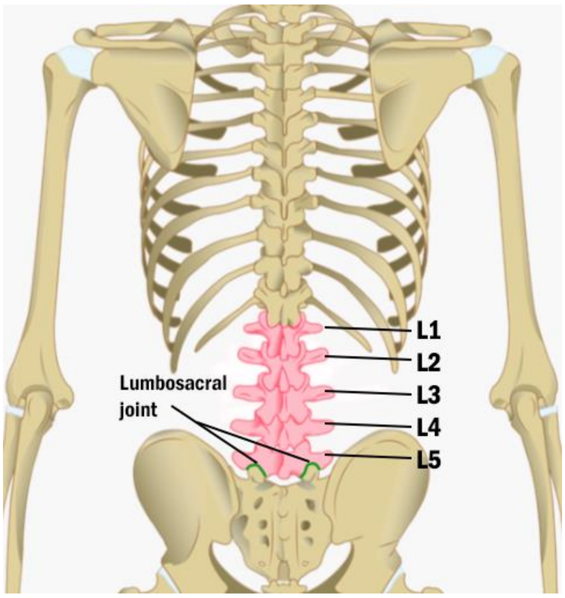
Internal (medial) rotators of the hip joint (Picture 12) are responsible for rotating the femur inwards towards the midline of the body. The primary movers are Gluteus medius (anterior fibers), Gluteus minimus and Tensor fascia latae along with the synergists – Adductor magnus, Adductor longus, Adductor brevis. (Mansfield & Neumann, 2018, p. 273; Tortora & Derrickson, 2017, pp. 384–385.)



Picture 12. Internal rotators of the hip joint. Posterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

4.1.3 Lumbar spine

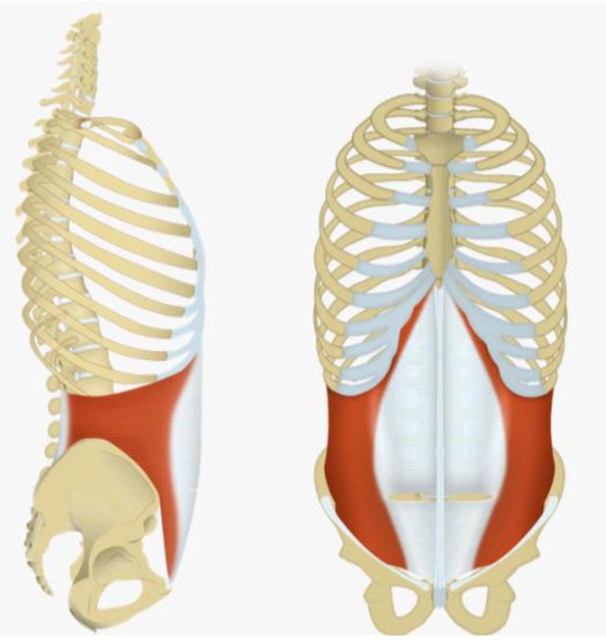
The lumbar spine, often referred to as the lower back, is a compartment of the inferior end of the spinal column. The lumbar spine consists of bones, cartilage, ligaments, nerves, and muscles. The lumbar vertebral column consists of five vertebrae, labeled as L1 through L5. It plays a significant role in providing support and stability to the upper body, protects the spinal cord and spinal nerves, and serves as the origin point for several key muscles in the human body. The lumbar vertebrae are characterized by their large, wide bodies, that increase in size moving more inferiorly, and the lordotic curvature (lordosis), which makes them suitable for supporting and bearing the weight of entire upper body. The alignment of superior articular facets permits flexion, extension, and lateral flexion movements, while limiting rotation. (Mansfield & Neumann, 2018, pp. 186–188; Sassack & Carrier, 2023; Waxenbaum et al., 2023.)



Picture 13. The skeletal system. Lumbar spine (in red). Posterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

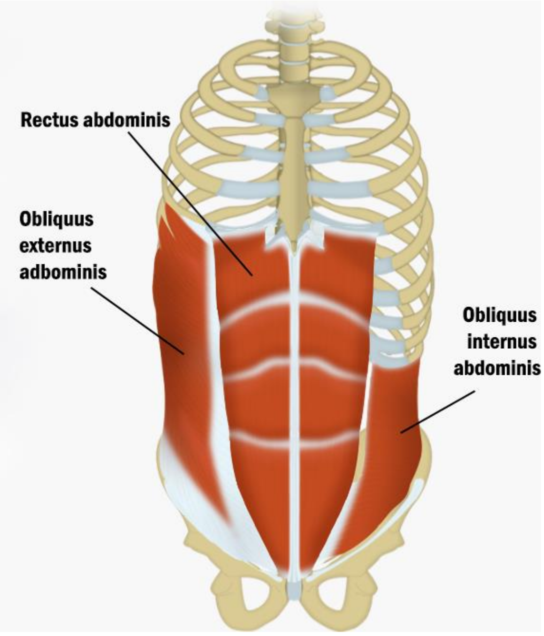
When grouped according to function, four muscles groups are attached to the lumbar spine, where it serves as an origin or insertion point. These muscles allow for movement in different movement planes and function as secondary stabilizers of the spinal column. (Sassack & Carrier, 2023.)

Transversus abdominis (TA) is one of the core muscles and it is the deepest muscle of the anterolateral abdominal wall muscles. It originates from the inner surfaces of the costal cartilages of the ribs 7^{th}-12^{th}, as well as the iliac crest, thoracolumbar fascia, and the inguinal ligament. It is one of the key muscles of the core and works in tandem with Multifidus. Together they protect and provide stability of the spine. TA also compresses abdomen, thus increasing the intraabdominal pressure, and supports the contents of the abdominal cavity. The fibers of TA are oriented horizontally, therefore it functions as a support belt for the lumbar spine. Neuromuscular inhibition or poor activation of TA is a contributing factor to lumbar instability and subsequent symptoms of LBP. (Agur et al., 2013, p. 108; Lynders, 2019.)



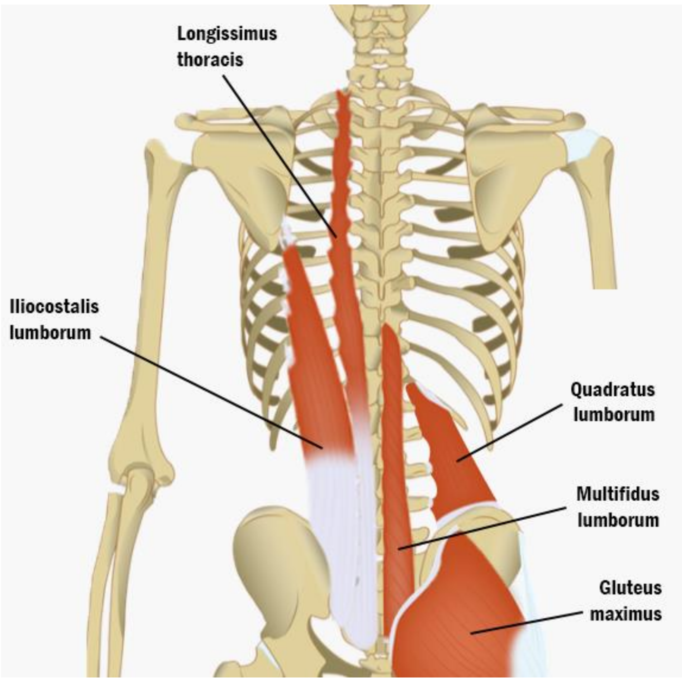
Picture 14. Tramsversus abdominis muscle. Lateral and anterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

The lumbar flexors (Picture 15) lie anterior to the lumbar spine and contribute to the flexion (bending) of the lumbar spine. The primary flexors of the lumbar spine are Rectus abdominis, Obliquus internus & externus abdominis, and the synergist - Psoas major. (Mansfield & Neumann, 2018, pp. 216–221; Sassack & Carrier, 2023.)



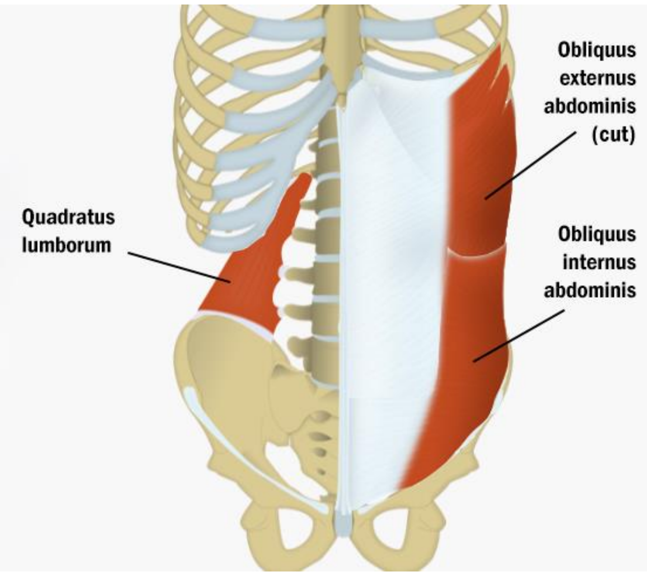
Picture 15. Primary flexors of the lumbar spine (Psoas major not shown). (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

The lumbar extensors (Picture 16) lie posterior to the lumbar spine and contribute to the extension (straightening) and stabilization of the vertebral column. The main movers are Iliocostalis lumborum, Longissimus thoracis (both are part of the Erector Spinae muscle group), Multifidus lumborum, and their synergists Quadratus lumborum, Gluteus maximus, and Interspinales lumborum. (Mansfield & Neumann, 2018, pp. 222–226.)



Picture 16. Extensors of the lumbar spine (Interspinales lumborum not shown). Posterior view. (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

Lateral flexors of the lumbar spine (Picture 17) contribute to the lateral flexion (side-bending) of the lumbar spine. The primary movers are Quadratus lumborum, Obliquus internus & externus abdominis with their synergists – Psoas major, Iliocostalis lumborum, Longissimus thoracis, and Intertransversarii lumborum. (Mansfield & Neumann, 2018, pp. 213–215.)



Picture 17. Main lateral flexors of the lumbar spine (Synergists not shown). (Modified Clinical Anatomy, n.d). CC BY-NC-SA 4.0.

The rotators of the lumbar spine facilitate rotation (twisting) of the lumbar spine, allowing to turn torso to the right or left. Although the position of the lumbar facet joints limits rotation, small rotational movements are possible. The main contributors of the rotational movements of the lumbar spine are Multifidus lumborum and Obliquus internus & externus abdominis (no picture). (Mansfield & Neumann, 2018, pp. 216–226.)

5 MOBILITY AND FLEXIBILITY

Mobility and flexibility are terms used in context of one's ability to perform certain movements effectively. All these components are interconnected, however each of them has their own role in contributing to proper movement. Flexibility describes soft tissue length and ability to lengthen and stretch (extensibility). Mobility is defined as the ability of a body structures or segments to move a joint freely and comfortably allowing for movements within functional ROM. Mobility relies on joint integrity and flexibility of soft tissues surrounding and crossing the joint – they must possess sufficient extensibility to enable and facilitate the movement. (Kisner et al., 2017, pp. 82–83; Radák, 2018, pp. 119–120.)

Mobility can be further divided into dynamic and passive mobility. Dynamic mobility refers to the degree of ROM to which an active muscle contraction can move a joint through, and it depends on a muscle's ability to contract through the ROM, and the flexibility of the soft tissues involved in active movement. Passive mobility refers to the degree of ROM to which a joint can be passively moved through (e.g., by a therapist), and it depends on the flexibility of the soft tissues surrounding and crossing the joint. Hypomobility refers to decreased mobility - reduced or restricted functional ROM, caused by insufficient soft tissue flexibility, impaired muscle performance (due to length or weakness), postural misalignments, trauma etc. (Kisner et al., 2017, pp. 82–83.)

Good mobility and flexibility are a prerequisite for athletic performance and injury prevention in sports requiring large ROM. Specifically in ice hockey, mobility and flexibility training should target the lumbo-pelvic-hip complex, as it plays a crucial role in supporting the load bearing, force generation, and movement execution. Mobility and flexibility can be addressed through mobility specific training, warmup, and cooldown activities. (Twist, 2007, p. 29; Twist & Rhodes, 1993, pp. 69–70.)

6 RISK FACTORS FOR LBP ASSOCIATED WITH DYSFUNCTION OF THE LUMBO-PELVIC-HIP COMPLEX

The relationship between the function of the hip joint and LBP has been the topic of interest since 1990's, and large number of studies have been conducted investigating this theory ever since. Although the specific nature of this relationship remains unclear, this relationship is based on hypothesis suggesting that dysfunctional hip joint might affect the kinematics and function of the lumbo-pelvic region. These changes lead to alteration of mechanical loads on the structures and joints above and below in the kinetic chain, in this case - the lumbar spine, and as a result produce symptoms of LBP. (Avman et al., 2019, pp. 38–39; Boyle et al., 2010; Harris-Hayes et al., 2009, pp. 61–63.)

6.1 Hip joint ROM

The association with hip joint ROM and LBP has been studied in an extensive number of studies. Limited hip joint ROM is a risk factor for LBP, and it is a concern among hockey players, as it impacts their ability to perform complex hockey skills. Ice hockey players that have decreased hip joint ROM are at greater risk of injury. (Sadeghisani et al., 2015, p. 456; Wilcox et al., 2015, pp. 304–305.)

In Avman et al. (2019) systematic review, studies investigating association between limited hip joint ROM and LBP were analyzed. Studies of Adegoke & Fapojuwo (2010) and Mellin (1990) found limited hip flexion ROM in individuals with LBP; studies of Ashmen et al. (1996), Mellin (1990) and Van Dillen et al. (2000) reported reduced hip extension ROM; Chesworth et al. (1994), Ellison et al. (1990), Murray et al. (2009) and Vad et al. (2003, 2004) reported limitations in hip internal rotation ROM; studies of Chesworth et al. (1994) and Van Dillen et al. (2008) reported limited hip external rotation ROM in individuals with LBP. Studies investigating ROM of hip abduction and adduction failed to demonstrate statistically significant results or the quality of the studies was poor (Avman et al., 2019, pp. 38–51).

Asymmetrical hip joint ROM is another risk factor contributing to LBP. It can lead to uneven, asymmetric force transmission to the lumbopelvic region, thus altering the biomechanics and overloading structures of LPHC. (Cejudo et al., 2020; Harris-Hayes et al., 2009, p. 63.) Studies by Almeida et al. (2012), Cibulka et al. (1998), Harris-Hayes et al. (2009) and Van Dillen et al. (2008) reported limited total hip rotation (combined internal and external rotation) ROM and asymmetrical total hip rotation ROM between left and right lower extremities in subjects with LBP.

Findings of the abovementioned studies support the hypothesis that limited hip joint ROM is a risk factor for LBP (Sadeghisani et al., 2015). Limited hip joint ROM might be even a greater risk factor to LBP for people who regularly participate in sports and other activities that require repetitive large ROM movements at the lumbo-pelvic-hip complex (Harris-Hayes et al., 2009; Van Dillen et al., 2008). These findings are in accordance with the physiological profile of ice hockey (Boyle et al., 2010; Twist & Rhodes, 1993).

Limited and asymmetric hip joint ROM can be caused by various factors - for instance, shortened muscles surrounding the joint, a stiff joint capsule, overuse injuries, trauma, and different pathologies (Kisner et al., 2017, p. 82). Muscle length and joint restrictions (capsular mobility) can be addressed through different flexibility and joint mobility drills (van Asten, 2022, pp. 46, 55).

6.2 Asymmetrical posture

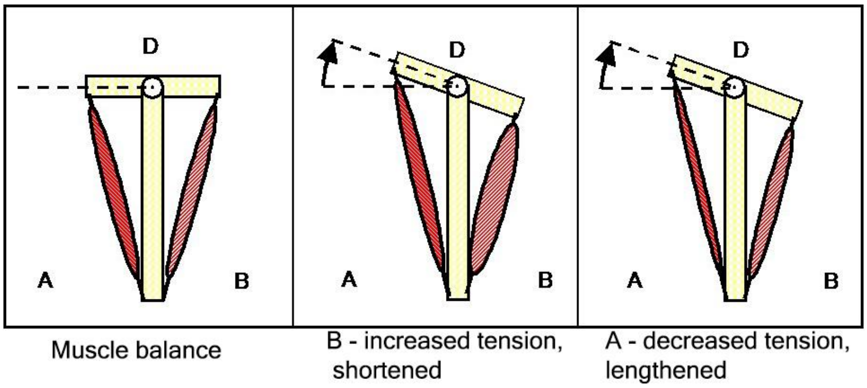
A certain degree of asymmetry is entirely normal and accepted phenomena of the human body. The development of the right and left side of the body is determined by various factors, both genetic and environmental. The degree of asymmetry can be affected by functional factors such as work or training. The most typical factor contributing to body asymmetry is related to the more frequent use of the preferred (dominant) side extremities. This asymmetry is usually reflected in differences in muscle development – size and strength. For instance, dominant right-sidedness is reflected in greater dimensions of the upper right extremity due to its more frequent use than the other non-dominant extremity. (Bergman, 1993; Wolanski, 2005, as cited in Krzykała & Leszczyński, 2015, p. 380.)

Side to side asymmetry is often encountered in sports, specifically in asymmetrical and rotation-related sports like hockey, golf, and tennis. While in most sports it is possible to choose the better limb to perform an action (to kick a football, shoot a basketball etc.), in hockey the players must adapt to one grip (either left or right), meaning that most movements occur on one side of the body. Furthermore, it is common for players to stop and/or turn on one preferred side. In response to these unilateral high loading repetitive movements, the body produces musculoskeletal adaptations – changes in joint mobility, muscle length and strength. Zemkova et al. (2019) described the typical hockey players back as a long relatively flat thoracolumbar region, and erector spinae muscle asymmetry on the dominant side. Over time, these adaptations can lead to functional problems of the LPHC and other body segments, thus producing pain and increasing the risk of injury. These asymmetries cannot be overlooked, and should be addressed in training. (Cejudo et al., 2020; Krzykała & Leszczyński, 2015, p. 380; Twist, 2007, p. 29; Zemkova et al., 2019, pp. 1, 7.)

6.3 Muscle balance

Normal muscle balance allows for coordinated agonist-antagonist muscle interaction and efficient movement execution; it is important for injury prevention and sports performance. Muscle balance is characterized by muscle length (flexibility) and strength ratio between the agonist and antagonist muscles. Ideally, agonist and antagonist muscles be similar in length and strength to promote joint stability and efficient movement. (Porter, 2013, p. 306; Twist & Rhodes, 1993, p. 69; Ylinen, 2008, p. 12.)

Muscle imbalance (Picture 18) can be described as either passive or active. Passive imbalance is characterized by disproportion in muscle length or strength in one or the other muscle groups. Changes in muscle strength can result from hypertrophy of one of the muscle groups due to overtraining of one side, for instance, shooting off from one side in hockey. Changes in muscle length often result from overuse, muscle becoming weak or adaptation from continuously being held in one position, for instance, skating in continuously flexed position (hockey stance). Muscles of the LPHC that are too overactive and/or shortened, weakened and/or lengthened will alter the biomechanics of the LPHC, thus leading to dysfunction of the kinetic chain - impaired movement and force production; overload of structures, and symptoms of LBP. (Ashmen et al., 1996, pp. 283–284; Porter, 2013, p. 306; Ylinen, 2008, p. 12.)



Picture 18. State of muscle balance and muscle imbalance. (Modified DrKlee, 1995). CC BY-SA 3.0.

Active muscle imbalance is identified when one of the synergistic muscle pair dominates during the movement. Increased synergist muscle activity is related to prime mover weakness or inhibition. For instance, inhibition of Gluteus maximus muscle during hip extension movement will lead to hamstring muscles becoming the prime mover. Muscles and structures involved in the compensatory movement patterns may become prone to fatigue, overuse, and eventual injury. (Behm, 2018, p. 99; Porter, 2013, p. 306.)

6.4 Lumbopelvic rhythm

Coordinated movement (symmetry, timing, rotation, ROM) between the lumbar spine and pelvis allows for maintaining stability, efficient movement execution, and load transfer and distribution. An altered or disrupted rhythm can increase the movement in the stable segment – the lumbar spine, thus increasing load on the tissues and affecting the efficiency of the kinematic chain. As aforementioned, the lumbopelvic rhythm is controlled by concentric and eccentric interaction between agonist and antagonist muscles. Poor posture, inadequate core stability, hip joint dysfunction, overload, muscle weakness, imbalances, and/or inhibition are contributing factors to lumbopelvic rhythm dysfunction and lower back pain. (Avman et al., 2019, p. 49; Harris-Hayes et al., 2009, pp. 61, 64; Sadeghisani et al., 2015.)

7 EXERCISE STRATEGIES ADDRESSING MOBILITY AND FLEXIBILITY

Various methods can be used to improve soft tissue extensibility, for instance, stretching, foam rolling (self-myofascial release), proprioceptive neuromuscular facilitation and others. The most common method to improve tissue extensibility is stretching. Stretching interventions affect the muscle-tendon system through muscle spindles and Golgi tendon organs – sensory receptors and regulators of muscle length, and muscle tension during muscle contraction respectively. Adaptations achieved through stretching can increase muscle length and flexibility, thus improving the performance capability, and reducing risk of injury. (Kisner et al., 2017, pp. 97–99; Ylinen, 2008, pp. 3, 40.)

7.1 Flexibility exercises

Stretching can be subdivided into static and dynamic stretching. Static stretching is a method where the joint is moved to the point of soft tissue resistance. The joint is then held in a lengthened position and sustained stretch force is applied to the soft tissues for a certain period. The stretch is repeated in multiple cycles to reach the doses of the desired effect. According to Kisner et al. (2017, p. 98) one to two cycles of 30 second stretch time daily will effectively increase muscle flexibility. Furthermore, static stretching can be conducted actively (self-stretching) – meaning that the stretch is performed by the person using voluntary contraction of the agonist muscle; or passively – the stretch is performed using external force applied by an assistant or other external aid, or the person themselves pulling their extremity or using gravity and different body positions to produce necessary stretch-force. Active stretching is mainly used for maintaining normal joint mobility, whereas passive stretching methods are used to improve soft tissue extensibility. (Kisner et al., 2017, pp. 97–99; Ylinen, 2008, pp. 46–47.)

In dynamic stretching the muscle is stretched for a short period while the joint is actively moved through its ROM. The stretch is sustained for short duration and repeated multiple times, while gradually increasing the ROM. Boyle et al. (2010) and van Asten (2022, p. 49) suggest to hold the stretch for approximately two seconds, and perform 10-15 stretching cycles per exercise. Dynamic stretching is associated with enhanced physical performance, therefore it must be implemented in the pre-activity warmup routine. (Kisner et al., 2017, p. 99; Ylinen, 2008, pp. 46–48.)

Self-myofascial release (SMR) is another method to increase soft tissue flexibility. It is used for stretching and releasing dysfunctional tissues - tender, painful spots, trigger points and/or areas of increased muscle density, thus alleviating pain, increasing ROM, and muscle contractibility. SMR is performed by using specific tools - foam roller, massage ball. Pressure is applied on the area of concern, and the tissue is loaded for a certain time (approximately 60 seconds) or until release of the tissue is reached. SMR prior warmup can enhance the stretching process and allow for more effective warmup. (Boyle et al., 2010; Seidenberg & Beutler, 2008, p. 441.)

7.2 Joint mobilization drills

Joint integrity is another important component of mobility. Joint integrity is a prerequisite for normal joint function and athletic performance. Every joint is surrounded by a joint capsule providing structural support and stability. Hypomobility often results from restricted joint capsule, therefore these restrictions must be addressed to maintain joint integrity and movement capacity. Different joint self-mobilization techniques can be performed to modify these joint restrictions. van Asten (2022) suggests three joint mobilization methods that can be included in the training plan and applied by the athlete by themselves – joint distraction, joint gliding, and distraction combined with joint gliding. The goal of the joint distraction method is to create more space between the joint’s articulating surfaces, thus allowing for better joint lubrication, and reduced joint friction. Joint gliding is used for improving ROM and enhancing the function of surrounding tissues. Combination of both is effective when more complicated capsular restrictions are present. (Manske et al., 2019, pp. 3–4; van Asten, 2022, p. 55.)

7.3 Mobility exercises

Mobility exercises are dynamic stretching exercises that incorporate functional movement patterns and joint mobilization movements that are often sports specific. Mobility exercises performed in pre-activity warmup will increase ROM and enhance neuromuscular control, thus optimizing movement patterns and improving overall performance. Furthermore, dynamic mobility exercises performed in large ROM will challenge body’s proprioceptive system and core stability. Similarly to dynamic stretching, mobility exercises can be performed for short periods and repeated multiple times. (Kisner et al., 2017, pp. 82, 87; Terry & Goodman, 2018, p. 111; Twist, 2007, p. 29.)

8 PRE-GAME OR TRAINING WARMUP PROGRAM

One solution for preventing LBP and improving athletic performance is through well-structured training programs. A proper warmup routine prior high intensity activity is the best way to prevent injury and prepare athletes body systems for optimal function. (Boyle et al., 2010; Ylinen, 2008, pp. 23–24.)

Many protocols and methods are widely used for structuring and executing warmup activities, however universally standardized specific guidelines or protocols have not been established in ice hockey. Ryan van Asten, who is one of the leading strength and conditioning coaches in elite ice hockey (National Hockey League) in his book “Complete conditioning for ice hockey” has established a science and experience-based framework for training ice hockey athletes, which is based on Boyle et al. (2010) concept of warmup training. A similar training concept has been described by Terry & Goodman (2018) in book “Hockey Anatomy”. Subsequently, this warmup program’s structure is established following the framework suggested by van Asten.

8.1 Structure of the program

As Boyle et al. (2010) and van Asten (2022) suggest, the pre-activity preparation (warmup) should follow a specific sequence of performing preparatory tasks to achieve the best possible results:

1. Inhibition of tight tissues
   Decreasing muscle tone, density, and release of tight tissues is recommended by Boyle et al. (2010) and van Asten (2022, p. 43) as it helps release tension in the muscles and surrounding connective tissues and enhances the stretching process. The area of interest should be the large muscle groups – Hip flexors, Hip abductors (TFL, Gluteus medius), Quadriceps femoris, Hip adductors, Hamstrings, Triceps surae (Gastrocnemius, Soleus), Erector spinae, and others (if any). (Boyle et al., 2010; Cejudo et al., 2020; van Asten, 2022, pp. 43–45.)

2. Muscle length

   After muscle tone is addressed, static stretching should be performed to restore and maintain appropriate muscle length in the areas of concern – Hip flexors, Quadriceps femoris, Adductors, Hamstrings, muscles surrounding lumbar spine, and muscles of the shoulder girdle – Pectoralis, Latissimus dorsi. (Boyle et al., 2010; Twist & Rhodes, 1993, pp. 69–70; van Asten, 2022, pp. 46–54.)

3. Dynamic mobility drills

   Dynamic stretching incorporated into functional movements together with joint mobilization using joint gliding method. The area of interest must be the ankle joint, hip joint, thoracic spine, and shoulder joint. (Boyle et al., 2010; Terry & Goodman, 2018, p. 114-134; van Asten, 2022, pp. 55–61.)

4. Muscle activation

   Static muscle lengthening exercises are associated with decreased muscle performance. Muscle activation exercises are performed to stimulate and reactivate inhibited muscles and increase force potential. The area of interest must be all the large muscle groups of LPHC. Exercises targeting primary function of the muscle groups in concern can be performed to reverse the inhibition. (Boyle et al., 2010; van Asten, 2022, pp. 62–64; Ylinen, 2008, p. 29.)

5. Movement integration

   Movement integration drills are intended to prepare the musculoskeletal and central nervous system to perform complex movement patterns. A complex movement is split into separate movements, and each movement is performed separately to optimize each movement's performance. These movements must be specific and related to the tasks the person is preparing to perform. (Boyle et al., 2010; van Asten, 2022, pp. 64–67.)

6. Structural and neural priming

   These drills prime (prepare) the musculotendinous and neuromuscular systems for complex task performance. Structural priming exercises improve joint mobility and movement execution, whereas the neural priming exercises enhance muscle recruitment and coordination for optimal force production. (Boyle et al., 2010; Kisner et al., 2017, p. 87; van Asten, 2022, pp. 64–69.)

8.2 Practical implementation

The warmup program underwent two trial sessions before it was finalized. The trials were conducted in a small group of five players where the content suitability was tested. Once finalized, the author hopes that this warmup routine will become standard practice for the players to prepare before stepping onto the ice.

It is planned that the author will be systematically guiding the warmup activity for the players, however the goal is to get the players familiar with the warmup routine and become independent with the preparation process. The reason for this is that it might not be always possible to provide such activity; and second – LBP is a universal issue and not exclusively related to ice hockey, therefore the players might benefit of transferring these exercises to everyday life.

9 THESIS PROCESS

The thesis process started in late 2022 with the initial idea of conducting research on the lower back pain issue in amateur ice hockey players. Initial idea was to conduct an assessment intervention with symptomatic players from the Latvian amateur ice hockey league "Entuziastu Hokeja Liga" and use collected data for research and trial an exercise intervention according to findings/conclusions of the research. Unfortunately, the proposed idea was not approved by SAMK due to complexity and intricacies of this kind of research compared to the level of work typically conducted in bachelor's thesis. Other research options within the topic of interest were considered, and the design of this bachelor's thesis was established and further developed.

During the thesis process, consistent communication with the team and its players was maintained. Several off-the-record training interventions were conducted based on the ongoing research results at the time to assess the result transferability to the target group.

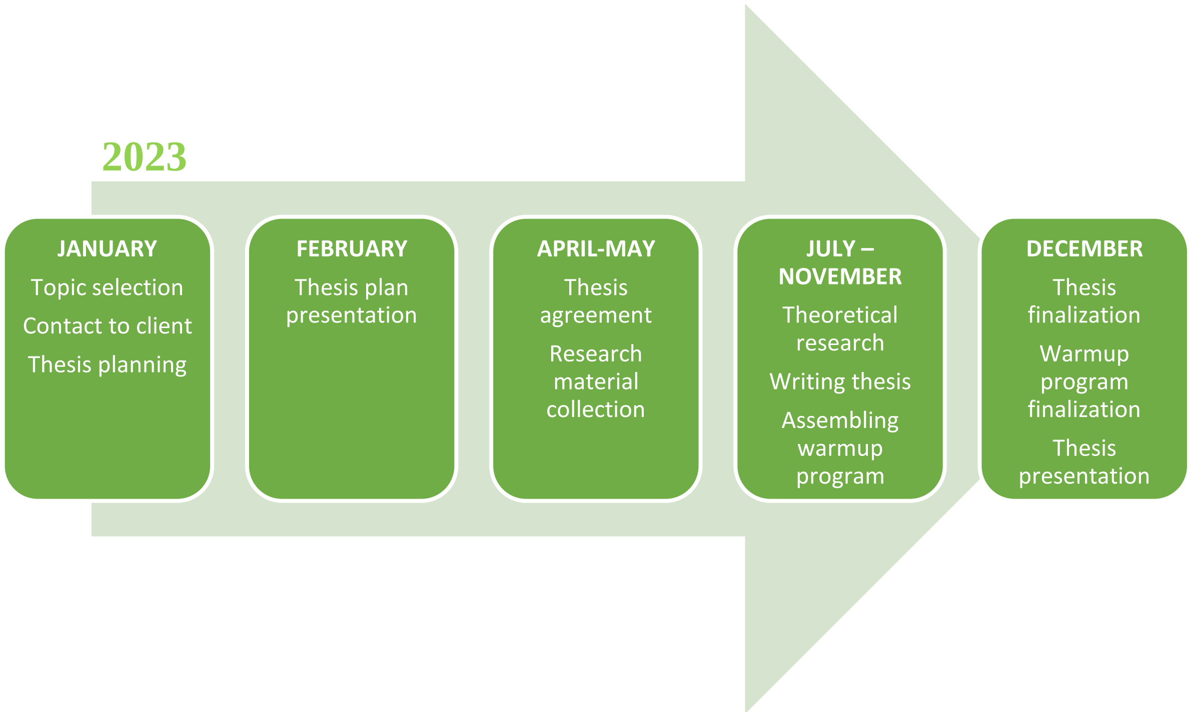


Figure 1. Thesis process

As a result of the conducted research and acquired information a warmup guide was created. The warmup program was assembled following structure suggested by van Asten. The program takes the athlete through six different exercise methods addressing all areas of concern of LBP and preparation for physical performance. In total seven self-myofascial release, six muscle stretching, five dynamic mobility, four muscle activation, eight movement integration, and four neural priming drills with demonstrational images and/or videos (accessible using QR codes) were included in the warmup program. The content of the program was assembled to match the average players' abilities and it has been accepted by the head coach of the team. Further exercise progression and modifications could be implemented outside the thesis process.

9.1 Method

An action-based research method was used in this thesis. Based on the results from the theoretical research a practical warmup-guide was produced and provided to the client. Information search for the theoretical part was conducted using Finna, Google scholar, PubMed, PubMed Central, ScienceDirect, DOAJ, and scientific literature in book and e-book formats.

9.2 Ethical considerations

The information used for the theoretical and practical parts was acquired from reputable and scientific sources, ensuring evidence-based approach was established and maintained during the thesis process. The exercise program was assembled based on the results of theoretical research, and the exercises were selected following the suggestions in the scientific literature and the industry standards.

10 AUTHOR'S REFLECTION

The aim and objectives were reached, and both the author and the client were satisfied with the result. However, this specific research design was not the first choice, and the author was less satisfied while working on it. Subsequently the author wants to outline some of the downsides that had an impact on the thesis process and overall outcomes:

1. Lack of research and information on the specific sports and population - amateur ice hockey and ice hockey in general.
2. Poor study design and inconsistency of the results in the available literature.
3. Subsequently, lack of systematic information gathering for the thesis research.
4. The inability to confirm the transferability of research results to the target group.
5. Inability to assess the effectiveness of the created exercise intervention.

Overall, this thesis was an extensive and very demanding learning experience. A huge amount of new information and knowledge was acquired; new perspectives in the field of physiotherapy and performance training were discovered. Above all, the author experienced significant personal growth, a development that will certainly contribute to professional development in the future.

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