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Motor skills training for youth, junior and top-level athletes:

TAITOC Pro Ice Hockey

Jussi Jaakola

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Supervisor: Vladislav Bespomoshchnov
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Abstract

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Author(s)
Jussi Jaakola

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The pace of ice hockey has increased over the past years and more demands are put on the skills of the players. The player and the goalkeeper must have both the motor and cognitive capabilities to face the challenges that emerge on the ice. As the game speeds up within physical domain of execution, it is difficult to stand out. Nevertheless, enhanced observation, faster decision-making and a well-developed coordinative ability can make a difference in cognitive speed within sports performance.

Skill has traditionally been viewed largely through the lens physical constructs. Nowadays, however, sports experts have started viewing skills from cognitive perspective as well. The same elements can be seen within skilled performances, where movement solutions are always slightly individual depending on game situations and one's own methods of performing a skill or task. Motor skills can be divided into different categories according to different classification systems. Adaptive training, mastery of fundamental skills in a variety of settings, the development of coordinative skills and the conditions of movements, have been shown to benefit motor learning and development.

Sports analysis can be used to consider the kind of motor skills are specifically needed in ice hockey and which skills contribute to the development of mastery of the skills required in this particular sport to improve performance on ice and decrease the risk of overuse injuries. Motor learning can manifest itself in several different ways as the learner's development path is unique and has a non-linear nature. Although, the end result is most often seen as an improvement in the quality of physical performance, learning in development is as important contributor in athletes' journey.

Based on a sport analysis of ice hockey and motor learning theories, TAITOC Pro Ice Hockey was developed as an off-ice motor skill training tool to promote transfer effect between physical and sport specific motor demands of ice hockey skills. It consists of coach education materials which include theory, skill assessment tools, and practice plans containing all materials.

Keywords
Ice hockey, Off-ice training, Skill training, Skillfulness, Motor learning

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1 Introduction

According to the Finnish Ice Hockey Association (FIHA 2020) successful performance at the top level requires more and more advancement in all four domains (i.e. physical, psychological, technical and tactical) of player development. In recent years, international top-level ice hockey has become a game at an ever-faster pace, and as the game speeds up, so do the skill requirements of individual players (Savolainen 2016, 565). As sport-specific demands grow, it also means that players need to be holistically more diverse and skilled. (FIHA 2020; Tiikkaja, Arvaja, Laaksonen, Mustonen, Savolainen & Vähälummukka 2016, 564-579).

Talent in sports has always been a much-debated topic. Over the years, several sport-specific definitions of talent measurement have been developed. Many of these models defined only physical properties, but later definitions have also been developed that take other properties into account. (Jaakkola 2014, 52-54.) Studies have shown that there is little inherited talent in sports, excluding, for example, body length and limb length, as well as length ratios. However, the biggest factors for the development of talent and the learning of skills are the growth environment and diverse and quantitatively sufficient training experiences. Other factors include psychological and cognitive factors as well as motivation. (Jaakkola 2014, 52-54.)

According to Wormhoudt, Savelsbergh, Teunissen & Davids (2018, 3), in recent years, there has been a lot of discussion about the decline of sports and general physical activity among youth. The current generation of youth has a much lower overall fitness level than that of youth 30 years ago. This is illustrated by a lack of movement experience, body orientation and general athletic skills, which are imperative to fundamental skills. (Wormhoudt 2018, 3.) The physical activity and habits of Finnish youth and children have been studied with a nationwide Liitu survey (Kokko & Martin 2019). According to a study by Liitu (Kokko, Martin, Ng, Mehtälä & Villberg 2019, 17), only about 20% of 15-year-olds and about 30% of 13-year-olds achieve the daily World Health Organization (WHO) exercise recommendation, which is at least one hour of exercise a day every day of the week, including strenuous exercise at least three times a week. The percentage is even lower among high school and vocational school-age youth (Terveyden ja Hyvinvointialojen Liitto 2020).

However, the number of sports club enthusiasts has increased slightly in recent years. According to the study, 44% of 15-year-olds and 58% of 13-year-olds exercise in sports

clubs, but also for many of them the total amount of exercise per week is too small both in terms of general international exercise recommendations and, above all, training for top sports. Children start exercising in a sports club at an average age of 6-7, and the decision to focus on one sport is made at an average age of nine. (Blomqvist, Kokko, Koski & Mononen 2019, 48-55.) According to a 2010 survey, 95% of upper elementary school-age team sport enthusiasts had already chosen their main sport and 75% of ice hockey players only practiced their main sport, other than occasionally. The most common secondary sports for ice hockey players were football and floorball. (Aarresola, Mononen & Kuitunen 2014, 109.) When other sports disappear alongside the main sport, it also often means a reduction in the total amount of exercise. At the same time, the self-implemented versatility of different sports is reduced. (Finni 2014, 118.) At the youth stage, however, the number of practices should gradually increase to a peak, especially in goal-oriented and top-level sports, as youth recover faster from practice than adults (Hakkarainen 2020; Vänttinen 2014, 57).

It is not necessary for an athlete to compete in multiple sports to train diversely. Practice can also be done in a variety of ways within the sport. In this case, above all, the importance lies in supplemental training, for example off-ice training in hockey, and the increased versatility that it offers. (Kalaja 2014, 33.) Mastering fundamental skills facilitates the learning of sport-specific skills, and the lack of sufficient mastery of these skills can sometimes be an obstacle or slow down the learning of sport-specific skills (Wormhoudt & al. 2018, 164-221). Developing diverse fundamental movement skills as a child is important, but a youth athlete or an athlete who is already at the top level will also benefit from versatile fundamental skill training (Kalaja 2014, 33) and especially development of coordinative abilities (CA) (Wormhoudt & al. 2018, 165).

The importance of school physical education (P.E.) lessons in the total amount of exercise has also increased as independent exercise has decreased, especially among youth. According to studies by the Liitu (Heikinaho-Johansson, Lyyra & Palomäki 2019, 85-88) the amount of P.E. lessons for youth in physical activity or sports classes is significantly higher (average 175min / week) than for other youth. Similarly, there is a big difference between ninth graders and seventh graders in the total amount of school exercise if the student also chooses all optional exercise classes. Seventh graders have the least school exercise (average 111min / week) compared to fifth-graders and ninth graders. (Heikinaho-Johansson & al. 2019, 85-88.) The main topic of the Finnish physical education curriculum is the learning of physical skills for diversification, and sport-focused classes are offered to aim for enabling high-quality and varied training for youth that are

competing in competitive and top level sports, but coordinating the quality of teaching is very challenging (Kalaja, 2014, 84-86). Also, the number of P.E. lessons in schools has increased slightly in recent years, but at the same time, the importance of school P.E. lessons has changed slightly among youth. Today, the most important thing in school sports is seen as socio-emotional skills and the promotion of well being. Learning exercise skills comes only third on the list, but still up to 60% of the ninth graders consider it important to learn versatile fundamental and motor skills. (Heikinaho-Johansson & al. 2019, 85-88.)

A recent work of O´Sullivan, Davids, Rothwell, Rudd, Woods (2020, 2-5.) highlighted that like talent, motor learning and related issues have been seen in the past as very physically focused activities. The skill was taught, and its learning was described as a very linear and physical process in which the learner was a purely physical being. However, as described by Blomqvist & Mononen (2016, 20), skill or skillful performance also consists of other elements of skill, and as a result of their development and mastery, good playing skills of a hockey player are created (Savolainen 2016, 565).

Nevertheless, nowadays, alongside the linear learning model, which is physically focused, the non-linear learning model has received attention in academic literature (See O´Sullivan & all. 2020). In this model, the learner is seen as a much more multidimensional character with their own ways of learning, and these learning styles, as well as overall learning, are also influenced by many non-physical factors. (O´Sullivan & all. 2020, 2-5.) Studies have also shown that motor learning has also been found to be very individual and lacks periods of sensitivity (Jaakkola 2014, 54.).

This thesis deals with the theory of motor ability demands of ice hockey, as well as general motor skills. It also introduces theory pertaining to the background of today´s knowledge about motor learning and learning styles and also opens up the philosophy behind the Athletic Skills Model (ASM). Based on the theory that is introduced, TAITOC Pro Ice Hockey Skill Coaching product has been created specifically for ice hockey off-ice training for clubs and school´s academy training. The product is also presented in the remainder of the thesis. All in all, the purpose of this thesis is to develop training material, including lecture material, test and skill assessment tools, as well as the training curriculum. However, as TAITOC Pro Ice Hockey is a market-oriented product based on the purchase of content, only one example exercise has been presented in-depth. Conversely, the theory and ideology behind the development process of the materials, testing and skill assessment, and exercises have been presented in this thesis.

2 Skillfulness in Sports

The theoretical background illustrates the ideology regarding talent development in ice hockey. This includes the motor ability demands of ice hockey, overall skillfulness in sports, motor skills classification systems and motor learning. (Wormhoudt & al. 2018, 115.)

In sports, skill often means the timely selection and introduction of techniques, for example, the basic movements of different sports (Jaakkola 2010, 47). Skillful performance in sports is based on a combination of cognitive and motor abilities (Blomqvist & Mononen 2016, 20; Jaakkola 2010, 47). According to Kalaja (2016, 234), sports performance consists of different stages, which are perception, decision making, and movement control. Although athletes' performances often have individual characteristics, one can often find common features in skilled performances. In them, the performer achieves the goal of the task or environment more confidently and more likely than a less skilled person, and thanks to the automation of movements, time is no longer consciously spent regulating movements, allowing the task goal to be achieved in the shortest possible time. (Jaakkola 2010, 47.) Blomqvist and Mononen (2016) have pointed out that

> ″the importance of cognitive skills is particularly emphasized in sports that are challenged either individually or as a team, whereas in these sports the athlete / player has to constantly adapt to changes due to the opponent, teammates and the environment, and in order to succeed in the sport. Individual solutions must be made effectively and in a timely manner, taking into account individual strengths and weaknesses. ″ (Blomqvist and Mononen 2016, 20.)

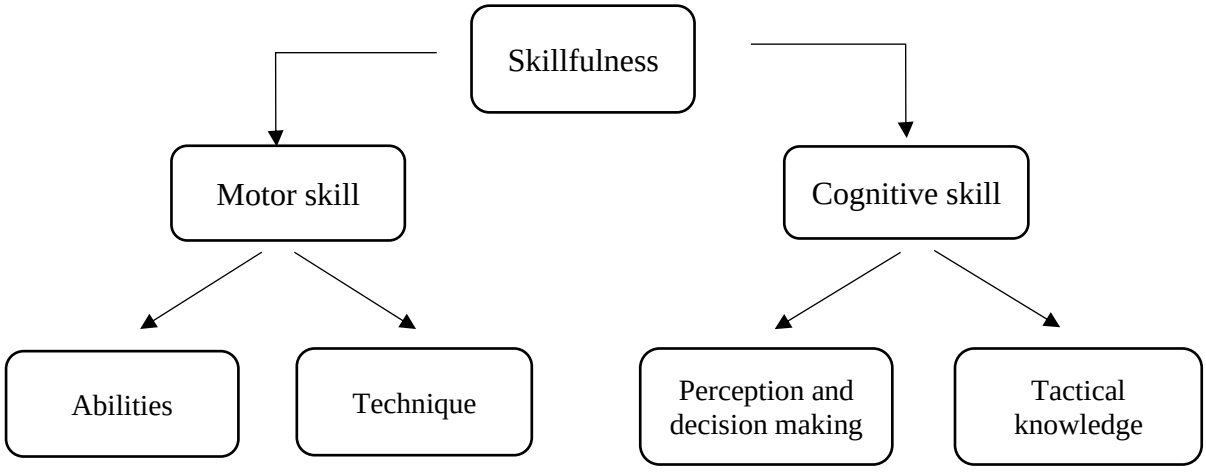

Figure 1: Development of skillfullness (Blomqvist & Mononen 2016, 20.)

Skillful performance in sports requires a sufficient amount of physical capabilites, the ability of perceptors to operate in a functional state and well-developed central nervous system (Forsman & Lampinen 2008, 435.). Sports impose specific demands on an athlete's strength, speed, and endurance, which determine the needs for components of physical ability. With the help of the senses, the athlete receives feedback from their environment to the central nervous system, through which the body facilitates the regulation of coordination of movement. (Forsman & Lampinen 2008, 436.) The ability to coordinate depends on this feedback loop (percpetion-action coupling) and the corrections that guide the movement. Receptor performance refers to the performance of different senses. (Forsman & Lampinen 2008, 436.) The capacity of human attention is limited (Kauranen, 2011, 129) which´is why, specifically in fast-paced sports, it is important that performing the movement does not occupy too much of the athlete's focus (conscious level), but that the coordination is sub-concious and the athlete focuses attention on the environment and the external stimuli (Forsman & Lampinen 2008, 436; Kauranen, 2011, 129). As a result, the athlete has the ability to adapt the movement to the environment and anticipate the future in the matter of seconds (Kauranen 2011, 129). Therefore, even in terms of skills, it is very important to create and develop a sufficiently wide range of movements that could be executed sub-consciously (Forsman & Lampinen 2008, 436). Forsman and Lampinen (2008, 437.) have described the aspects of the skill as seen in Table 1 below.

Table 1. Elements of skillfulness

Elements of skillfulness	Meaning
Orientation	Ability to perceive limb and body postures and their changes.
Kinetic differentiating	Ability to regulate muscle tension and relaxation as well as fluency and economy.
Reacting	Ability to respond appropriately and quickly to stimuli received by different senses.
Balance	Maintaining or achieving stability and regaining it.
Rhythm	Ability to find and implement an appropriate timing of coordination movement.
Coupling	Combining sub-movements into a whole, making simultaneos movements.
Adaptation	Ability to adaps trajectories and use of force to changing situations and conditions.
Controlling	Motion accuracy and standartization.
Differentiation	The ability to distinguish between closely similar movements.
Agility	Ability to change the direction of movement of the body quickly.
Anticipation	Ability to quickly analyze and predict the movements of an opponnent or external stimuli before they occur while utilizing the correct motor skills.

Wormhoudt & al. (2018, 133.) has also introduced The Athletic Skills Model (ASM). The ASM is built in three intertwined building blocks.

- The basic movement skills (fundamental skills) (BMS)
- The coordinative abilities (CA)
- Conditions of movement (COM)
  Wormhoudt & al. (2018, 133, for more detailed description see 2.3.4)

The philosophy of the ASM is: *"A good mover becomes an all-round athlete. The all-round athlete becomes a specialist."* (Wormhoudt & al. 2018, 105.). Based on the model, BMS, CA and COM are essential for the quality of optimal movement development. ASM can also be used to create a structural foundation for healthy athletic development and physical literacy. (Wormhoudt & al. 2018, 103-133.)

Moreover, according to Kauranen (2011, 12.) human motor performance refers to the totality of optimal motor responses resulting from central nervous system control. More specifically, it refers to a functional entity formed by sensory senses, the central nervous system and motor immune response functions. Human motor performance is one of the components of human performance and is influenced by individual characteristics, the task to be performed, and the execution environment. The current level of performance is affected by several factors such as motivation, alertness and physical fitness.

Human psychomotor performance, in turn, means proper control of movement, the ability to perceive time and space, and the cooperation between the eye and the hand. It's central factor is perceptual skills, where sencory perception and movement are inextricably linked. (Kauranen 2011,12.)

3 The Motor Ability Demands of Ice Hockey

Ice hockey is a fast-paced game, which is accelerating all the time. The increasing speed also means that situations become faster and the time to react and predict the next move as an individual athlete is reduced at the same time. This increase in speed has set new criteria for the skill of the athletes. (Savolainen 2016, 565.) Additionally, the athlete needs to be holistically agile, in terms of life skills, mental skills, athletic skills, playing skills as well as game perception (Tiikkaja & al. 2016, 564-579). The underlying physical aspects

of the movement within the game of ice hockey, which athlete need to handle, are those such as technical, tactical and motor skills (Laaksonen 2011, 20).

Ice hockey is a team sport. Thus, it demands not only individual technical skills but also team tactics to promote collaborative actions in performance environment. (Woods, McKeown, O'Sullivan, Robertson & Davids 2020, 3-10.) The goal of having team tactics is so athletes can use their individual technical skills better during the games and prevent their opponents from taking advantage of their own team's weaknesses. However, if a athlete's technical skills, playing skills and reactions are not at the appropriate skill level it is quite difficult to accomplish the team tactics. (Westerlund 1997, 532-535.)

Figure 2. below describes the relationship between an individual athlete's game skills and team performance. The table is an adaptation of Savolainen's (2016, 565.) work of the connection between game analysis and playing skills and team performance.

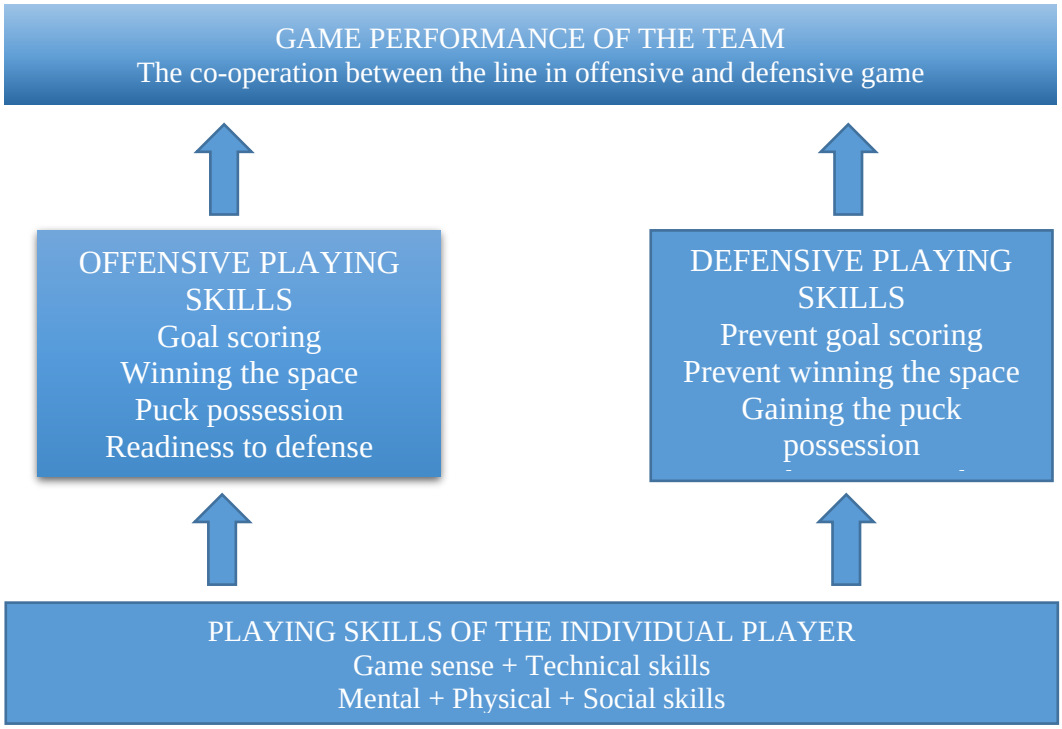

Figure 2. Game Performance of the Team

3.1 Player – Physiological and skills requirements

According to the International Ice Hockey Centre of Excellence (IIHCE 2020), ice hockey sports-specific techniques are divided into skating, puck control, passing and receiving a pass, shooting, face offs, battling and blocking. Sport-specific skills include the appropriate use of sport technique according to different situations, the ability to correct errors in technique and the ability to learn new techniques quickly, such as combining skating with puck handling, deception, passing and shooting as required by different game situations. (IIHCE 2020)

The most important sport specific skill in ice hockey is skating. The basic principles of good skating are versatility, strength, speed and endurance. Skating can be divided directly into forward skating, forward cross overs, straight backward skating, backward crossovers, stop and starts, and turns/pivots. (IIHCE 2020.) The quality factors of a good skating stance are keeping the eyes up in the game, an angle of about 90 degrees between the legs and thighs, the foot performing the skating stride under the body, the center of gravity over the foot, hands and feet reciprocal rhythmic movement forward and backward, and the upper body and kick-starting leg the tilt of the lower leg is the same. The technical performance of skating can be broken down into four core points; stance, kick, slide and return. (IIHCE 2020; Laaksonen 2011, 12-14.)

Because the situations in the game and the direction of the game change quickly, in addition to the direct skating speed, the player must swiftly coordinate between agility skills and reaction speed. In addition to sufficient speed characteristics, the player must have the ability to further accelerate the speed of skating and maintain skating posture even at high speeds. (Laaksonen & Vähälummukka 2016, 571.)

The game of hockey also places a wide variety of other demands on agility and quick decision-making. Rapid turns, changes of direction, and stops/starts, not only require sport specific technical competencies, but also reaction speed and the ability to quickly reach a fast pace. (Laaksonen & Vähälummukka 2016, 571.) At the international top level, it was observed that forwards perform crossovers or glide turns about 72% of their ice time during the game (Krause, Smith, Holmes, Klebe, Lee, Lundquist, Eischen & Hollman 2012, 1423).

Today, the player must be able to shoot quickly with different techniques directly from skating, receiving a pass, direct from the pass (one-timer), and straying from different situations and positions (IIHCE 2020). In game situations, shooting and scoring usually

always take place under the pressure of the opponent (Laaksonen 2011, 17). Another factor affecting the speed of the game is the ability to pass and receive a pass while keeping the feet moving (IIHCE 2020). Both passing and receiving a pass often take place from different positions and speeds. The athlete's ability to perceive the environment becomes extremely important because multiple players are involved in passing. An athlete must be able to give and receive a pass many times under the pressure of the opponent. (IIHCE 2020.)

The core points of puck control are contact with the puck, the rhythm of the hands and feet, the range of motion (hands far from the body) and visualizing the game (IIHCE 2020). The ability to maintain the rhythm of the hands and feet, control the puck with the wide range of motion in various playing stances and to observe the environment at the same time are very important features for the player in terms of puck control, especially in game situations (Laaksonen 2011, 18).

Face-off skills include different sorts of face-off techniques. Important skills of battling are the skills of staying in the puck as well as the skills of removing the puck. Also blocking the shots and cutting out of the passing lines are counted as a sport specific techniques and skills in ice hockey. (IIHCE 2020.)

In terms of individual in-game performance, playing skills play a significant role. Playing skills combine game sense with the player's sport specific technical skills, player's physical characteristics (i.e. speed, strength, endurance), mental (i.e. courage, creativity, determination) and social (cooperation skills) capabilities. (Savolainen 2016, 565.) Top players on a team are able to perform the technical skills during the game, in different situations as required by the situation in the interests of the team. For this, the player also needs excellent ability to perceive the environment, as well as, quick decision-making. (Laaksonen 2011, 24.) According to Savolainen (2016, 568), the player´s game sense consists of the player's ability to observe environmental stimuli, such as the directions of movement of players and the puck, distances, speeds and changes in rhythm.

The player seeks to anticipate and read what is happening in the game mainly based on visual cues (Laaksonen 2011, 24), but the reaction also takes place parallel to the auditory and sensory senses, this is due to the small playing space and contact. Efficient utilization of reaction speed in hockey requires a lot from the athlete, such as technical readiness, knowledge and experience, perception, tactical readiness, initiative and decision-making, skill, orientation, balance and motivation (Laaksonen 2011, 69).

Ice hockey is an interval-driven, physiologically diverse game with a lot of starts, stops, change of direction, battling and maximum accelerations. This requires the player to have well-developed aerobic and anaerobic conditioning, strength, power output, speed, agility and balance. (Laaksonen & Vähälummukka 2016, 567.) According to Karhunen (2012, 29-34), ice hockey players' physiological demands can be split into six different categories: endurance, strength and speed, dynamic mobility, balance, coordination and body control. Because the game situations and direction of the game change quickly, the important aspects of the speed in a game situation are the speed and power of the first skating strides. In addition to sufficient speed characteristics, the player must have the ability to further accelerate the speed of skating and maintain skating technique even at high speeds. (Laaksonen & Vähälummukka 2016, 571.)

Sport-specific speed often manifests itself in different ways in different sports, which in turn means that sport specific speed is also affected by a variety of different factors (Hakkarainen 2009, 219). In general, the components of sport specific speed can be divided into four categories: reaction speed, explosive speed, movement speed and speed skills (Forsman & Lampinen 2008, 430). According to Hakkarainen (2009, 222-223) speed characteristics, especially sport specific speed, are affected by several different components such as reactivity, sense of rhythm, frequency of movement, speed, skill, mobility, elasticity and relaxation. It is important to pinpoint that each of the above-mentioned components are trainable. In order to ensure the development of speed and speed skills, it is very important to vary the stimuli that affect it, for example conditions, environment, duration, speed, step and pull lengths or density of the performance (Forsman & Lampinen 2008, 431.).

Although jump height and acceleration speed have been reported to have a strong effect on a player's skating speed, agility is also affected by other factors such as quick change of direction without losing balance and incorporating strength and power. Besides to accelerate skating speed quickly, the other important abilities for changing the direction quickly include the ability to maintain speed in fast turns as well as the ability to stop quickly. (Nightingale, Miller & Turner 2013, 1744.) Table 2. Illustrates an overview of different physical components that affects the player´s skating speed (Laaksonen 2011, 31.).

Table 2. Factors effecting skating speed in ice hockey

Component	**Importance in speed**
Technique	Critical for skating efficiency
Power	Body support from low knee angles → longer skating stride and power production Maintaining the playing stance in fast paced pivots without slowing down
Efficiency	Power output of the skating stride
Frequency (speed)	Amount of the skating strides
Agility	Quick change of directions and coordination of movement
Mobility	Range of motion of the skating stride
Anaerobic energy producing	Energy production for fast and efficient muscle function
Aerobic energy producing	Quick recovery in sprint situations
Body composition	Low fat usually means better relative strength and more efficient movement
Nervous system function	Better ability to activate muscles at a high level

An ice hockey player needs balance for producing high quality movements while staying on top of a single thin support point, the skate blade (Karhunen 2012, 33). Forward skating requires the player to perform on a single leg approximately 80% of the time (Laaksonen 2011, 11). Body control is of utmost importance. The key is to control the body's center of gravity in respect to the support area. (Karhunen 2012, 33.). Body control is also needed to make a movement by using many muscles at the same time. For example, in skating some parts of the body need to be stable while other parts of the body are mobile. (Karhunen 2012, 33-34.)

Good coordination gives players possibilities to move rhythmically and to combine and modify basic individual skills. As an example, ice hockey players continuously use their legs and arms in different rhythms simultaneously. (Karhunen 2012, 33.) According to Laaksonen (2011, 18-19), "good rhythmic motion of the hands and feet enable weight transfers in the direction of the puck and away from the puck, different rhythms (fast - slow), a smooth combination of skating and puck handling, as well as, the effective use of deception in gaming situations." Also, from the point of view of receiving a pass Laaksonen (2011, 17) states that the player must have the physical abilities of hand and foot cooperation, body control and mobility, which allow to receive a pass rhythmically while skating and the ability to continue game quickly afterwards.

Underlying all of the player's movement, balance, shooting, and battling power is the strength of the hips and middle body. In skating, versatile control of the gluteal muscle area, eccentric control of the proximal and hip flexor muscles, and concentric force of the

extensor muscles of the knee are important. (Laaksonen & Vähälummukka 2016, 569.) Battling force, the shot, and the rhythm of skating emphasize the muscle control and strength of the chest and shoulders. As an example, battling and shooting require strength in the lower back to be able to maintain the isometric control, strength and grip required in the position. (Laaksonen 2011, 30-32.)

According to Wormhoudt & al (2018, 157.) sport-specific strength training does not always need to increase an athlete's muscle mass to increase strength. It is important to increase the athlete's control and a well-considered strength training program should also improve the athlete´s flexibility (range of motion), power and a coordination. (Wormshoudt & al. 2018, 157.)

While in the skating stride, the kicking leg should have full extension from the pelvis to ankle. Good mobility of the hips, groin and hamstrings is especially important for the player in terms of skating position and skating strides, all of which are powered from those areas. Good mobility in these areas also prevents injuries. (Laaksonen & Vähälummukka 2016, 571.) Particular attention should also be paid to the mobility and muscle condition of the lower back area. For example, corner battling situations, as well as shots, cause mid-body rotations which requires good mobility. (Laaksonen & Vähälummukka 2016, 571.) Puck control, with the wide range of motion, requires the player to have good movement of the mid-body and hands in many different directions (Westerlund 1997, 541).

Listola, Ruismäki, Valtonen, Welling & Hakkarainen (2012) studied injuries of Finnish Elite Junior Ice Hockey Players. According to the study, the most common overuse injuries occurred to the hip and groin area. The same study found that the most traumatic injuries occurred to the shoulder / clavicula. (Listola & all. 2012, 1208.)

3.2 Goaltender - Physiological and skills requirements

Goaltenders have a unique position, they need to approach every situation differently than players, while they simultaneously develop similar skills to their teammates. All goaltender actions should start and end with the playing stance. After saves and other types of movement, the goal is to always get back to the playing stance as quickly as possible and be ready for a new movement or save. (IIHCE 2020.)

Goaltender skating can be divided into normal or basic skating, which does not differ from player skating, and goalie-specific skating, or movement. Typical game-like movements of the goaltender are based on good skating skills which require the right playing stance,

good balance, agility, coordination ability, good game sense and fast movement in different directions. (IIHCE 2020.) Good basic control of saving techniques is a prerequisite for goaltender´s puck control. According to the IIHCE (2020.), basic saves can be divided according to the height and direction of the shot as follows:

- Saving low shot by stand-up stance
- Saving low shot by one knee stance
- Saving low shot by using butterfly stance
- Saving high shot by stand-up stance
- Saving high shot by using butterfly stance
- Saving a shot along the ice by stand-up stance
- Saving a shot along the ice by one knee stance
- Saving a shot along the ice by using butterfly stance

IIHCE (2020.)

Goalie stick handling and control, in regard to goalie specific techniques, together with movement techniques and basic saving techniques, lay the foundation for high-quality gameplay. The goalie uses their stick in a multitude of ways including but not limited to passing, flipping, stopping and playing rimmed pucks, playing loose pucks, cutting off passes. The primary goal of the goalkeeper´s game, using skating and movement techniques, is to be located between the centre line of the goal and the puck at the shot is taken. The goalie’s position should allow for controlled movements that are as short, fast and economical as possible. Proper placement requires timely movement, anticipation of goal situations, and good movement and skating skills. (IIHCE 2020.)

The basis of goaltender game sense, understanding and perceiving the game and making decisions, in its simplicity, is the ability to make the right decisions for goal-blocking and reversing play to help create offensive attacks. It also consists of an understanding of the right physical movements and doing them at the right time, in the right place depending on game situations. (IIHCE 2020.) Reading the game requires observing the position, direction, and pace of the puck, opponents, and your own players relative to the playing field and events. What is essential in reading the game is the ability to anticipate the next move and the ability to react correctly to the resulting scoring threat, for example, taking into account the opponent's puck carrier as well as dangerous non-puck-carriers. (Kilpivaara 2011, 2.)

At the top level, the goaltender requires agility, sport-specific speed, explosiveness, quick reactivity, hand-eye coordination, good body control, mobility and quick decision-making (Kilpivaara 2011, 53). In terms of speed characteristics, the goalkeeper is required to have excellent reaction speed, limiting speed, agility as well as sports-specific movement speed and speed skills (Kilpivaara 2011, 56). Power is a necessary characteristic for goaltenders, especially in regard to upper body, and the properties of velocity force and explosive force. For the lower body and core, in addition to speed and explosive force characteristics, good muscle endurance is emphasized so that a good playing position and saving readiness can be maintained throughout the game, even between saving movements. (Kilpivaara 2011, 55.)

To become an elite athlete, a goalkeeper must have a proficient athletic-skill base so that he or she is able to quickly internalize and implement sports-specific skills and techniques. In particular, motor skills and coordination are important for movement and conducting combat movements. Body control is also emphasized, especially in maintaining continuous readiness for saves. (Kilpivaara 2011, 57.)

Goaltenders often play using the butterfly technique, which requires them to move vertically and horizontally at a rapid pace. These controlled movements put high demands on the glutes, pelvic region and core. Without developing strength and muscle control in these areas the continuation of the game will be considerably more difficult. (Kilpivaara 2011, 56.)

The mobility characteristics are emphasized in the goalkeeper game, as the goalkeeper must strive to achieve the best possible range of motion in many combat movements in order to be able to save while maintaining the most balanced and controlled saving stance. It is therefore very important to pay attention to the mobility of the pelvis and hips, as injuries to goalkeepers have become more common in these areas with butterfly style technique. (Kilpivaara 2011, 56.)

3.3 FIHA priorities for player and goaltender developing

In October 2020, the current head coach of the Finnish National Ice Hockey Team, Jukka Jalonen hosted a seminar on physical coaching. The seminar focused on the importance of off-ice training in Finnish youth and top-level ice hockey. Emphasis was placed on the overall importance of training as a whole. (Jalonen, Hakkarainen, Keränen, Kalaja, Yrjövuori & Jaakola 2020.) According to Jalonen and Hakkarainen (2020), all training, as

well as other team activities, should support each other, creating synergy, which takes into account the individual development of the athlete.

Finnish Ice Hockey Association (FIHA) has also defined functional priorities for different ages as part of the ice hockey player's path. According to the athlete pathway, emphasis should be put on the development of speed skills and development of physical characteristic that support playing skills for both youth and top-level training. (FIHA 2020.)

In addition, each year FIHA creates focus points for elite and youth level ice hockey players in terms of games, training, skating and fitness, as well as mental training (FIHA 2020). One of FIHA`s priorities targeted towards players during the 2020-2021 season is that the development of speed skills will be emphasized within the confines of training skill and physical characteristics. FIHA emphasizes the importance of strong legs, pelvis, gluteal muscles, aerobic endurance, balance, body control, a strong core, and strong and fast hands. The importance of training hand-eye coordination is also highlighted, especially in the development of hand speed skills. The importance of jumps and leaps in developing the strength properties of the legs is also emphasized. (FIHA 2020.)

4 Motor skills

Motor skill refers to a skill that requires voluntary movement of the head, body and/or limbs to achieve a goal (Magil 2011, 3). The key definition is that the motor skill is always learned. Motor skill development always includes a goal to be pursued. Because motor skills are required for physical performance, they are strongly related to athlete performance. (Jaakkola 2010, 46.)

The concept of motor skills is often confused with movement. However, different skills require varying movements. Movements are individual parts of a skill, pieces that help tie together a whole skill. (Jaakkola 2010, 46.)

4.1 Motor skills classification systems

Motor skills and tasks can be classified according to several different reference frameworks (Jaakkola, 2010, 48; Kauranen 2012, 360). Motor skills classification categories are usually based on the definition of general or similar skill areas (Magill 2011, 7). According to Jaakkola (2010, 48), Kauranen (2012, 360) and Magill (2011, 7) motor tasks and the skills required in them are usually viewed in such a way that two opposite attributes are placed at some stage in the segment that best describes their attribute. By

classifying skills this way it means many skills are combinations and variations of different degrees, both within the classification scale and between different classification scales (Kauranen 2012, 360-36; Magill 2011, 7). Jaakkola (2010, 50.) also presents a different classification model (two-dimensional grading system) in which skills are considered simultaneously, according to several attributes. This classification model was developed because a classification model in which a skill is placed in a particular category according to one prevailing attribute does not simultaneously consider several skill attributes according to the developer of the classification model.

One way is to classify skills into gross and fine motor skills. This way is based on whether small or large muscle groups are needed to perform them. (Jaakkola 2010, 48; Kauranen 2012, 362; Magill 2011, 7-8.) If large muscle groups are needed to practice the skills, the correct term is gross motor skill. Fine motor skill, in turn, is related to the functioning of small muscles and muscle groups. (Jaakkola 2010, 48; Magill 2011, 7-8.)

Skills can also be distributed according to their performance environment, depending on whether the skills are implemented in static or changing environments. If the environment is static and does not change when the skill is implemented, it is refered to as a closed motor skills. If the skill is implemented in an unstable and dynamic environment that varies during and between performance, it is an open motor skill. In such situations, the successful completion of skills requires the athlete to take into account dynamic environmental challenges and requirements. (Jaakkola 2010, 48-49; Kauranen 2012, 360; Magill 2011, 10–11.) Versatile skills place very different demands on motion regulation and observation. In closed skills, the focus is put on the individual and autonomy, while using open motor skills, the athlete needs to pay more attention to the changing environment. Open motor skills place more emphasis on perceptual and decision-making skills, while closed skills may place more emphasis on performance reproducibility. (Blomqvist & Mononen 2016, 21; Jaakkola 2010, 49; Kauranen 2012, 360.)

A third way to classify motor skills is to divide them into discrete, serial, and continuous skills. Discrete skills include one separate movement with a clear beginning and end. Serial skills include two or more matched individual skills. Continuous motor skill means repetitive skill, where the start and finish cannot be easy identitied. There are tasks between discrete and continuous movements that require a series of movements. (Jaakkola 2010, 49-50; Kauranen 2012, 361; Magill 2011, 9.)

The fourth way is to categorize skills is according to whether or not there are other performers in the environment (Jaakkola 2010, 50; Kauranen 2012, 360). If the

performance is done separately or alone and other people do not affect or complicate the performance, this is refered to as a self-paced skill. Externally paced skills are performed together and in collaboration with other performers. An example of this is team sports involving a ball such as football or basketball. In this case, the field has its own team of players and an opponent, and the person interacts with the attitudes and obstacles involved. (Jaakkola 2010, 48-50.)

Kauranen (2012, 361.) also presents a way to divide skills into motor skills or cognitive skills. Although, all motor performances require both of the above skills, in this model the ratios of their involvement vary from task to task. When using this classification, motor skill refers to an activity in which motor performance is maximized and decision-making is minimized, while in cognitive skill, motor performance is minimized but decision-making is maximized. (Kauranen 2012, 361).

In a two-dimensional grading system, skills are considered simultaneous according to several traits. The classification includes two dimensions; the environment in which the skill is performed and the requirement or purpose for which the skill is performed. Both dimensions include four categories, so the skill requirements in this classification are divided into a total of 16 different categories. The classification is dependent on the type of performance environment, whether the body is static or in motion and whether object control is required or not. (Jaakkola 2010, 51.) This can be seen in Table 3 below.

Table 3. Skill requirement is dependent on performance environment

<table>
<tr><td rowspan="2">Performance environment</td><td colspan="4">Skill requirement</td></tr>
<tr><td colspan="2">Body is static</td><td colspan="2">Body in motion</td></tr>
<tr><td>The environment is immobile and unchanging</td><td rowspan="4">No object handling</td><td rowspan="4">Object handling</td><td rowspan="4">No object handling</td><td rowspan="4">Object handling</td></tr>
<tr><td>The environment is still but changing</td></tr>
<tr><td>The environment in motion but unchanging</td></tr>
<tr><td>The environment in motion and changing</td></tr>
</table>

4.2 Fundamental skills

Fundamental skills are general non-sport-related skills. They are divided into three categories. The number of each fundamental skills varies slightly when reading different literature. Jaakkola (2010, 78.) defines fundamental skills as follows:

- Stability skills: Turning, stretching, bending, spinning, swinging, twisting, stopping, giving way, balancing
- Locomotor skills: Walking, running, leaping, jumping, jumping over an obstacle, galloping, sliding, jumping, climbing
- Object handling skills: Throwing, catching, kicking, scooping, hitting, hitting from the air, bouncing, twisting, kicking from the air
  Jaakkola (2010,78.)

A majority of the fundamental skills are acquired and developed during childhood, however, it is also possible to learn them later in life and acquired skills will last a lifetime (Kalaja, 2014, 23). Contemporary general phenomena, the general passivation of everyday life and the premature specialization of children and youth in one sport, have led to a general decline in the level of mastery of fundamental skills in children and youth (Kalaja, 2014, 23).

Versatile fundamental skill training is the basis for versatile skill learning (Jaakkola, 2010, 77-79), sport-specific skill learning (Jaakkola & Sääkslahti, 2012,109) and prevention of stress injuries (Jaakkola & Kalaja 2014, 22-24). The versatile development facilitates the adaptation of performance technique to new environmental requirements and also enables the transfer of various elements to sport-specific training (Jaakkola & Sääkslahti 2012, 109; Wormhoudt & al. 2018, 39). Sometimes, if an athlete does not learn a sport-specific skill or technique, it may be the result of a lack of basic motor skills or the underlying motor skills. As skills develop, the athlete's sense of competence also grows. (Jaakkola 2010, 77-79.) Diversity and variable stimuli keep the nervous system primed to learn new skills, contribute to mental variation, reduce one-sided training and maintain training motivation (Jaakkola & Sääkslahti 2012, 109).

According to the works of Jaakkola & Sääkslahti (2012, 104.) on youth and children, there have been differences in the management of fundamental skills between boys and girls. Girls have been found to outperform boys in static balance tests, while boys have been found to outperform girls in dynamic balance tests as well as object handling skill tests. No differences were found between girls and boys in tests measuring locomotor skills.

Human movements consist of different controlled positions and individuals who perform various movements flawlessly are often said to have good coordination as well as the ability to control movement (Kauranen 2012, 198-202). Locomotor skills can be seen as the body’s ability to move horizontally or vertically from one place to another by means of movement skills, utilizing the ability to perceive and make decisions (Kalaja 2020).

Locomotor skills, for example jumping, leaping and running, are often also used to develop physical characteristics. For example, absolute speed or endurance is often developed by running. Running speed can be considered a picture of overall natural speed, which is why it is a good indicator to assess developing for overall speed quality. (Hakkarainen 2009, 195-330.)

As it has been discussed earlier in this thesis, skating speed of an ice hockey player is also affected by many other factors than just the absolute running speed. For example, power output/production plays a role in the efficiency of the skating stride (Laaksonen 2011, 31). Power of the lower limbs are often developed by jumping and/or leaping (Forsman & Lampinen 2008, 442; Wormhoudt & al. 2018, 216). To facilitate greater learning and physiological transfer, jumping and leaping exercises have to take into account specific movement patterns (i.e. angle, position, etc.) of the target sport (i.e. ice hockey). Ice hockey players who have better movement control in jumps, leaps, and takeoffs in a variety of ways (single-legged jumps, different directions, etc.) have also been found to be faster as skill requirements increase in skating in different directions, agility and skating techniques (backward, crossovers forward and backward). (Villemejane 2009, 42-48.) However, in order to adequately develop strength and prevent injuries, the athlete must also have good jumping and landing technique (Kalaja 2020).

Kauranen (2012, 180) has defined human stability as the ability to control body position/mass/center of gravity relative to the support surface between muscle strength and incoming sensory information. Indeed, balance skills are considered the basis of movement because each movement contains an element of balance skills (Wormhoudt & al. 2018, 101). Humans are accustomed to moving, acting, and combining movements in three different dimensions, body stability is required to adapt, transform, and react quickly to different situations and postures (Kauranen 2012, 180).

The regulation of human stability takes place through various stability movements and the requirements for regulating stability vary depending on the situation. For example, the task to be performed, the environment, and one’s own physical and mental characteristics. (Kauranen 2012, 181-197.) Stability control consists of several different components, the most important factors influencing the regulation of stability are visual sense, sense of touch, vestibular organ, support surface, environmental factors, musculoskeletal system, preventive measures, coordination and eye-head stabilization (Kauranen 2012, 181-197).

A balance definition from Kalaja (2020.) has also often been used, especially in connection with skill training. According to that, stability can be defined as either static or dynamic based on whether the body is stationary or in motion. In addition to maintaining posture, rotating the horizontal axis of the body as well as the vertical axis are related to stability skills.

The ASM (Wormhoudt & al. 2018, 122) also emphasizes the importance of developing the concentric balance for a number of different sports, such as ice hockey. Stability skills paired with locomotor skills form the basis for an athlete's skillful and agile movement in a variety of game situations (Wormhoudt & al. 2018, 122). In ice hockey, the athlete must be able to control his body and move in different directions, as well as spin, dodge and stop, even when unbalanced on one foot on a thin blade of the skate. For an athlete to be able to act on the ice in a game situation in a balanced manner, stability skills have to be a part of daily training on and off the ice. (Laaksonen 2011, 66.) If an athlete is unable to control his body in the way required by the sport, or when exercising physical characteristics, the risk of injury then increases considerably (UKK Institute 2020).

Ball skills can be divided into either gross motor ball skills or fine motor ball skills. However, what is common to all ball skills is that they involve an external object. A common definition for gross motor ball skills is that they use several large muscle groups, while fine motor ball skills emphasize motion accuracy and motion control. Ball skills usually require more practice to develop than locomotor skills or stability skills. (Kalaja 2020.)

For example, many ball skills are based on good cooperation between hand and eye. The cooperation between the visual system and the upper limb is referred to as hand-eye coordination. (Kauranen 2012, 235.) More specifically, it refers to *"the ability to coordinate, control, direct, and head upper limb movements based on vision and visual feedback of motor tasks"* (Kauranen 2012, 235).

According to Kauranen (2012, 235-241) the eye and hand are the most important components involved in the hand-eye coordination but other supporting factors and systems are also involved in the design of motor movements that require hand-eye coordination. The object is most often detected from the environment by visual observation or sometimes also possibly by other information. If the subject is located in the middle of the field of view, only eye movements are naturally used to capture and focus the gaze, but if the subject is located on or outside the extremes of the field of

vision, then in addition to eye movements, head movements are often involved. (Kauranen 2012, 235-241.)

However, the subject can be detected from the extremes of the field of view even without head movements, and then the detection is also faster because the movement of the eyes takes place faster than the movement of the head. At the same time, if the head is moved, the field of vision also changes. Thus, observation with slight head movements is also important in ice hockey for speed skills. (Kalaja 2020.)

First, the identification of the object is assessed, then a conscious observation is formed about the object. Once the information related to the movement, direction and position of the object has been processed and the eyes, probably also the and the body have been pointed at the target, the upper limb is visually guided to the target. (Kauranen 2012, 235-241.)

There is a clear relationship between the speed and accuracy of upper limb movements (Kauranen 2012, 243). The higher the speed of movement, the less accurate the movement of the upper limb. Also, when the upper limb crosses the centerline of the body, the movement becomes slower as well as less accurate. Another significant factor in many motor performances is the timely execution of movements. In this case, we are talking about temporal accuracy. (Kauranen 2012, 243-244.)

The Finnish Ice Hockey Association has outlined the development of hand-eye coordination as one of the priorities for the 2020-2021 training aims. Hand-eye coordination exercises can be used to develop athletes' observation and decision-making ability. Good observation ability and quick decision-making have a positive effect on the development of speed skills and puck handling abilities. (FIHA 2020.)

4.3 Athletic Skills Model (ASM)

According to the ASM classification system, fundamental skills are divided into ten different basic movement skills (BMS), as illustrated in Table 4. Like fundamental skills, ASM emphasizes the importance of extensive mastery of these skills for the learning and development of sport-specific skills and performance in all sports. Every sport approaches the execution of BMS in a different way. Analysis of BMS will bring a structured approach for training and for developing a well-rounded and balanced athlete. (Wormhoudt & al. 2018, 91-92.)

Table 4. Basic Movement Skills. (Wormhoudt & al. 2018, 92.)

Basic movement skills (BMS)	
Balancing and falling	Representations of balance: supporting, gliding, rolling, rotational, air, hanging, and all combinations of, balance; acrobatics; the art of falling.
Romping and fighting	Pulling and pushing, lifting, raising and carrying; dueling
Moving and locomotion	Swimming and cycling; walking, running, sprinting, frolicking, galloping, hopping, crawling, and turn, stop and go.
Jumping and landing	Flight, high and rotation
Rolling, tumbling and turning	Rotating in different axes and planes.
Throwing, catching, hitting and aiming	Moving or hitting objects with the upper extremities; dribbling, bouncing, all types of throwing, pitching, hitting, catching, heading and juggling.
Kicking, shooting and aiming	Moving or hitting objects with lower extremities; dribbling, passing and kicking.
Climbing and scrambling	Learning and hanging in multiple positions.
Swinging	Swinging; Swinging while hanging, swinging while leaning and swaying.
Music in motion	Moving to music and making music.

According to ASM, analysis of BMS will bring a structured approach for training and for the development of a well-rounded athlete. However, every sport approaches the execution of BMS in a different way as BMS can be divided into four different categories that are grouped by their relevance to the target sport for the athlete: skills that are sport specific, sport adaptive, sport related and sport supporting. (Wormhoudt & al. 2018, 103.)

All people have abilities, but the differences come in that the amount of an individual ability varies between individuals (Jaakkola 2010, 79; Kauranen 2012, 205). This is why abilities are one of the most important factors between individual differences in learning skills (Jaakkola, 2010, 79-82). Abilities have often been referred to as genetic and relatively permanent traits, but according to current knowledge, diverse and high-quality training in an environment that provides various stimuli can compensate for the development of innate abilities (Kalaja & Jaakkola 2014, 22).

Literature of skill learning illustrates the most common way to divide abilities is to divide them into physical abilities as well as perceptual motor abilities (Jaakkola 2010, 79-82). The physical abilities can still be distributed to coordinative abilities (CA) and conditions of movement (COM) (Wormhoudt & al. 2018, 116-165). The ASM (Wormhoudt & al. 2018, 116-132.) divides the coordination into following abilities (CA) shown in Table 5.

Table 5. Coordinative abilities (CA)

Ability	Occurrence in use
Adaptability	Ability to perform a skill or task in different environments as required by the environment.
The ability to maintain balance (balance ability)	Ability to maintaining and restoring the balance as required by the situation and environment.
The coupling ability (synchronization of movement)	Ability to synchronize movements and directions efficiently, and to let different body parts cooperate in order to achieve smooth movements.
The kinetic differentiating ability	The ability to movement differentiation in the areas of distance, force, timing, speed, and the way of moving
Spatial orientation ability	Ability to maintain the body orientation and posture in relation to key objects, surfaces and people in the environment
The ability to react	The ability to observe, make decisions and respond quickly to various sensory-observed stimuli
Rhythmic ability	Ability to adequate rhythms and change the rhythm as required by the situation or environment

In addition, it is important to highlight that, that BMS serve as building pillars for the development of all aspects of coordination, just changing the environmental circumstances in order to focus on a specific ability (Wormhoudt & al. 2018, 116).

According the ASM (Wormhoudt & al. 2018, 134-165.) the five conditions (COM) that are a prerequisite for good, effective and safe movement performance are those listed below in Table 6.

Table 6. Conditions of movement (COM)

Conditions	
Agility (i.e. maneuverability)	Agility can be seen as the skill and ability to stop, start and explosively change direction, velocities or modes rapidly and in a controlled manner.
Flexibility (limberness)	A range of motion of multiple or single joints both passively and actively. Limited flexibility can have a negative effect on performance.
Stability (i.e. posture/balance)	Adequate use of movement coordination such as bracing, alignment, balance, strength and posture all of which are imperative to desirable stability. Optimal core stability of the body is very important; it is responsible for the transfer of forces between the upper body and lower body.
Power (i.e. force and speed)	Power is determined by the way one can coordinate strength and speed. Power in sports requires an optimal combination of speed, strength, producing a higher level of power.
Endurance (i.e. local and total endurance)	The ability to both physically and mentally preserve through a process or task for a long period of time.

All the elements of COM can also be developed by well planned and progressive versatile fundamental skill (or BMS) training and the improvement of general COM will lead to a better development of sport-specific COM (Wormhoudt & al. 2018 133-165).

4.4 Perceptual motor skills

Perceptual motor skills refer to an entity that includes perceptions, decision-making and action. It includes the skills to use a person's own body and its various parts in relation to the surrounding space, time spent, and power. (Jaakkola 2010, 58.)

In Table 7 below, Jaakkola (2010, 55-56.) describes the different aspects of observational motor skills and their purpose as follows:

Table 7. Observational motor skills

Observational motor skills	Purpose
Body knowledge	• Locations and names of different parts of the body, relationships with each other and importance during activities • How to move and/or relax the body and its parts effectively
Spatial perception	• Perceiving things and objects in relation to your own body. • How much space does the body needs to perform the activity?
Perceiving direction	• Perception of laterality and directional awareness, ability to move effectively in space, perception of environmental proportions and left and right.
Perceiving time	• Knowledge of rhythm, simultaneity and order, timely implementation of order of action.

In sports performance, the athlete first observes and perceives a stimulus from the environment in various senses, after which it is processed at the central nervous system level (Jaakkola 2010, 59). The memory is searched for a reference point to which the stimulus can be attached. If a familiar stimulus is not found, the stimulus is combined with the previous closely related factor and the response consists of one of the previously known responses. The denser the athlete's central nervous system nerve network is, the faster and more certainly a familiar response can be found. If a familiar object is found in the memory, the data processing time is faster, because it is not necessary to compare the stimulus with several objects, and thus the reaction to the stimulus in the form of movement is also faster. Athlete alertness and motivation also affect reaction time and speed of brain data processing. (Kauranen 2011, 120-123; Davids, Vilar, Renshaw & Pinder 2013, 21-34.)

With the help of our senses and, above all, the information they collect, we regulate our visible movements. Indeed, the various human senses and sensory functions play a very important role in the motor of perception and its development. Observations made by the senses create new and change old already existing perceptions of skills, which also sharpens the notion of performance in neural network density. (Jaakkola 2010, 58-61.) Jaakkola (2010, 58-61.) also mentions that the most important senses in motor control in the regulation of movements are the visual, touch and kinesthetic senses but also the sense of hearing is utilized in sports.

Since perceptual function and movement cannot be distinguished from each other, for example in the practice of sports performance or the skill to be learned (Jaakkola 2010, 55), the athlete's actions are always based on the observations and decisions they make (Kauranen 2012, 120-123). Studies have shown that it is also possible to develop human observation skills through various exercises and therefore it should also be taught to athletes (Kauranen 2012, 120-123).

One way to develop perceptual motor skills, especially in the final stage of skill learning, is to limit the knowledge produced by the athlete's different sensory channels. At the same time, this often also develops the athlete's ability to anticipate as well as read situations, especially when the restriction is directed to the dominant sensory channel, which is usually the visual sense. Of course, by developing the sense of sight through various exercises, the athlete's perceptual motor skills can be developed. Importantly, the challenges of decision-making become more difficult as the skill improves. (Jaakkola 2010, 190).

The role of the visual sense is the most significant of the human senses in the regulation and control of movements (Jaakkola 2010, 61) by drawing attention, identifying objects and perceiving distances (Kauranen 2012, 235). The visual sense consists of two different systems; clear vision as well as peripheral vision. Accurate vision identifies the characteristics, colors, and shapes of objects. It also plays an important role in anticipating situations. This phenomenon is called the Quiet eye moment. The Quiet eye moment has it´s own section later on. Peripheral vision, in turn, is responsible for perceiving the spatial relationships of the objects seen and for controlling and regulating previously programmed movements. (Jaakkola 2010, 61-65.)

Our skin's sensory receptors provide information about pain, temperature and movement. Receptors also respond to skin stretching and joint movement. The senses have been found to be particularly important for the accuracy of movements, their uniformity, the regulation of force and the assessment of distant causes. The senses are also used in instrument handling to control movements. (Jaakkola 2010, 68.)

The kineasthetic sense is also involved in the regulation of movements. There are sensory receptors in the muscles and tendons that bring information to the central nervous system about the stretches, strength and pressure of the muscles and tendons. The role of the Golgi tendon organs, in turn, is to protect the muscles from injury caused by overload. The kinesthetic system also provides feedback to the performer on limb location, velocities, and strength. In addition, the kinesthetic sense optimizes the timing of movement initiation, limb coordination, and balance. (Jaakkola 2010, 68-69.)

The sense of hearing is also surprisingly important for an athlete in terms of learning a skill and skillful performance. When learning a skill, we talk about shifting attention outside the body and this can refer to what kind of sound is heard at the most essential point for skillful performance. An example of this is when a racket hits a ball. (Jaakkola 2010, 163.) There is also a balance body in the ear, which plays a major role in maintaining balance and thus also in controlling movements (Kauranen 2012, 175-178).

When the regulation of an athlete's movements is automated and occurs largely unconsciously, attention can be directed further from the body. In this case, a skilled athlete is also able to regulate their movements faster and activate the movement chain required for the movement. Also, the correction of movements is smoother when performance is not disturbed due to analysis caused by excessive performance. However,

the object of attention must be related to the activity and the athlete must understand the causal link between his activity and its outcome. (Jaakkola 2010, 188.)

According to Jaakkola (2010, 161), already in the early stages of skill learning, attention should be shifted from internal to external. At the beginning, however, it is worth keeping attention in the vicinity of the body, but when the regulation of the athlete's movements is automated and happens unconsciously, the attention can be directed further from the body. Shifting attention externally helps the athlete to regulate their movements faster and activate the chain of motion needed for the movement, and in that case the correction of movements is smoother when performance is not disturbed due to, for example, analysis caused by excessive performance. However, the object of attention must be related to the activity and the athlete must understand the causal link between his activity and its outcome (Jaakkola 2010, 188).

Nowadays, ‘Quiet eye’ moment is a concept that appears to be topic for the debate in skills acquisition literature (Jaakkola 2010, 63-67). In simple terms, ‘Quiet eye’ moment means where the athlete pays attention to the moment that is more relevant to performance. It has been showed that more skilled and experienced athletes are able to pay attention to the most relevant moment in terms of performance, and the object of attention / gaze does not vary during performance as often as a less skilled and inexperienced athlete. (Jaakkola 2010, 63-67.) Also in ball games, for example, it is an important skill to find the object to be watched quickly and keep the eye on the target (Kalaja 2016, 234).

The same perspective of mindfulness is now being utilized to support skill learning (Jaakkola 2010, 164; Winkelman 2018, 13-25). Although the athlete usually strives to direct attention internally in the early stages of learning a new skill, for safety reasons, it is worthwhile to try to move attention away externally as soon as possible and from the beginning of the skill learning to a more relevant skill or skill. Even then, it is worthwhile to pay attention at the start and as the skill progresses, the attention can be moved further externally. (Jaakkola 2010, 164; Wulf, McConnel, Gärtner & Swartz 2002, 171-182.)

5 Motor learning

Motor learning can be defined as a set of internal processes influenced by practice and experience, leading to relatively permanent changes in motor ability and skillful performance (Magill 2011, 249). It can manifest as development in practiced performance,

congruency of performance, or transfer of learned performance to a new environment. (Kauranen 2012, 291). However, learning a skill takes place both explicitly and implicitly (Kalaja 2016, 233). According to Kauranen (2012, 398), noticeable changes are exhibited as a result of increased knowledge of motor learning and understanding of the required operational strategies, development of movement control and coordination, changes in muscle activation times, reduction of energy consumption required for operations, reduction in attention requirements and development of self-assessment.

Diverse experiences have been called the talent of learning new skills. Although there may be periods in human development when certain motor skills develop faster, skills can be developed throughout the life and learning process is unique for every individual. (Jaakkola 2010, 79.) The most important thing for the coach to keep in mind is to plan the practices with purpose that is carefully considered to be best for the athlete's development for the particular training session and/or period of time (i.e. offseason, pre-season or in-season) (Forsman & Lampinen 2008, 437; Jaakkola 2010, 79).

In traditional skill training, cognitive factors were not given much value, but the main emphasis has been on the development of physical abilities (Jaakkola 2010, 117) and skill learning was thought to be based solely on conscious learning (Kalaja 2016, 233). However, current knowledge has shown that learning a skill is always a cognitive process too and the training environment and stimuli should be sufficiently challenging enough for both motor skills and cognitive skills. (Blomqvist & Mononen 2016, 20-21; Jaakkola 2010, 117; Wormhoudt & al. 2018, 27-28). In addition, skill learning, and skill training must still take into account the characteristics of the skills, the characteristics of the learners and the individual learning style. (Blomqvist & Mononen 2016, 20-21.)

Indeed, today's research has found that if physical skills training immediately takes into account the skills of perception and decision making, learning is faster and more effective, rather than teaching physical activity alone (Jaakkola & Kalaja 2010, 22). The athlete's problem-solving and decision-making abilities/skills develop best in an environment that encourages athletes to actively search for the possible movement solutions, make decisions, and, inevitably, make mistakes (Kalaja 2016, 233-235).

In terms of skills and motor learning, the coach's most important task is to develop the athlete's perceptual motor skills by creating motivating, stimulating, concrete and as authentic environment as possible, through which it is possible to learn diverse skills and, above all, perception and decision-making skills (Jaakkola & Kalaja 2010, 22). However,

it is important that the athlete is aware of the mistakes made in the performance and with the help of the athlete`s own reasoning and the right kind of feedback received by the coach, performance will improve through training (Ericsson & Pool 2006, 99-100). The coach's methods should therefore be built based on the understanding of performance analysis, practice design, and effective feedback (Chow 2013, 471-472). According to Jaakkola (2010, 190) one way to develop perceptual motor skills, especially in the final stage of skill learning, is also to limit the knowledge produced by the athlete's different sensory channels. At the same time, this will also often develop the athlete's ability to anticipate, as well as read situations, especially when the restriction is directed to the dominant sensory channel, which is usually the visual sense. Of course, by developing the sense of sight through various exercises, the athlete's perceptual motor skills can be developed. Importantly, the challenges of decision-making become more difficult as the skill improves. (Jaakkola 2010, 190.)

In the early stages of skill learning, it is important to generate internal motivation for the athlete (Jaakkola 2010, 155.) Internal motivation can be influenced by several factors, but perhaps the most important are the feeling of competence, positive feedback, social cohesion, and the emergence of positive emotional experiences. (Jaakkola & Kalaja 2010, 22; Jaakkola 2010, 155-157.) The importance of autonomy as a motive for human behavior has been studied extensively in the past two decades with examples of high-performance coaches (Mallet 2005, 417-429). Also, it has been found that at the later stages of the athlete pathway autonomy has greater importance and impact on individual athlete's motivation. (Jaakkola 2010, 155-157.) Other things to consider in skill learning, are the importance of alertness, supporting memory, practicing overall performance, directing attention, practicing the most essential part of the skill, and varying environments and tasks. (Jaakkola 2010, 157-165.)

Researchers have created many different theoretical models of motor learning during the years. All of these have many common concepts, although terms and levels of learning may vary between the models. (Kauranen 2012, 356.) Perhaps the most radical way is to divide the teaching of skills in traditional and cognitive approaches. These two philosophies differ in whether the learner is encouraged to think and solve problems themselves, or whether instructions and patterns of action are given ready-made from the coach to the athlete. (Jaakkola 2010, 123-124.) The other terms for these approaches that are used are linear and non-linear approaches (Chow 2013, 471-472).

5.1 The Fitts´ and Posner´s model of skill learning

Fitts and Posner (1967, 11–14.) have created one combination of motor learning. As shown in table 8, it divides motor learning into three phases; cognitive stage, associative stage and autonomous stage. According to Kauranen (2012, 356), this model has guided other researchers in the development of their own models.

Table 8. Fitts´ and Posner´s skill learning model

Stage	Characteristics
Cognitive stage	• Attention requirements high → For safety reasons, it is advisable to perform the first tasks in the most stable and predictable environment possible • Great variations between performances • Degrees of joint freedom are limited • Progress fast • Lots of feedback is beneficial • It is worth using previously learned skills and trying to transfer them to new task • The stage will take from few days to few weeks
Associative stage	• The movement begins to form an engram • Attention requirements decrease • The degrees of freedom of joints are increasing • Reliability increases • Progress is slowing down • Development of a cross motor program for a task that requires fast movements • Better use of sensor feedback system in slow movements • The anticipation and timing of the movements required in the task is improved, making the movements more fluid • Exercises can be transferred to an open environment; the attention requirements required by the motor task begin to decrease and the attention can be focused more on external stimuli • The athlete strives modify the performance consistently or to create different variations required by the environment depending on whether the skill is needed in a closed or open environment
Autonomous stage	• The movement is automated • Attention requirements are low • Movements are well coordinated • All degrees of joint freedom in use • High reliability • Progress very slow • The movements are automated so the athlete does not have to pay attention to performing the movements, but the ability to pay attention can be transferred to the observation of the environment as a whole and to anticipate future events • The athlete can easily change the performance according to the requirements of the environment • The athlete´s self-confidence and pressure resistance increase as performance reliability increases

5.2 Transfer of learning

Transfer of learning can be addressed as a multi-dimensional concept including different learning mediums such as, but not limited to, movement skills, rule understanding, pattern recognition, decision making, physical conditioning and creativity (Wormhoudt & al. 2018, 84). According to recent findings, the human central nervous system contains general motor systems corresponding to whole sets of similar skills. The existence of general motor systems thus means that previously learned skills are utilized through the transfer effect in learning new skills, choosing the combination of the central nervous system that is closest to the skill to be trained to implement the skill. (Jaakkola 2010, 94.)

Although the transfer effect can be positive, negative or neutral, if there are many different and varied motor systems in the central nervous system, it is very likely that there will also be a program that is close to the new skill or supports the new task in some way. This in turn supports the multifaceted importance of mastering fundamental skills in different environments, providing diverse stimuli. (Jaakkola 2010, 94.) A positive transfer effect occurs when a previously learned skill facilitates the learning of a new skill or the application of a learned skill in a different environment (Magill 2011, 290)

According to Jaakkola (2010, 98.) The positive transfer effect in motor learning has been justified by three different mechanisms as follows:

- The characteristics of the two skills or environments are so close to each other that what has been learned or implemented in the past facilitates the learning or implementation of the latter
- Similar cognitive requirements between two skills or environments
- Similarity in the idea of performances, for example, the different sports performances of different is a sport game idea similar, as in many different team ball games.

Jaakkola (2010, 98.)

According to Magill (2011, 298), the motor learning can also be used to practice the skill of different limbs on the body. A learning can occur in skill development when practicing either from a stronger limb/side to a weaker one or from a weaker limb/side to a stronger one. Wormhoudt & al. (2018, 86-89.) introduced a perspective that the human physiology and motor-learning principles are the same within all sports; it is all human movement after all, just with different surfaces, rules of the games and materials. The authors introduce five different transferable elements which can be distinguished within ASM model. These elements, as presented in Table 9., are movement transfer, perceptual transfer, conceptual transfer, physiological and physical condition transfer and competence transfer.

Table 9. Transfer elements (Wormhoudt & al. 2018, 86-89.)

Element	Meaning
Movement transfer	Transfer between the movements, sports and techniques for similarities in the form of biomechanical and anatomical actions, which are required to perform a task transferred.
Perceptual transfer	Tactical awareness, pattern recognition, scanning behaviors for space awareness, and decision making, mostly based upon comparable visual information.
Conceptual transfer	Sports, activities and games comparable rules, guidelines, strategies or techniques
Physiological and physical condition transfer	Conditions of movements (COM): agility, stability, flexibility, power (strength/speed), endurance and coordinative abilities.
Competence transfer	A total integrated system of knowledge, attitudes and skills can be learned from other disciplines, sports and cultures.

The use of imagery in teaching, overall performance and training in real environments, as well as diverse stimuli, also increase the positive transfer effect, especially as long as the training also remembers progressing more easily to more difficult skills or fundamental skills, and the athlete understands the similarities and differences between skills. (Jaakkola 2010, 96-97.) The use of images emphasizes the understanding of their congruence, which usually also increases the meaningfulness of movements. At the same time, the learner's attention often shifts from making the movement itself to its end result and the performance thus becomes more fluid. (Jaakkola 2010, 130-132.) However, according to Kalaja (2016, 234-235), it is important to remember that while skill learning can be supported by imaginative exercise, watching what others do, or watching videos, nothing can replace doing it yourself.

5.3 Non-linear pedagogy

According to Kalaja (2016, 241.), skill training has traditionally been seen as guiding an athlete towards an ideal performance technique, believing that skills are learned only by repeating the correct techniques. According to non-linear pedagogy as well as the thinking model of differential learning, there are no two similar performances in sports and therefore no optimal performance technique, but instead of pursuing a complete technique, skill training should aim to develop the athlete’s ability to correct mistakes (Kalaja 2016, 241).

In the non-linear learning model, task, environment and the performer are always present in skill learning (Chow 2013, 470). In the model, learning is seen as a very individual process in which the mind, body and environment are seen to be constantly interacting with each other, modifying the learner's behavior. In non-linear pedagogy, motor learning can also be seen as a process of acquiring movement patterns that satisfy the key constraints of each individual, environment and the task. (Chow 2013, 470-471; Kalaja 2016, 241.)

In a non-linear learning approach, the learning environment should always be built as a representation of the performance environment. Learning takes place as a result of the interaction between the athlete and the environment while the athlete simultaneously gathers information about their environment with the aim of making intelligent and informed decisions based on the information provided by the environment. (Chow 2013, 471-472; Kalaja 2016, 241.).

However, despite the fact that the constraint-based coaching approach does not provide ready-made exercise programs or development models for motor skills training, it equips practitioners with a theoretical basis to be considered in exercise design (Chow 2013, 470). In non-linear pedagogy, motor learning can also be seen as a process for acquiring movement patterns that meet the key constraints of each individual. (Chow 2013, 470-471). The coach's job is to guide athletes to various functional movement solution by manipulating constraints within a training session, such as varying the speed of movement, rhythm or equipment. (Kalaja 2016, 241).

5.4 Assessment of skill and motor learning

According to Kauranen (2012, 392) the assessment of motor learning focuses on the athlete's motor characteristics and learning outcomes, using the starting situation before the training or pre-defined criteria, and objectives as a reference in the assessment of learning. The subject of the assessment can be the performance to be practiced and the changes that have taken place during the learning (Kauranen 2012, 392) or the preservation of learning after the end of the training (Jaakkola 2010, 40; Kauranen 2012, 392). Testing the persistence of a learned or practiced skill is based on the fact that the development of the skill will continue long after the end of the training. It takes time for the neural pathways to form and shape and once the process starts, learning will continue even after the end of the training. (Jaakkola, 2010, 40.) However, the transfer of learning or practiced skills to some similar achievement can also be chosen as the subject of consideration (Jaakkola 2010, 40; Kauranen 2012, 392).

According to Magill (2011), skill learning can be viewed through the following five characteristics:

1. Performance has improved over a period of time
2. The variation at the beginning of the training disappears and the performance becomes more consistent
3. The effect of internal and external distractions on performance is reduced
4. Good performance can be performed at any time
5. The learned skill can be applied to different situations as required

Magill (2011, 249-250.)

The measurement of motor learning should always focus on the learning process itself and the changes that take place within it. The evaluation can take place in connection with training or in actual assessment situations by observing training and changes which take place. Other examples of assessment tools are interviews, surveys and various measurements. (Kauranen 2012, 392.) Kauranen, (2012, 395.) also points out that "*there is as little systematic and random error as possible in a good estimation method, and the end result is the highest possible partial value."*

When evaluating motor learning, the quantitative result of a test can be selected as a measurable variable. In this case, the value of the variable always tells and expresses something about the final output or result of the movement or activity. Examples of this are execution time, score, execution frequency, travel distance, or execution accuracy. (Kauranen 2012, 395.)

Another way to assess motor learning is to choose a qualitative factor related to the production of a movement as a measurable variable. Qualitative evaluation targets can be, for example, the correct way of performing movements, the accuracy of movements, the aesthetics of movements, the airiness of movements and the efficiency of movements. (Kauranen 2012, 395.)

6 Project Aims, Constraints and Limitations

The aim of this project is, as it was stated previously, to create an off-ice skill-training tool for ice hockey clubs, teams, coaches, players and goaltenders. The product includes coaching clinics, the skills to be tested and the criteria for assessing the skill, as well as ready-made training program models with their contents.

Ice hockey, as a sport, requires a general skill set from all players, however when working with individual athletes the approach is not as straightforward. It requires an understanding of the individual athlete's needs and an individualized non-linear approach to skill development. This thesis presents a way in which coaches can better assess those individual needs and better identify the skill strengths and weaknesses of each individual athlete. Specifically, this promotes a more comprehensive approach to training, as well as a method driven by adaptive training.

TAITOC PRO Ice Hockey provides a comprehensive set of objective assessment tools, which provide its users with reliable and valid results. With that being said, constraints and limitations can be observed within some of the assessment tools and criteria that naturally have a more subjective nature. In this project, the skill assessment criteria as well as the quality factors of the movements are based on the making of the ice hockey sport specific skills (sport specific techniques and playing skills) in different situations of the game.

However, one constraint was the translation process of the material. The outcome of this thesis is a Finnish built product that is developed for the sports-specific needs of Finnish ice hockey players and most of the resources and relevant research used is in Finnish. Despite deliberate efforts to merge international literature that is written in English with works of Finnish authors, this field of motor learning literature has a diverse use of domain specific jargon that makes it challenging to identify relevant terms that would carry the same meaning.

7 Project planning

The planning process for this project was launched in March 2020. The inspiration for this project stemmed from an interested in off-ice training of ice hockey and, above all, how off-ice training should take place with on-ice training to better support each other. The skill-training concept (TAITOC) has been around for about ten years and the company had a need for building off-ice skill training materials for ice hockey. These materials include theory sections, skill testing plans and assessment criteria.

The development process for this product started immediately. The base and foundation of the exercise plans and assessment were carefully created based off of the Athletic Skill Model. However, it was imperative to first understand the philosophy of the TAITOC concept and the materials of the previously created modules (Fundamental Skills and Advanced Skills) so that the TAITOC Pro Ice Hockey product would retain the same ideology as that of the other TAITOC modules. A few experienced high-level ice hockey coaches were consulted to get a current picture of what they saw as important in ice hockey in terms of an individual player´s skills and ability, as well off-ice training for the sport.

Once an organized outline and structure was created for the product, the focus was shifted to getting acquainted with the theory of learning skills, and at the same time building a testing battery and structure for the practice plans. In October 2020 most of the exercises were videotaped and. the practice plans were downloaded to the server. The product should be published in January 2021 and at that point ready for marketing to national and international federations, ice hockey clubs etc.

7.1 The philosophy of TAITOC

The philosophy of TAITOC (2020) is based in three phases

1. Inspiration
2. Development
3. Using and applying the skills

TAITOC concept is built from three main movement-training blocks, called Fundamental Skill, Advanced Skill and Pro Skill. The TAITOC Training System offers comprehensive tools for optimal skill training for children and youth as well as for aspiring elite athletes. The primary goal is to support the all-round physical and athletic development and to lay the foundation for learning the specific skills of a given sport. (TAITOC 2020)

7.2 The implementation of the project

TAITOC Pro Ice Hockey is meant for federations, clubs, teams or individual coaches and athletes as a off ice skill training tool. Coaching clinics and materials can be acquired either with a separate module only, for example, TAITOC PRO Ice Hockey or all the three modules (Fundamental Skill, Advanced Skill and TAITOC Pro Ice Hockey).

Pre-made training plans of the TAITOC Pro Ice Hockey, as a whole or parts of them, can be included for the team´s or player´s weekly, monthly or yearly plans. During the off-season or pre-season, it can be the own topic/characteristic to be trained inside of the weekly or monthly plan. During the season premade training plans or parts of them can replace, for example, traditional speed or plyometrics training. Another option is to include pre-made training plans or parts of them in the “Academy training” organized by schools or the clubs, either so that all players do same exercises or, for example, if the aim is to develop individual´s weaknesses or strengths, the coach or the player can pick up the pre-made practice plans or individual exercises that are create to trained aim characteristic. A third option can be to pick individual exercises to include in the initial warm-ups.

7.3 Project Description

Where the TAITOC level I and II coaching contents of the TAITOC skill coaching concept (fundamental skills, advanced skills) are more general training exercises, the PRO level coaching contents are more sport specific. (TAITOC Pro) This specificity means that the training content takes into account sport-specific biomechanical and physiological factors, such as sport-specific directions of movement, modes of movement, articulation angles, power generation patterns and musculoskeletal factors, as well as musculoskeletal factors such as musculoskeletal and muscle balance. Although sport specificity has also been taken into account as a large part in the content, testing and exercises, diverse fundamental skills as well as advanced skills still play a major role. This also ensures that the training is diverse, which is still conducive to the development of overall skills and the prevention of stress-related injuries. The development of sport-specific coordinative abilities as well as perceptual motor skills and non-linear pedagogy has also been strongly taken into account in the planning of exercises. The purpose of this skill-coaching concept is also to serve as a sport-specific off-ice training tool that takes into account the skill elements of the sport. The coaching content at these levels is primarily aimed youth and top-level athletes. (Wormhoudt & al. 2018, 187-221.)

The materials of the TAITOC Pro Ice Hockey include a theoretical basis, the skills to be tested and the criteria for assessing the skill, as well as ready-made training program models with their contents.

7.3.1 Theory materials

The theoretical part focuses on the researched knowledge about the exercise and training backgrounds and habits of today's youth athletes in Finland and justifies the importance of versatile skill training in the daily training of youth ice hockey players who are still reaching or are already at the top level. It also introduces the connection between the sport specific ice hockey training and versatile skill training. The theoretical part covers the theory of skill and its learning, as well as assessment methods. (Wormhoudt & al. 2018, 86-89; TAITOC 2020)

7.3.2 Testing and evaluation of skills

The testing exercises design and the evaluation criteria have taken into account the theory of motor skills and motor learning, as well as the motor ability demands of the ice hockey, as outlined by Table 10 below. The skill assessment should always take place before starting a training program and continuous assessment of development measures should be done on a regular basis. The same is said for on-ice performance. The players' performance on-ice should reflect the progressions made during off-ice training. Baseline assessment measurements help provide coaches and trainers with a starting point for practice plans. (Magill 2011, 249-250; Jaakkola 2010, 40; Kauranen 392-395; TAITOC 2020.)

Table 10. Testing and evaluation of the skills

Skill	Quality factors
Leaping, jumping, push offs and landings	• The "naturalness" of a single leap, jumps, push offs (posture, extensions, landings.) • "Naturalness" and rhythm of successive performances (legs + legs and hands) • Clear start and stop of the perform
Rhythm and ability to direction change (agility and coordination)	• Ability to accelerate / regulate movement rhythm and regulate / change power output with different stimuli (jumps, leaps, push offs)
Stability (body control and balance) skills	• Body and movement control • Finding / maintaining balance

Ball skills	• Ability to control the object with different rhythms and range of motions
Speed Skills (Coordinative abilities, hand-eye coordination and observation & decision making)	• Performs clear movements / sets of movements as quickly, vigorously, rhythmically and in a controlled manner • Speed skills of the lower limbs (legs) • Mid-body and upper limbs speed skills (a stick behind the neck and a series of movements with straight hands) • Speed skills of hands (hand-eye coordination) • Comprehensive speed skills
Maintenance support movements and mobility	• Functional mobility of the shoulders, thoracic spine, hip and ankles

7.3.3 Practice plans

The practice plans are divided into three main categories:

- Leaping, jumping and push-off development
- Agility and coordination development
- Ball skills development

Six training units have been built on the basis of each category. Entities are built to develop a particular sport specific skill. Exercises in each category also take into account the development of balance, body control, flexibility and mobility. Although within the exercise set, each section has a specific theme, within the theme, different stimuli have been added to the exercises, which make the exercises more diverse and challenging, and the techniques can be broken down. Thus, training also corresponds to the skill required for ice hockey. The difficulty level of the exercises also increases as the exercises progress. A choice has also been added to many exercises, allowing everyone to choose the turnover option that best supports their own development. (Wormhoudt & al. 2018, 187-221; TAITOC 2020.)

Training plans do not provide a certain number of repetitions or sets per movement. All the practice plans are structured in such a way that each exercise within the exercise plan is related to the sport specific skill to be developed and the training goal is mainly transfer of learning. It is therefore important to focus on the quality of performance and change exercises or stimulus regularly. Within the practice plan, different sections can be implemented in stations. The time spent in each station should be about 10-12 minutes. It

is also good to remember that learning is often non-linear and that learning and/or transfer of learning often does not occur in an instant. If one wants to develop a particular physical aspect using different exercises provided in the practice plans, they should take into account the number of repetitions and sets that are relevant to developing that aspect. (Jaakkola 2010, 136-146; TAITOC 2020.)

Structure of the practice plans includes:

- Warm up
- Development of movement models
- Different ways to 'break' the movement models
- Balance and body control exercises that support the development of the sport specific skill to be trained

Goal of warm-ups is to prepare the athlete for training holistically, but also to develop flexibility (range of motion), coordination, balance and body control, as well as to prevent injuries. Maintenance support exercises and mobility exercises have also been added to the warm-ups, with the aim of increasing the mobility and strengthening of the ankles, pelvic region, and the shoulder region.

The exercises that develop push offs, jumping and leaping are divided into three different groups;

- Jumping and leaping movement models
- Leaping trails
- Jump or leap chaos

The goal of jumping and leaping movement models is to develop push-off skills in different directions, to develop jump/push-off and leap rhythms, and to develop a balanced and controlled landing. The exercises are performed in a closed environment so that the athlete can leisurely focus on the quality factors of the movement models, for example, the movement rhythms and safe and controlled landings without external stimuli and disturbances from the environment.

With the help of leaping trails, different stimuli are introduced such as different platforms, obstacles and other factors that determine, among other things, the directions and ways of execution of movements. Thus, more environmental observation is also involved. Push offs, jumps, leaps and landings take places on different platforms and different positions.

With jump chaos, push off, jump or leap and descent are to be taken to an open environment that is sport-specific, which also increases the requirements for skillful performance, for example due to diverse observation of the environment.

The transfer of learning has been considered, as seen in Table 11, for player's skating kick and successive skating strides, as well as the goaltender´s skating stride and push off from blade to slide or save. The observation and decision-making have also been taken into account several ways as part of motor learning.

Table 11. Transfer from fundamental skills and coordinative skills for players' and goaltenders' skating and movement skills

Skill / exercise	Player	Goaltender
Push off skill (single/double leg) vertical, forward, lateral and backward	- Skating stride	- Push offs from the blade
Push off skill from different positions vertical, forward, lateral and backward	- Skating strides from different positions	- Push offs from the blade in different positions
Push off skill from different platforms	- Skating strides from the blade in different positions and shaken position	- Push offs from the blade in different positions
Rhythm of legs and feet + hands (multiple push-offs / jump / leap in a row in the same rhythm	- Skating rhythm	- Push off rhythm
Balanced landings (pelvic / knee line control)	- Fast power output for skating stride from normal playing stance / unbalance playing stance	- Stopping the movement and quick readiness for new push off/ save

The exercises that develop agility and coordination are divided in two different groups.

- Change of direction
- Change of rhythm and power output

The goal of the exercises in the group of change of direction is to develop the ability to change direction quickly, to develop a balanced and controlled stopping, and to develop the speed skills of the lower body. Observation of the environment and response to stimuli, as well anticipation, will also increase as the exercises and exercise units progress.

The aim for change in rhythm and power output is to develop the acceleration and regulation of movement rhythm, to develop the regulation and change of power output, and to develop lower body speed skills. Observation of the environment and response to stimuli, as well as anticipation, will also increase as the exercises and exercise units progress

The transfer of learning has been considered as seen in Table 12, for players' game skating (agility and accelerations etc.) and also for the movement of the goaltender. The observation and decision-making have also been taken into account several ways as part of motor learning.

Table 12. Transfer from fundamental skills and coordinative skills for players' and goaltenders' agility and acceleration

Skill / Exercise	Player	Goaltender
Ability to quickly change direction	- Pivoting and stopping and starting in different directions	- Moving
Different foot rhythms when changing movements and directions, as well as, hand and feet coordination (quickly and slowly)	- Movement rhythms - Ability to change the rhythm and power output/production of the movement - Speed skills of lower body/legs	- Movement rhythms - Ability to change the rhythm and power output/production of the movement - Speed skills of lower body/legs

The exercises that develop ball skills are divided in two different groups:

- Rhythm
- Hand-eye coordination

The aim of rhythm exercises is to develop rhythmic and non-rhythmic treatments, to develop hands cooperation, to develop the movement skills of the legs and hands in different rhythms at the same time, to develop extensive trajectories and chains of movements. Observation of the environment, response to stimuli and anticipation, will all increase as the exercises and exercise units progress.

Hand-eye coordination exercises aim to develop visual observation, rhythmic and non-rhythmic treatments, cooperation between hands, treatments in different positions, and peripheral and accurate vision. Observation of the environment and response to stimuli, as well as anticipation, will also increase as the exercises and exercise units progress.

The transfer of learning has been considered, as seen in Table 13, for player's puck handling skills (shooting, passing, carrying the puck, faking, controlling the puck in the air), as well as goaltender´s saving and stick playing. The observation and decision-making have also been taken into account several ways as part of motor learning.

Table 13. Transfer from fundamental skills and coordinative skills for players' puck handling skills and goaltenders' saving skills

Skill / Exercise	Player	Goaltender
Throws / catches / object handlings in rhythm and un rhythmic	- Puck handling skills	- Saving and stick playing
Cooperation between hands	- Puck handling skills	- Saving and stick playing
Extensive chains of body movement	- Puck handling skills	- Saving and stick playing
Strong body movement chains	- Puck handling skills and battling	- Saving and stick playing

The exercises that develop stability are divided in two different groups:

- Balance
- Body control.

The aim of the balance exercises is to develop the maintenance of a balanced stance on different platforms, to develop the maintenance of a balanced stance in different positions, to develop the finding of a balanced stance and to develop the maintenance of a balanced stance in an unbalance position. It is possible to add various stimuli to the movements, for example in the form of object handling, which increases the demand for skill. The goal of body control movements is to develop body control in different positions, to develop stability and to develop agility.

The transfer of learning has been considered, as seen in Table 14, for player´s skating stance, playing stance and battling, as well as goaltender´s playing stance, sliding and moving on the ice. The observation and decision-making have also been taken into account several ways as part of motor learning; this is seen below in Table 14.

Table 14. Transfer from fundamental skills and coordinative skills for players' and goaltenders´ stance

Skill / exercise	Player	Goaltender
Balancing in different positions → Ability to quickly reach a balanced stance / maintain balance in different stances	- Battling and faking	- Playing stance and Playing on ice and getting up from the ice → Saving readiness and readiness to move
Staying in a balanced stance	- Playing stance in different situations and sliding	- Playing stance and sliding
Pelvic control	- Skating, shooting and battling	- Moving on stand and on ice - Sliding - Maintaining the playing stance
Controlling the body in unbalanced stance	- Receiving the body check - Battling - Controlling the body and staying in a playing stance unbalanced	- Moving on stand and on ice - Sliding - Maintaining the playing stance

7.4 Results of the project

The results for his project are presented in this thesis as an example practice plan for development of the jumping, leaping and push offs skills. An example practice plan is the first of the six practice plans created to develop jumping, leaping and push offs skills. The practice plans always include the video of the exercise and the quality factors that are taken into account when an athlete is performing the exercise. The amount of exercises within TAITOC system significantly exceeds the amount that could be used in one training session. Therefore, the exercise selection for one practice should be done exclusively for every athlete in order to meet his or her needs.

8 Discussion

Recently, FIHA has placed an additional emphasis on the off-ice practice, development of motor skills, and specifically ‘speed skills’ (in Finnish: nopeustaitavuus). Concerns have also been expressed that, as strength coaching is often outsourced, off-ice training (physical training) and ice training become separate entities. Whereas, the goal of any program should be for off-ice training and on-ice training to be intertwined, creating synergy between these activities.

It has become quite evident throughout this project just how extensive the meaning of the word ‘skill’ is in general and as a concept in sports. As it has been presented in this thesis, skill does not solely involve physical activity. There are many diverse and dynamic building blocks that assemble the skill capabilities of an athlete. Certainly, in sports like ice hockey, the end result is always the output of physical activity but a substantial number of overring constraints affect the quality of the athletes’ performance output. The importance of the motor skill, as a whole or the concept of motor learning is not understood very well in Finnish ice hockey training, and particularly in off-ice training.

It has been clear that motor skill is a wide concept in sport. Moreover, several different terms are used internationally in the literature related to motor skills as well as their learning adds complexity to the understanding and research in this field. Different terms may carry or prescribe the same meaning, yet it commonly varies depending on the authors of the work. This presented great challenges especially in the early stages of the thesis. For this reason, throughout the process of writing of this thesis, I had to consider many times the terminology to use so that the readers would also understand all concepts are discussed above.

In ice hockey, motor tasks in-game situations consist of combinations of different constraints as it is required by the performance context. Although there are sport-specific techniques can be used to solve these motor tasks, each individual player implements these techniques in-game situations differently due to the uniqueness of game situations, the player's body position in the current situation, or the individual player's idiosyncratic way of implementing the technique. Nevertheless, it has to be acknowledged that there are always common characteristics in sport techniques and skills that appear in skilled performances. Kalaja (2020) pointed out that when it comes to speed skills in ice hockey especially at the top level, it is easier to adjust visual scanning actions and decision-making of the individual than the technical execution of motor skills. This ideology of motor learning and skill development has also been taken strongly into account when designing

the TAITOC Pro Ice Hockey theory base for coach education, skill assessment criteria and the contents of training sessions.

TAITOC Pro Ice Hockey training content is by no means intended to compensate for the practice of physical characteristics at the youth stage or at the top level but it has been created as a link between physical training, and sport-specific techniques/skills. However, the exercises and the movements from TAITOC practice plans can also be used to develop physical characteristics. Despite the fact that the motor skill training alone cannot sufficiently replace, for example, strength training as an ancillary form of skate power development, it can help to facilitate the transfer of strength acquired in training to the skating as a result of enhanced coordination between the muscles and / or movement rhythm development. In addition, ball skills exercises can serve as a good supportive dual-task learning mechanism for the development of puck handling skills.

National statistics demonstrate that intrinsic motivation of children and youth has decreased towards self-guided/directed versatile moving, and the overall levels of physical activity fall short of the recommendations even for youth that are actively engaged in training purposefully and aiming for the top level. Although the goal of P.E. lessons in schools should still be teaching and learning of diverse motor and sport-specific skills, the ideology of P.E. lessons has changed slightly and the practice often does not support the fulfillment of the set goals. for example, because it is very difficult to control the level of teaching and the students' goals for P.E. lessons can vary widely. Today, children and youth specialize in one sport earlier than before, leaving out the diversity that automatically accompanies other sports. All this means that in ice hockey, for example, the importance of diverse training that comes through organized team practices should be emphasized. Therefore, the training should always be diverse, especially in the youth phase, and the athletes' skills in different aspects should also be developed in the accompanying training, which was numerously emphasized in this thesis, for both: junior and professional athletes. In Finnish ice hockey, the importance of versatile skills training is well emphasized at the youth and junior stages, and also at the top level. Nevertheless, its importance is not seen in everyday training as much as it should be.

Nowadays, especially at the top level, but also in some junior organizations in Finland, the teams have their own strength and condition coaches, who are responsible for off-ice training. In my own experience, however, many times the advantages of the strength and conditioning coaches lie in the development of the physical characteristics and nutrition but the transfer effect between the physical qualities and the sports relevant motor skills may be insufficient by this kind of isolated physical training. Therefore, such training alone may limit the athletes from reaching their full potential. In this case, the TAITOC Pro Ice

Hockey module provides ice hockey organizations with tools that can support strength coaches' training program design. Especially in the youth stage, but also at the top level, there are also clubs and teams that do not have outsourced strength coaches, but it is a responsibility of the team coaches (head coach or assistants) to take care of the planning and practical implementation of the off-ice training. In this case, there is often a danger that the coaches of the team may not have the sophisticated knowledge of physical development of athletes or time to devote to the off-ice training to get the most out of the available opportunities. In this case, the existing structure of the TAITOC Pro exercises may bring relief to the coaches' daily lives, and, although, coaches themselves need to know exactly what they are coaching, the ready-made training plans help them use time and organize quality practices without the need to (over)think the planning of those and do everything by themselves.

Although TAITOC Pro Ice Hockey material has already been built to ensure training to be done in a progressive manner, broken down into the development of general motor skills as well as sport-specific motor skills, it is important to highlight that it is always the coach's responsibility to choose the right level of training for the team is being coached or individual players. Some of the exercises have also been given different variations that can either make it easier or more difficult to complete the tasks by adding different stimuli. Also, in this case, the coach must know why the stimulus at hand is added to the training and what it aims to do, and whether the addition of the stimulus serves the needs of the particular player or group. In other words, coaches must understand what kind of emerging movement outcomes they are trying to achieve by the manipulation of the constraints in training.

All in all, my own knowledge of skill learning, as well as transfer effect, really deepened a lot as I did this work. There is a lot of international literature and research related to the field of understanding and adopting a modern view of skill learning, for example, from the coaches´ point of view for how to create and build quality training. As it has been stated on several occasions in the thesis, the development of various skill attributes is not limited to the training at the youth stage, but also at the junior stage when the training aimed to develop top athletes, as well as in the training of the professional level. A versatile skill training, both off-ice and on ice, is very important not only for the development of skills, but also for the prevention of stress-related injuries and the meaningfulness of the training.

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APPENDIX 1

Development of jumping, leaping, push offs and landing – Practice plan 1

WARM UP

Rotation of joints	
Exercise	**Quality factors**
Ankle rotation https://player.vimeo.com/video/473317584	- Controlled and balanced body posture - Controlled and wide range of motion (both directions) - Clear start and stop of the movement
Knee rotation https://player.vimeo.com/video/473318462	- Controlled and balanced body posture - Controlled and wide range of motion (both directions) - Clear start and stop of the movement
Crucifix https://player.vimeo.com/video/473319518	- Keeping the shoulders on the ground - Controlled and wide range of motion (both directions) + stopping the movement and light stretching on the sides – Clear start and stop of the movement
Scorpion https://player.vimeo.com/video/473319438	- Keeping the flat of the hands on the ground - Controlled and wide range of motion (both directions) + stopping the movement and light stretching on the sides - Clear start and stop of the movement

Shoulder rotation https://player.vimeo.com/video/473317761	- Controlled and balanced body posture - Controlled and wide range of motion (both directions) - Clear start and stop of the movement
Wrist rotation https://player.vimeo.com/video/473319239	- Controlled and balanced body posture - Controlled and wide range of motion (both directions) - Clear start and stop of the movement
Neck rotation https://player.vimeo.com/video/473317663	- Controlled and balanced body posture - Controlled and wide range of motion (both directions) + stopping the movement and light stretching on the sides - Clear start and stop of the movement

Hopping	
Exercise	**Quality factors**
Hopping forward and backward using two feet https://player.vimeo.com/video/473316622	- Flexible and balanced landing, toes knees and hips line and pointing forward all the time, control of the core - Extension by ankles while push offs from the ground and controlling the body in the air - Rhythmical hops and clear start on stop of the movement
Hopping laterally using two feet https://player.vimeo.com/video/473316961	- Flexible and balanced landing, toes knees and hips line and pointing sideways all the time, control of the core

	- Extension by ankles while push offs from the ground and controlling the body in the air - Rhythmical hops clear start on stop of the movement
Hopping laterally moving forward and backward using two feet https://player.vimeo.com/video/473316826	- Flexible and balanced landing, toes knees and hips line and pointing forward all the time, control of the core - Extension by ankles while push offs from the ground and controlling the body in the air - Rhythmical hops clear start on stop of the movement
Hopping forward and backward moving laterally using two feet https://player.vimeo.com/video/473316537	- Flexible and balanced landing, toes knees and hips line and pointing sideways all the time, control of the core - Extension by ankles while push offs from the ground and controlling the body in the air - Rhythmical hops clear start on stop of the movement

Activations	
Exercise	**Quality factors**
Gluteus stretch + upper body/ thoracic spine rotation https://player.vimeo.com/video/177549079	- Core control - Controlled rotation - In the extreme position hand-shoulder-shoulder-hand straight line
Salmiakki whirl https://player.vimeo.com/video/198682574	- Controlled movement - Range of motions - Movement rhythm
Lounges to different directions + holding up https://player.vimeo.com/video/135657024	- Core control - Foot, knee, hip line + pointing

– Add for the exercise ⇒ Hold a basketball/fitness ball, stick or weight in hands directly out in front of your body ⇒ Pulling with a band from different directions ⇒ Holding the slightly heavy object with a straight hand up above the head	straight forward - Controlled and balanced movements
Cross lounge https://player.vimeo.com/video/177548445	- Core control - Foot and knee line (pointing the same direction) - Flexible and accelerating push off back to the up position
Squat pumps https://player.vimeo.com/video/139323882 – Add for the exercise ⇒ Hold a basketball/fitness ball, stick or weight in hands directly out in front of your body ⇒ Pulling with a band from different directions ⇒ Holding the slightly heavy object with a straight hand up above the head	- Foot/knee and hip line - Core control and eyes straight forward - Flexible pumping + body control
Clock https://player.vimeo.com/video/129196375	- Shoulders aligned - Core control - Continuous movement
Whirl on the floor + openings https://player.vimeo.com/video/135657128	- Direct rotation - Arms and legs up in the air - Wide openings
Arch swinging https://player.vimeo.com/video/177548974	- Range of motion - Controlled swinging - Movement rhythm

JUMPS, LEAPS, PUSH OFFS AND LANDINGS

Jumping and leaping movement models	
Exercise	**Quality factors**
Jump squats https://player.vimeo.com/video/473317146	- Push off stance (Knee angle at least 90 degrees, foot/knee/hip line, core control, eyes up) - Fully extension in the air by hip, knees and ankles + body control - Movement rhythm of jumps + balanced, controlled, flexible and "glued" landing (Foot/knee/hip line and controlled core) - Clear start and stop of the performance
One-legged jump forward https://player.vimeo.com/video/473321009	- Push off stance (Flexible knee angle, foot/knee/hip line, core control, eyes up) - Rhythm of jumps (rhythm of hands and legs + movement rhythm) and extension of the jumping leg after push- off (hip, knee, ankle) - Balanced, controlled, flexible and "glued" landing - The performance starts from the playing stance and end to the playing stance
Forward leaping https://player.vimeo.com/video/473319835	- Push off stance (Flexible knee angle, foot/knee/hip line, core control, eyes up) - Rhythm of jumps (rhythm of hands and legs + rhythm of jumps) and extension of the jumping leg after push-off (hip, knee, ankle) - Balanced, controlled, flexible and

	"glued" landing - The performance starts from the playing stance and end to the playing stance
Vertical jump off of two feet with a 180-degree rotation and land on one foot https://player.vimeo.com/video/473317485	- Push off stance (Knee angle at least 90 degrees, foot/knee/hip line, core control, eyes up) - Full extension in the air by hip, knees and ankles + body control - Balanced, controlled, flexible and "glued" landing (Foot/knee/hip line and controlled core, no extra steps after landing) - Clear start on stop of the movement
- Add for the exercise ⇒ Hold a basketball/fitness ball, stick or weight in hands directly out in front of your body	

Leaping trails 1	
Exercise	**Quality factors**
One-legged jump forward in different platforms https://player.vimeo.com/video/473320807	- Control and rhythm of jumps (rhythm of hands and legs + movement rhythm) - Balanced, controlled, flexible and "glued" landings - Keeping the rhythm while changing the platform - The performance starts from the playing stance and end to the playing stance
Forward leaping in different platforms https://player.vimeo.com/video/473319675	- Control and rhythm of leaps (rhythm of hands + legs and movement rhythm) - Balanced, controlled, flexible and "glued" landings

	- Keeping the rhythm while changing the platform - The performance starts from the playing stance and end to the playing stance
Trail where are used one-legged jumps forward, forward leaping and jump squats https://player.vimeo.com/video/473317058	- Control and rhythm of jumps and leaps (rhythm of hands + legs and movement rhythm) - Balanced, controlled, flexible and "glued" landings - Keeping the rhythm while changing the jumps and leaps - The performance starts from the playing stance and end to the playing stance
– Add for the exercise ⇒ Hold a basketball/fitness ball, stick or weight in hands directly out in front of your body	

BALANCE AND BODY CONTROL

Balance	
Exercise	**Quality factors**
Balancing in one on top of the mattress or boom https://player.vimeo.com/video/473318262	- Skating stance (about 90-degree knee angle, the whole central of gravity on the top of the foot + controlled core, eyes up) - Controlled ankle, knee and hip (avoid lateral movement) - Clear start and stop of the movement
Balancing in two feet on top of the foam roller or bosu ball https://player.vimeo.com/video/473316098	- Skating stance (about 90-degree knee angle, the whole central of gravity on the top of the foot + controlled core, eyes up)

	- Controlled ankle, knee and hip (avoid lateral movement) - Clear start and stop of the movement
Balancing in one foot on top of the foam roller or bosu ball https://player.vimeo.com/video/473316330	- Skating stance (about 90-degree knee angle, the whole central of gravity on the top of the foot + controlled core, eyes up) - Controlled ankle, knee and hip (avoid lateral movement) - Clear start and stop of the movement
- Add ball skills, hand eye coordination or/and mobility to the exercises ⇒ Bringing a basketball/fitness ball/weight to extreme positions on different sides of the body ⇒ Throwing a basketball/fitness ball explosively from in front of the body and from extreme positions of the body	
– Add other factors that make it more difficult to balance ⇒ Different head positions ⇒ Slight destabilization to different stage of the exercise	

Body control	
Exercise	**Quality factors**
Somersault forward https://player.vimeo.com/video/473317277	- Spine mobility - Controlled rolling to the feet - Controlled end position
Somersault backward https://player.vimeo.com/video/473317351	- Spine mobility - Controlled rolling to the feet - Controlled end position
Head standing https://player.vimeo.com/video/473318558	- Support triangle (head and hands) - Extending the legs up to a balanced position - Controlled landing on the feet