Ice hockey specific strength training with elastic bands

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Abstract

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The importance of muscular strength training during the career of all athletes is remarkable in competitive sports. Actual strength training can be started when children are still quite young. Research has proven that elastic resistance can provide similar properties than free weights or weight machines, making it ideal and effective device across ages from sedentary people to elite athletes Elastic resistance makes it possible for muscles to be strengthened along sport specific patterns throughout the motion

The video project and all its material were produced as a commission for the International Ice Hockey Development Centre. The purpose of these elastic band exercise project was to provide ice hockey coaches and players with a tool that addresses hockey strength training efficiently, diversely and specifically, regardless of the training location. Further, the idea of elastic bands is to provide a safe and easy way for young athletes to start strength training.

The starting point was to get know the exercise device and define primary muscles taking part in ice hockey performance. After that, exercises applicable to on ice performance and following similar movement paths were conceived. The main idea was to improve ice hockey game performance.

Altogether there are 81 exercises, all of which have been filmed and are available on the Hockey Centre Internet server. All the movements have been designed to activate muscles used during an optimal hockey performance. The exercises have been divided into lower body, core, and upper body exercises. Many of the exercises activate the entire body.

The device has been declared to be effective and beneficial in practical use and is being widely used in ice hockey practices. Elastic band exercises help players recognize the muscles used in hockey and activate them in a correct sequence required in an optimal hockey performance. In addition, elastic device has had a central role in the coaching seminars held by the Finnish Ice Hockey Association.

Key words
ice hockey, resistance training, elastic bands, elastic resistance, sport-specific training.

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1 Introduction

Ice hockey is a physically holistic sport, which requires players to have many diverse physical qualities and characteristics. In-game situations such as checking, battling, skating, shooting, and puck handling demand the use of all three types of strength and coaction of many different muscle groups.

Elastic resistance bands are popular and have been widely used method for over 100 years in fitness and conditioning programs. Recently therapists and trainers have used this method also in rehabilitation to strengthen muscles. Further, research has proven that elastic resistance can provide similar properties than free weights or weight machines, making it ideal and effective device from young children to older adults, as well as from sedentary people to elite athletes. Elastic resistance training is popular because it is convenient, portable, inexpensive, versatile, simple to use, and it allows individual to achieve variety of training goals. Major advantage of elastic training is that it does not rely on gravity allowing individuals to perform movements in various places and situations. For the same reason elastic resistive devices have the ability to execute virtually any training movements, making it ideal for sport specific resistance training. Altering platforms the exercises can be made more challenging and to improve balance. (Ellenbecker & Page 2011, 1; Hughes & Page 2003.)

This thesis will cover the advantages of using elastic bands for all three types of strength training in terms of reaching the physical demands set by the sport of ice hockey. All the movements have been designed to support ice hockey game performance. Special focus has been placed on sport-specific power production, movement ranges and paths, and posture control. Implementing these simultaneously in various movements activate ice hockey specific kinetic chains. These specific motion chains enhance the activation of muscles used in ice hockey, improve endurance and improve overall performance as a result of increased power production. Elastic band exercises activate the stabilization muscles of the optimal skating position. This aids players to function more efficiently during the constantly changing game situations. These exercises provide a safe starting point for young hockey players, with special emphasis on increasing strength and control of the core and hip areas.

This thesis and all its material will be produced for the International Ice Hockey Development Centre. All exercises will be filmed and later available on the Hockey Centre Internet server. The exercises will be divided into lower body, core, and upper body exercises. However, many of the exercises will activate also the entire body. The drive to participate in this project came from the opportunity to work with and develop supportive hockey specific exercises with a tool that is so rarely used in strength training. In addition, functional training which complements the sport-specific movement chains and patterns has been a key focus in various strength training books and events.

The purpose of these elastic band exercises is to provide ice hockey coaches and players with a tool that addresses hockey strength training efficiently, diversely and specifically. Another goal of the project was to provide a safe, easy-to-use and effective training tool that can be used regardless of the training location by individual ice hockey players, especially youth players, or by entire ice hockey teams to work on strength training. In addition, the descriptions were made clear so that ice hockey coaches could easily understand them.

2 Sport analysis

Over the years, ice hockey has become a much faster game requiring players to make decisions in a shorter time (Aravirta 2000, 5). According to Montgomery, hockey players today are bigger, stronger, faster and physically in better condition compared to the players in the past decades (Montgomery 2006, 181).

Ice hockey is an intensive and physical sport that contains intermittent and explosive skating, sudden changes in direction, body checking, and struggling with opponents on the boards. Players need to have speed, agility, strength, power, endurance and flexibility, since ice hockey is one of the most demanding sports. Additionally, ice hockey requires technical skills such as shooting, passing, stick handling, rapid skating and interaction with teammates. (Rhodes & Twist 1993a, 68.)

A typical professional ice hockey game consists of three periods, with each period lasting 20 minutes. There are 15-18 minute breaks between each period. During a period, players have 7-10 shifts lasting from 15 to 60 seconds each. Resting time between shifts is about 1-3 minutes. The number of the shifts depends on the role of the player and whether he is a defender or a forward. Usually defenders get the most time on ice, and fourth line forwards the least. (Hakkarainen 2008.) However, in some cases the length of the periods, shifts and breaks can be completely different due to the age and skill level of the hockey players (Moeller & Rifat 2004, 237).

During a shift, a player's lactate levels vary from 4 to 15 mmol/l, demonstrating that the nature of ice hockey is anaerobic. Lactate levels highly depend on the game situation and the player's role in the team. According to Twist and Rhodes (1993) forwards tend to have higher lactate levels because their work requires more intensity. Between shifts immediate energy stores are replenished and lactate removed from player's body through the aerobic energy system (Hakkarainen 2008). Due to the explosive movements during shifts, the ATP-PC energy system is important together with anaerobic energy system. Long shifts with maximal bursts place high demands on the anaerobic system. According Montgomery, (1988, 105) anaerobic energy system supplies nearly

70 percent of the energy requirements during a shift. A good aerobic energy system is vital for the recovery process and the foundation of physical training. (Rhodes & Twist 1993a, 68-69.)

Hockey players need to have strong and powerful leg muscles, a strong core and a muscular upper body without excessive fat mass. The lower body is needed for skating, acceleration to top speed, and body checking. Upper body strength contributes to puck handling skills, shooting and body contact. Core strength together with powerful lower and upper body strength helps players win battles along the boards, in front of the net and on open ice. Hockey requires both absolute strength and relative strength from the players. Absolute strength and muscle strength give an advantage when struggling against opponents during one-on-one confrontations all over the rink. Additionally, muscle mass reduces the risk of injury by protecting bones and joints from extreme contacts. Relative strength contributes in harder shooting, quicker acceleration in skating, and more effective hitting and checking. (Rhodes & Twist 1993a, 69; Moeller & Rifat 2004,237-243.) Since a complete hockey game including warm up and cool down, lasts about three hours, the sport also requires strength endurance, which is the foundation for hypertrophic and power training (Hakkarainen 2008).

The training program of young junior hockey players should focus on mobility, strength endurance, and kinematic skills. Before proceeding to sport specific training, junior players should have a versatile foundation of skills and a good base condition. (Summanen & Westerlund, 23.)

3 Physical profile of a hockey player

The anthropometry of ice hockey players has changed significantly during the last 80 years. Today, hockey players in the National Hockey League (NHL) are notably bigger, stronger, and faster when compared to the players in the early 1900s. According to research, the mean body mass in the 1920s was 75 kg and the mean height was approximately 1,75 m. In 2003 the average height was 1,85m and the average weight 92kg. Regardless of the remarkable increase in height and weight, body fat percentage levels have remained relatively unchanged at around 10%. (Montgomery 2006, 181-185.)

An increase in body mass index (BMI) indicates clearly that players are not only larger, but also larger relative to their height nowadays. According to a survey conducted for the Montreal Canadiens, in the 1930s, the average BMI was 24,3 kg/m^2 and in 2000, the average was 26,6 kg/m^2. The increase of body mass in an average player continues until he is approximately 25 years old. (Montgomery 2006, 181-185.)

The structure of a hockey player is mesomorphic. Most likely due to positional demands, defensemen tend to be, on average, taller and heavier than forwards. Since players of both positions take part in strength training, and because player selection criteria have changed, forwards and defensemen are much more similar in size nowadays. (Twist 1993b, 44-46.)

In addition to the fact that professional players today have more body mass than players in the first decades of the NHL, their $VO_{2\,max}$ results are also higher. In 1982 the mean $VO_{2\,max}$ was 51,9 mL x (kg x min)$^{-1}$ and in 2003, $VO_{2\,max}$ averaged at 59,0 mL x (kg x min)$^{-1}$. This improvement with larger body mass suggests that aerobic power has increased slightly. (Montgomery 2006, 181-185.) According to Rhodes, (1993b) forwards have slightly higher $VO_{2\,max}$ rates than defensemen.

The anaerobic threshold is a good indicator of an ice hockey player's physical performance capacity. A hockey game requires high-power output from players but excessive lactate accumulation should be avoided. The anaerobic threshold of the players in the best physical condition is 80% of $VO_{2\,max}$. (Summanen & Westerlund 2000, 17.)

The on ice heart rate during a game is between 170 and 180 beats per minute. On average, the heart rate of defensemen is approximately 10 beats per minute lower. Today elite teams play with four lines instead of three; despite this the overall beats per minute have increased. Throughout a game, a player's heart rate rises close to or slightly above the anaerobic threshold. During the breaks between shifts, a player's heart rate declines between 110 and 120 beats per minute. (Summanen & Westerlund 2000, 20-21.)

Since off-ice strength training is a part of the conditioning program during the entire season and year, elite players are much stronger today than in the past (Hakkarainen 2008). In a contact game like hockey, muscle strength and power in both the lower and upper body are necessary for players. Muscle strength is a factor that makes the difference between elite and amateur players. Handgrip strength is higher among professional players than it is in amateur or junior players. Compared to other muscles of body, the hip flexors are very strong. (Montgomery 1988, 116-118.)

Strength and power have been measured using many different tests. Two of the most common testing movements are the power clean and back squat. For hockey players, an adequate level of anaerobic strength endurance is 15-20 squat repetitions with 70% of 1RM. An adequate maximal power level a 1RM execution with load a of 1,3 – 1,4 times the player's weight and in the power clean and 2,2 times the player's weight in the squat. (Hakkarainen 2008.) According to Montgomery (2006), highest results in strength and power are attained between 25-29 years of age.

In 1992, the NHL pre-season maximum repetition results with a load of 200lbs in the bench press were 12 for forwards and 14 for defensemen. Defensemen have been notably stronger in the past. Due to the increased amount of strength training as part of conditioning programs, forwards and defensemen today, reach very similar results in strength and power tests. (Rhodes & Twist 1993b.)

4 Biomechanics of ice hockey

Skating

Skating is a regularly repeated locomotion chain of the legs and upper body. In every phase of the skating locomotion, both legs push alternately to move the skater in the desired direction. The crucial parts of body taking part in this skating action are the feet, shins, thighs, and trunk. Most of the energy is produced by the extension and flexion of the joints between these four parts (ankle, knee, and hip joints). (Haché 2003, 69-70.) Although most skating research has been conducted for speed skating, the results suggest that muscle activation and kinematics in ice hockey are similar to those in speed skating (Upjohn et. al 2008, 218).

Skating is a complex locomotion task created by contractions of volitional muscles. The central nervous system coordinates the skating locomotion. Muscle coordination, the rate and direction of force production are essential when performing optimal skating locomotion. (Montgomery 1988, 100-101.) Magnitude and direction of force production alternate in skating. The muscles used in skating are activated in a specific sequence and with different powers. (de Boer ym. 1987 , de Koning ym. 1987.) In effective skating, the activation of buttock, thigh, and calf muscles are emphasized. Control of core muscles and a relaxed back and forth movement of the hands and shoulders contribute to skating. (Mennander 2011, 54-56.)

Skating can be divided into three separate phases. All of them are meaningful to a proper skating performance. The gliding phase starts when the skate is placed on the ice and the skater is gliding forward. During the push-off phase, the skater pushes sideward in order to gain more speed. After push-off is the repositions phase during which the leg is brought back to the starting position for the gliding phase and the following stroke. (De Koning 1991.)

The push-off phase is generated when a stimulus from the central nervous system is transmitted to coordinate muscle contraction for a skating stride. In the push-off phase, the kinetic chain of a skating stride starts from the core muscles and proceeds downward to the lower body while joint angles change. The highest force production is at the end of the push-off as the leg is fully extended and the skate rises from the ice surface. (de Koning ym. 1987, De Koning 1991, 144.) In order to have long and powerful stride, the push-off phase should start below the center of gravity (Upjohn et. al 2008, 208). According to Montgomery (1988) an effective stride is directed perpendicular to the gliding direction of the skate.

The gliding phase refers to the part of skating when the skate glides on the ice. In an optimal skating performance the skate continues to glide during the push-off. At the beginning of the gliding phase the center of gravity is on top of the lower limbs. As this phase proceeds, weight is distributed more equally. Proper gliding technique allows powerful force production during the stride. The gliding phase ends when the skate is lifted from the ice surface. (de Boer ym. 1987; de Koning ym. 1987; de Koning 1991.)

The repositioning phase begins when the gliding phase ends and the skate is removed from the ice surface. After the limb is fully extended and the skate is brought back below the upper body and right next to the other skate, the repositioning phase ends and push-off starts again. (de Koning ym. 1987; de Koning 1991.)

In proper skating posture, the upper body leans strongly forward. When the buttock, thigh and calf muscles are activated, the thigh and shin should form a 90-degree angle. (Mennander 2011, 54-56.) Deeper flexion of the knees and hip creates a longer and more effective stride, which makes the difference between elite and hobby players (Upjohn 2008).

Activation order and force production of lower body muscles changes in all three of the skating phases. The movement starts from the middle body and proceeds all the way down to the smallest muscles of the foot. At the end of the push-off phase, the lower limb should be fully extended so that all of the power is directed against the ice surface. Haché (2008, 69-73) reported that swinging parts of the upper body back and forth enhances force production and delivery. The most essential muscles of the lower body are gluteus maximus, rectus femuris, and vastus medialis. The hamstring muscles contract eccentrically during the gliding phase. Calf and foot muscles are activated and contribute at the end of the push-off phase. (de Koning ym. 1987; de Boer 1987, 371-378.)

A correct sequence of movements and maximal force production of the neuromuscular system are needed in order to attain maximal velocity in skating. Direction of force production as well as optimal frequency of the skating motion sequence also affect velocity. Optimal skating technique is a remarkably important factor when attaining maximal velocity. (de Boer 1987; de Koning ym. 1991.)

Optimal angles in the joints of the lower limbs allow for great production and the ideal direction of force. Ideally, force production in skating should be directed approximately at a 50-degree angle diagonally backward. (de Boer ym. 1987 , de Koning ym. 1987.)

The optimal stride frequency for skating is very difficult to define. It has been found that the faster and more powerfully that a push-off phase is produced, due to optimal joint angles, the higher the kinetic energy in skating. (de Koning ym. 1991.)

Shooting

The slap shot is a "whiplike" kinetic chain movement in which a shooter rotates his torso, shoulders, and forearms in sequence (Laliberte, D 2009). According to Moeller and Rifat (2004, 251) The entire movement can be divided into five separate phases: windup, acceleration, contact with ice, contact with puck, and follow through.

The biomechanics of the movement are very complex. In the beginning, the stick rises up and the upper body rotates to get loaded. Next, the blade makes contact with the ice and puck, causing the shaft of the stick to bend and create potential energy. Within the shot, weight transfers from the back leg to the leg in front, enhancing the kinetic energy. Finally, the velocity of the puck accelerates as it is released from the blade after recoil and before follow through. (Haché 2003, 126.)

The rotation of the trunk is the primary movement occurring during the shooting action. However, the transfer of weight from the back foot to the front foot is a purely linear movement. During weight transfer, the centre of gravity shifts forward in the direction of where force is applied. The crucial phase of a slap shot execution is the transfer of power from the stick to the puck. The rotational motion changes to a linear motion during this phase of an optimal slap shot. (Hayes 1965.)

In the windup phase, body mass is on the skate of back leg. The top hand holds the top end of the stick and the bottom hand is positioned halfway or little bit further down the shaft. As the stick moves backward, the player abducts the lower shoulder and adducts the top shoulder. At this point, the lower hand is raised to shoulder level and top hand is dropped to knee level. Both arms are flexed, however it should be noted that the arm holding the shaft is only slightly flexed. Although the blade of the stick is above the head, eyes remain fixed on the puck to improve accuracy. During the windup phase occurs also flexion, lateral flexion, and rotation of the trunk, hip rotation, flexion of the hips and knees, and dorsiflexion of the ankles. (Hayes 1965; Moeller & Rifat 2004, 251-254.)

The acceleration phase is a whiplike movement initiated by the abduction of the lower shoulder, adduction of the top shoulder, and rotation of torso and the hips. To increase the velocity of the stick, the elbow of the top arm should be held close to the body to shorten the radius of rotation. All the movements of the windup phase are reversed with high velocity in this phase. While the stick is brought forward, body mass is transferred from back leg to the front leg. (Hayes 1965; Laliberte 2009; Moeller & Rifat 2004, 251-254.)

Next, the blade of the stick contacts the ice approximately 7 – 30 centimeters before the puck. The shaft of the stick becomes loaded with potential energy as it bends when the blade hits the ice. The more potential energy a shooter is able to transfer to the puck, the higher the velocity of the puck. Great velocity in the acceleration phase allows for greater flexion in the shaft and a greater amount of potential energy. (Moeller & Rifat 2004, 251-254.) As the blade hits the ice, the wrist of the top arm extends while the wrist of the lower arm flexes, this culminates the build up of velocity. During this impact, skates should be close to the puck and parallel to the aimed direction. This improves balance and permits the hips to rotate properly. Additionally, the parallel stance enables a shooter to start a stride and move toward the goal for a rebound. (Hayes 1965.)

During the contact with puck phase, the stick recoils and transfers all of the potential energy to the puck (Moeller & Rifat 2004, 251-254). According to Laliberte (2009), extended blade contact time with puck clearly creates greater puck velocity.

The last phase is the follow-through. The movement created in the acceleration phase starts to slow down due to reciprocal inhibition. At this point, the arms are extended and the wrists are rolled out, just like in a baseball swing because this rotates the blade for a higher shot velocity. Weight is now completely on the front leg, and the back leg is in the air. Due to this weight transfer, the rotational motion has progressed into a linear motion allowing the shooter to move in the direction of the shot. (Hayes 1965; Moeller & Rifat 2004, 251-254.)

When executing a slap shot, the lower hand should be positioned at least halfway down the shaft or even further. This enables the shooter to put more body mass on the stick, generating additional flex in the shaft during the contact with ice phase. The greater the flex, the more energy can be stored in the shaft and then transferred to the puck while the stick recoils and returns to its original shape. (Laliberte 2009; Moeller & Rifat 2004, 251-254.)

Suitable stick flexibility contributes to the speed of slap shots significantly, especially with young players. A flexible bends more and this creates more potential energy during ice contact. It appears that greater recoil and extended contact time with the puck can be attained with a flexible stick regardless of the composition. (Laliberte 2009.)

There are three different shooting techniques in ice hockey, the slap shot, wrist shot, and backhand shot. The biomechanics of all three shots are almost identical. The wrist and backhand shot do not contain a windup phase, which leads to a quicker release. The velocity is slower, but accuracy is better in both compared to the slap shot. When executing a wrist shot, the top arm supinates and lower arm pronates in order to rotate the blade and create a higher velocity for the puck. The opposite movements of the wrists take place during a backhand shot. (Moeller & Rifat 2004, 254.)

5 Strength training methods

The importance of muscular strength in competitive sports is remarkable. In almost every sport increased levels in strength and power are responsible for the improved results during the last 20 years. (Häkkinen, Mäkelä & Mero 2007, 251.) Research has shown that resistance training improves performance. Due to this, a majority of athletes include resistance training as a big part of their overall training programs. (Costill, Kenney & Wilmore 2008, 204.)

The starting point of training in every sport is to conduct a sport analysis. This also applies for resistance training. All the key features of the sport have to be known before resistance training can begin. Force production times, forces, muscles working during performance, and joint angles all need to be examined by using existing data from research. Additionally, strength and power levels of top athletes in a given sport should be investigated to determine the objectives of resistance training. (Häkkinen et.al 2007, 253.)

Strength can be divided into three types, all of which differ in terms of energy production mechanisms, velocity, magnitude, and duration of force production. The different types of strength are maximum, endurance, and speed. Since muscles adapt as they are trained, athletes should be aware and take into consideration all this knowledge and sport specific training. (Niemi 2008, 95.)

All types of strength develop in children and adults according to heritage and external factors like games, training, and work. Hormonal growth during puberty is attributable to increased strength levels and muscle mass, especially in boys. (Häkkinen et.al 2007, 252.)

Strength training has a major role during the career of all athletes. Games and plays in young children develop strength and power. Actual strength training can be started when children are still quite young. The focus should be on correct technique, strengthening of the entire body, and improvements in mobility. Before puberty, speed and endurance should be stressed in strength training. At the end of and following puberty, maximal strength training can be added into the training program. (KIHU 2008.)

5.1 Strength training of children and adolescents

Strength training in pre-pubescent children

For many years there was a misperception that resistance training harmed the natural growth of children. In addition, children were discouraged from performing resistance training due to high risks of injury. Scientists also thought that resistance training was not beneficial for young children because they have seemingly insufficient levels of circulating androgens. (Anderson & Twist 2005, 56-65; Costill et al. 2008, 394-395.) Despite previous concerns, fitness professional associations and health organizations now agree that age appropriate resistance training and weight bearing activities can be a safe and effective method of conditioning when performed under qualified supervision (Baechle & Earle 2008, 142-150).

Internationally, it has been suggested that strength training for children should be initiated very early. A number of studies have revealed that children as young as age 6 can benefit from regular resistance training. Increases in strength can occur in maximum strength, speed strength, and strength endurance. Training must be executed with age-appropriate methods and correct techniques. Endurance and elasticity of supportive and connective muscle tissues can be developed with jumping, bouncing, and skipping exercises. (Hakkarainen 2009, 197 – 211.) Research has shown that speed strength training with moderate loads, repetitions of 13-15 and diverse exercises yield the best stimulus for adaptation in prepubertal exercisers (Anderson & Twist 2005, 56-65; Häkkinen, Mero & Vuorimaa 1990, 81).

Strength improvements in prepubescent athletes occur without any changes in muscle size. The low levels of anabolic hormones in their body limit hypertrophy, changes in strength appear to be more qualitative. At this age, the nervous system is highly trainable and the positive neural changes are behind the increases in strength. Such changes include increased motor unit activation within and between muscle groups, improvements in motor unit coordination, recruitment and firing, and other undetermined neurological adaptations. (Costill et al. 2008, 394-395.) All of these adaptations can be achieved in young children by training different motoric skills, strength training techniques, and body control (Hakkarainen 2009, 197 – 211).

In the beginning of strength training, particular attention should be paid to technique. Incorrect technique can cause harmful stress on musculoskeletal tissues and lead to an injury. Additionally, once learned, poor technique can be very difficult to change. Training programs can contain more complex movements, but the focus must be on learning the correct technique. As the correct technique is learned, it enhances the long-term progression of training, the long-term adaptation to training, and the transfer-of-training effect. (Baechle & Earle 2008, 142-150; Stone, Stone & Sands 2007, 208-209.) Correct technique must be learned before the end of puberty, when muscle mass oriented training with greater loads starts. Training with big weights requires strength and control of the middle body. Therefore, it is especially important to develop the strength and control of the core. Force production of the lower and upper limbs can be improved more effectively once the strength and control of hip area is at an adequate level. (Hakkarainen 2009, 197 – 211.)

Speed strength resistance training, such as skipping, jumping, or medicine ball throws are excellent methods for developing the nervous system and elasticity of young children. These types of exercises should be included in different games and plays that emphasize motoric skills. (Hakkarainen 2009, 197 – 211.)

Puberty

Heritage and extrinsic factors noticeably affect the increases in strength of children, adolescents, and adults. Maximal strength and muscle mass increase naturally during the first 20 years of life, even without any specific resistance training. Peak development of muscle mass and strength occurs during puberty, especially with boys. This peak is largely attributed to an almost 10-fold increase in testosterone production. Since girls don’t experience such a rapid testosterone development during puberty, their muscle mass continues to increase more gradually and linearly. According to research, the typical onset of puberty in boys is around the age of 12. (Costill et al. 2008, 385-388; Häkkinen 1990, 172; Häkkinen et.al. 2007, 252.) Muscle mass and maximal strength can be developed very effectively after the peak growth stage due to hormonal maturation. The best time for muscle mass acquisition is approximately 1-3 years after the peak growth stage, and it should be utilized if muscle mass is required in a given sport. (Forsman & Lampinen 2008, 418-419; Hakkarainen 2009, 197 – 211.)

Children's chronological age should be taken into consideration before engaging in a resistance training program. There can be significant variations in the emotional and physical rates of growth among children. The maturation level of some 12-year-olds might be similar to that of a 14-years-old, or vice versa. Emotional and physical maturation should be sufficient when initiating training in a weight room. (Stone et. al. 2007, 208-209.)

Resistance training with small weights can be taught to children at the beginning of the puberty. The focus should still be on strength endurance, elasticity, and muscle control. However, speed strength training at this point is recommended and can be added gradually to the training program. Forces in speed strength exercises, like skipping and jumping should remain at a low level. (Hakkarainen 2009, 197 – 211.) A resistance training program can contain complex multi-joint resistance exercises such as the snatch and clean and jerk. The main focus however, must be on learning the correct lifting technique. Children should start training with a long wooden stick and progress to an unloaded barbell in order to learn the proper technique. In addition, strength and control of middle body requires special attention together with correct technique. If proper technique cannot be maintained, the load should be lowered because there is a potential risk of injury. (Baechle & Earle 2008, 142-150.)

Adequate rest and recovery are essential parts of a successful resistance training programs for children during puberty. In the early stages, young athletes need more recovery between training days. It has been recommended that resistance training practices should be scheduled on non-consecutive days. (Gamble 2010, 215-217.)

At the end of puberty

At the end of puberty an athlete can progress to a more adult-like resistance training program. At this point the program contains sport specific, maximal, and speed strength training. Adolescent athletes may engage in the program if proper lifting techniques can be executed and an appropriate development of strength has been achieved. In the case of considerable deficits in technique or muscle development, the training of fundamental movements needs to continue in order to get rid of imbalances in strength or technique. (Gamble 2010, 220; Hakkarainen 2009, 197 – 211.) Athletes with a background of diverse and systematic resistance training can be trained safely and in a similar manner to adult athletes (Häkkinen et al. 1990, 85).

Young athletes and adults respond to sport specific training fairly similarly. Specific exercises should be included into the program gradually, as the skill level of the adolescent improves. Sport specific exercises are selected according to requirements of the sport and playing positions. Since typical dynamic movements in sports involve the flexion and extension of the hips, knees, and ankles, multi-joint lifts are commonly used exercises, especially in speed strength training. (Gamble 2010, 221.)

Rapid changes and strains on connective tissues during growth make young athletes more prone to injury than adults. Soft tissue injuries can be avoided by strengthening the muscles and connective tissues. It is highly recommended that adolescents strengthen these connective tissues in order to accommodate the rapid increases in muscle mass that occur during puberty. According to research, athletes with experience of strength training tend to suffer from fewer injuries. (Gamble 2010, 208-209.)

5.2 Strength training of adults

Sport specific strength training increases and the number of general strength training movements are reduced following puberty (Häkkinen et.al 2007, 257). The objective of strength training for adult athletes is to strengthen the muscles used primarily in sport performance and to maintain the strength levels of other muscles. Sport specific strength training is executed by using movements that are similar to the ones used in the actual performance. A good foundation established before adolescence will allow for constant loading of certain muscles. This means that the lifting technique, supportive muscles, mobility, and basic strength all need to be at a required level. (Kihu 2008.)

The hormonal growth in puberty leads to significant increases in strength and muscle mass in pubescent males. Peak strength levels are normally attained between ages 20 and 30 in men and by age 20 in women. (Costill et al. 2008, 387-388; Häkkinen et.al 2007, 252.)

5.3 Types of strength

Strength can be divided into three different types, which are maximal strength, speed strength, and strength endurance (Forsman & Lampinen 2008, 441).

These three types of strength differ in several ways. They recruit different amounts motor units and through the muscular nervous system in different speed. Primarily used energy sources are diverse among these three types of strength. Additionally, each type of strength needs to be trained differently. (Häkkinen 1990, 41; Kihu 2008.)

The importance of muscular strength in almost every sport is remarkable nowadays. Athletes should carefully examine the types of strength that are needed the most in their sport because muscles develop as they are trained. (Niemi 2008, 95.)

5.3.1 Maximum strength

Maximum strength is the greatest individual amount of force that a muscle or muscle group can generate in a single contraction. Time is not a restricting factor in maximum strength performance. (Häkkinen, Kalinen & Keskinen 2004, 138.)

Development that occurs during the first weeks of strength training is mainly due to improved neural effects. Progress occurs in the volitional contribution and in the co-operation of motor units, which leads to greater force production. Development in structures and cross-sectional areas of muscles can only be seen after many weeks of repeated strength training. (Kihu 2008.)

Maximum strength can be divided into hypertrophic and neural maximal strength training. Hypertrophic training improves concentric maximal strength and increases the size of muscles. Maximal strength training improves the recruitment of motoric units and hence enables athletes to produce greater power in a amount of shorter time. (Häkkinen 1990, 41-69.)

Maximal strength training increases the highest level of concentric force that an athlete can generate volitionally (Forsman & Lampinen 2008, 441). This type of training only differs from speed strength training in load amounts. To ensure the most effective training stimulus loads of 85-100% of the 1RM are used. Sets consist of 1-3 repetitions and 3-5 minutes of rest are held between sets. (Häkkinen et.al 2007, 261.)

It has been investigated that loads under 80% of the 1 RM do not improve the neural force production and can in some cases even impair the neural maximal force production. In many sports it is essential to achieve high maximal force production without developing too much muscle mass. Before this kind of emphasis athletes should increase their muscle mass at least a little bit and pay attention to the supportive muscles. (Kihu 2008.) Studies have indicated that neural maximal strength training with high loads and low repetitions result in relatively low increases in muscle size (Häkkinen 1990, 69).

Hypertrophic training increases muscle size effectively. The execution of hypertrophic training differs slightly from neural maximal strength training. Loads in hypertrophic training are 60-80% of the 1RM, there are 6-12 repetitions, and 2-3 minutes rest between sets. Very often the last repetitions should lead to exhaustion, causing an "overload" procedure. Although hypertrophic training increases muscle size, it also enhances the recruitment of motor units and therefore improves maximal force production. Muscle mass growth or protein increases occur in both fast and slow twitch muscle fibers. However, the growth of the fast twitch muscle fibers is usually greater than that of the slow twitch fibers. (Häkkinen 1990, 60-71; Häkkinen et.al 2007, 261-262; Kihu 2008.)

Additionally, there is a third way to execute maximum strength training. Neural-hypertrophic training is a combination of maximum and speed strength training. This type of training contributes to the neural recruitment of muscle cells and it also increases muscle mass. In neural-hypertrophic training loads are 80-90% of the 1RM with 3-6 repetitions per set. (Niemi 2008, 111.)

5.3.2 Speed strength

Speed strength improves the ability of the neural muscular system to produce the greatest force possible in the shortest possible time (Häkkinen et al. 2004, 149). In speed strength, force production can be acyclic and explosive when a lot of motor units are recruited quickly and production of force lasts from 0.1 – 2.0 seconds. In turn, speed strength can be dynamic and cyclic when force production can last several seconds. Elasticity is a major contributor in cyclic speed strength. (Häkkinen et.al 2007, 251.)

In dynamic speed strength, power is produced with maximal intensity repeatedly from 5 to 15 seconds. Repetitions range from 1-10, training load is 30-60% of the 1RM, and there are 3-5 mintues of rest between sets. The objective of this type of training is to improve the neural recruitment of muscle fibers, the elasticity of muscles, and sport specific speed abilities. (Niemi 2008, 108-109.)

Explosive speed strength is an acyclic movement. In training situations, an athlete tries to include power as much as possible in one or a few repetitions. Power is produced as quickly as possible and the duration of a single repetition is 0.01-2 seconds. As training explosive strength loads are from 40-90% of the 1RM, rest between sets is 3-5 minutes, and there are 1-5 repetitions when fast twitched muscle fibers are primarily behind the action. The objective of explosive strength training is to enhance the recruitment of fast muscle fibers. (Niemi 2008, 107.) Typical movements in different sports requiring explosive strength are single jumps, throws, shots, punches, and kicks. The correct explosive movement is created by a combination of technical skill and explosive strength. (Häkkinen et al. 2004, 165.)

Speed strength training is executed by following speed strength principles. Probably the most important principle is that of maximal effort and high intensity. An athlete must have high vitality and use all of his will power to direct all of his energy and aggression to the performance at hand. Loads in training are between 0-85% of the 1RM. Light loads (0-40%) with high velocity improve elasticity and speed. In turn, a heavy load (40-85%) with lower velocity develops strength and explosiveness. (Häkkinen et.al 2007, 258-259.)

The content and execution of speed strength training is very similar to that of maximum strength training. The main differences between these two are that in speed strength training, loads are usually significantly lower. Additionally, muscle contraction times are shorter and, therefore, velocity in speed strength exercises is remarkably higher than in typical maximum strength training. (Häkkinen 1990, 87-213.)

Long period of continuous speed strength training leads to structural and functional adaptations in the neural muscular system. Since speed strength training hardly increases muscle mass, adaptations deviate completely from typical maximum strength training. Although activation levels in speed strength training are very high, activation time is very short due to the light loads. This enables athletes to develop force production abilities through the neural muscular system without increasing muscle mass in the trained muscle groups. (Häkkinen 1990, 87–147.)

5.3.3 Strength endurance

Strength endurance matters when athletes are required to contract muscles with same resistance for longer periods of time or perform certain sport specific movements repeatedly with relatively short breaks. The ability to maintain a certain level of strength as long as possible is dependent on strength endurance capabilities. (Häkkinen 1990, 41; Häkkinen et al. 2004, 169.) Strength endurance is either aerobic muscle endurance or anaerobic strength endurance depending on the way of execution (Häkkinen et.al 2007, 251).

Typical of both types of endurance involves long duration training with low resistance loads. Muscle endurance training improves the overall aerobic condition, the efficiency of slow twitch muscle fibers, and aerobic metabolism by enhanced capillarization. Improved working efficiency of slow twitch fibers leads to more economic aerobic functioning. (Häkkinen 1990, 41.) Strength endurance improves basic strength, local strength endurance, and the working efficiency of fast twitch muscle fibers. The lactate buffering system also develops through strength endurance training. This leads to more economic anaerobic and sport specific strength training. (Forsman & Lampinen 2008, 441.)

The objective of strength endurance training is to improve overall endurance and to develop the muscular nervous system's ability to produce power for several minutes repeatedly. This develops the ability to produce energy through the aerobic metabolism and to work in circumstances when the lactic acid rate is high. Strength endurance provides the basis for the speed and maximal strength training. (Niemi 2008, 102.)

In strength endurance training, an athlete performs exercises repeatedly with a resistance, between 0-60% of the 1RM. This type of training affects the muscular nervous system or/and metabolism. Aerobic strength endurance training contains a large number of repetitions with low resistances (0-30% of the 1RM). There can be for instance 6-12 different exercises and 2-6 sets at a moderate tempo. In anaerobic strength endurance training the number of repetitions is lower but the resistance in slightly higher (20-60% of the 1RM). A single practice can consist of 4-8 exercises and 2-4 sets at a fast tempo. (Häkkinen et.al 2007, 263.)

5.4 Specificity of strength training

Specificity in strength training refers to the ability of the athlete to produce strength in a specific athletic movement and the capacity for a particular mode of strength training to carry over to sport performances. According to the principle of specificity, exercise adaptations are highly specific to the type of activity and to the volume and intensity of the exercises performed. In order to gain sport specific training adaptations, the training program should stress optimal physiological systems of the given sport. Carry over of adaptations to a sport is greater when the mechanical and metabolic requirements of the sport have been considered while designing training program. As young athletes progress during their careers and approach the elite level, the importance of specificity in terms of physical preparation and resistance training increases markedly. (Costill et al. 2008, 190; Gamble 2010, 1-38.)

In sport specific training the biomechanics of the exercises must replicate the movement patterns and joint angles of the sport performance. The overload element and individual aspects that contribute sport performance need to be considered as well. Additionally, the ideal neuromuscular coordination of a sport performance should be incorporated in the regularly used exercises. Neural specificity contains force, rate of force development and acceleration, movement velocity, type of muscle contraction, and direction and range of movement. The greater the possibility for contribution and transfer to a given sport, the more biomechanical and neural requirements of the actual sport performance are met. Since excessive loading may hamper the proper execution of fine motor skills the appropriate degree of loading will depend on the movement. (Gamble 2010,8; Hoffman 2002, 72; Stone et al. 2007, 221.)

Exercise selection should cater to similar joint angles and the full range of motion featured in the athletic event. Regardless of whether it is isometric or dynamic training, joint angles should at least be as great as those in the actual sport performance. (Baechle & Earle 2008, 87-90.) Studies have shown that improvements in strength and increased motor unit activation have been the greatest with exercised joint angles (Harman, Johnson & Morrissey 1995, 648-660; Kitai & Sale 1989, 744-748).

The majority of resistance training exercises should be either unilateral or bilateral movements, corresponding to what occurs during a competition of an athletic event. Most of the game-related movements executed are partly or fully unilateral. This applies to both upper and lower body movements. Accordingly, lower and upper body strength and power training exercises should comprise of single leg support movements and single-arm lifts. Unilateral exercises require greater stabilization of the core muscles, which corresponds to the requirements of an athletic event. Hence, the transfer of training effects is more likely to occur with unilateral movements. (Gamble 2010, 48-49.)

Some studies show that resistance training results are specific to the type of contraction featured in training. Consequently, the greatest increases in dynamic strength are a result of dynamic strength training, and in turn the greatest improvements in isometric training are gained with isometric training. (Bahm & Sale 1993, 374-388; Gamble 2010, 4.)

Furthermore, velocity specificity characteristics also need to be considered carefully when planning and executing exercises. Such characteristics include the timing profile (magnitude and duration) and the loading timing profile of the movements (acceleration and deceleration), and movement velocity. For instance, explosive exercises should be included in a resistance training program if the sport contains rapid generations of force. Despite the other biomechanical similarities between resistance exercises and an optimal sport performance, velocity specificity is a major contributor to sport performance. (Baechle & Earle 2008, 87-90; Gamble 2010, 5.)

Resistance training at a specific speed has been proven to provide the greatest increases in strength, at or near the training velocity. The transfer of training effect deviates farther from the desired effect if training speeds do not meet the velocities of a game-like sport situation. The adaptations may be attributed to both muscular and neural mechanisms (Bahm & Sale 1993, 374-388.)

It has been noted that a majority of athletes execute their resistance training using free weights. Movements with free weight can replicate and stimulate a sport's skill patterns more effectively in comparison with machines. Movements with machines are restricted by design and cannot take place in all three planes like when using free weights. Complex multiple-joint exercises with free weights also require much more from the central nervous system than the simple exercises with machines. Although these complex movements do not correspond fully to optimal sport performances, the complexity provides a greater degree of skill acquisition therefore, some transfer is likely to occur. Hence, the possible transfer of training effect is considerably greater with machines. (Stone et al. 2007, 245-254.)

5.5 Strength training in ice hockey

Hockey players need strong lower body, core, and upper body muscles. Since players must be able to make tight turns at high speeds, stop instantly, change directions on a dime, and accelerate quickly to top end-skating speed, muscle mass should be developed in the lower body. When the center of gravity is lowered, players can bend their knees and won't fall down in high speed turns. A strong upper body generates explosive power for high velocity wrist and slap shots. In addition, it contributes in pushing, pulling, and rotating patterns while battling against the opponents along the boards, in front of the net, and on open ice. Hockey players need a strong stabilized core permitting a better balanced skating posture, and improved application of strength to upper and lower body movements. Core muscles also need to be highly responsive and contract quickly in order to protect the spine by absorbing hard hits. Both relative and absolute strength are required in hockey. Absolute strength and muscle mass allows players to withstand contact and move opponents. Quickness, agility, and speed are also fostered by relative strength. (Twist, 69–78.)

Optimal skating and shooting require coordination of body. These actions are performed at high speeds in an explosive tempo through a linked system called the kinetic chain. Every joint and muscle group as well as the nervous system are activated during a certain task and affect the movement of the next joint and muscle group in the kinetic chain. This type of training is called linked system training, which is highly recommended for hockey players, especially for those who have experienced injuries. Linked system training strives to eliminate all the weak links in a kinetic chain and to build skillful coordinated movements on the ice. The transfer of strength to on-ice situations are better with linked system training because it resembles the joint angles used in hockey. Transfer effect will be even greater when resistance exercises are executed with an explosive tempo. (Twist 2007, 4-70.)

The primary stress of the exercises is in the lower, upper, and middle body muscles that are used during skating, shooting, and battling. Balance is included in many exercises because it is a crucial element in hockey games. To mimic the nature of ice hockey, upper body or core muscles contribute to the lower body exercises and vice versa. Strength training should stress functional training, maintenance of healthy joints, and muscle balance in relation to different parts of body and muscle groups. (IIHCE 2012.) The focus of the strength training, especially in young hockey players, must be on correct technique as well as control and strengthening of the core. When these requirements are found to be at a proper level and the growth spurt has passed, young players can progress to bigger loads and forces, and select more hockey specific movements. (Hakkarainen 2008.)

Typical periodization of strength training for ice hockey may follow the subsequent format. In the spring around, April, a couple weeks after the season, strength training is started with a focus on strength endurance. This period creates a good foundation and will continue until the beginning of or mid-June depending on when the program started in April. This strength endurance period is followed-up by an independent period in June and July. The focus of strength training during this period is to improve basic strength properties and individual weaknesses. As the on ice training period approaches, the primary stress of strength training shifts toward speed strength. Strength endurance will be improved again during the small breaks within the season. Strength training programs have two major challenges during the hockey season. First, the season contains a large number of games and the second, is difference in training backgrounds of the players. Each player's background needs to be considered and a specific training program needs to be created for every individual player inside the team. (Hakkarainen 2008.)

During the off-ice season, strength training sessions are executed as separate, long lasting practices. The main challenge of the season is the scheduling of strength training and ice practices. Neither should be harmful to the other. Due to that challenge, combination trainings are used very often. The goal is that the strength training would enforce on-ice training and maintain the strength levels achieved during the off-ice season. Therefore, strength training is normally executed as short practices before or after the on ice practices. The objective is to train all types of strength (endurance, maximum, and speed) once a week. Strength training is organized according to games and the duration of single training session is 20-40 minutes. (Hakkarainen 2008.)

The most commonly used resistance training exercises in hockey are different squats and traditional Olympic lifts like the power clean, snatch, and jerk. Since skating is a unilateral movement, and the single propulsion as well as the gliding phase are mainly executed with one leg, more and more single-leg resistance training exercises are used in training programs. Typical and commonly used exercises with one leg are squats, clean, snatch, and jerk. Additionally, different Borzow type strides without or with resistance (elastic band, barbell, medicine ball, etc.) are used very often in resistance training. These cyclic stride exercises strive to replicate the skating stride and gliding phase as well as strengthening skating muscles. Balance is an essential part of resistance training because the game is played on a slippery surface while standing on a narrow edge. Slippery ice places special requirements on control of the core and hip muscles. Soft platforms, balance boards and pillow in resistance training are very good tools to improve balance skills. This type of training prevents the occurance of groin area injuries. (Hakkarainen 2008.)

The objective of training the core is not to obtain large abdominal muscles and a nice six-pack. The aim is to improve a player's on-ice performance by increasing the strength and control of all the muscles around the torso with more sport specific exercises. Instead of performing hundreds of sit-up, curls-ups, crunches and other floor based abdominal exercises; core strength and stability exercises are linked to all the pushing and pulling exercises. These exercises are more sport specific requiring strong isometric contractions from the muscles of the core, much like in ice hockey. Core strength contributes to balance and control during top speed skating, directions transitions, and tight turns. In addition, core strength enhances the application of strength. Hence, legs can generate force more aggressively during skating and the transfer of power from the legs to the arms is more effective while shooting and checking. (Twist 2007, 74–77.)

6 Strength training modes

Different resistance training methods and exercises need to be considered when planning a resistance training program. There are a lot of alternatives; machines, free weights, exercises using one's own body, plyometrics with or without resistance, kettle bells, elastic bands, etc. Many factors influence the final choice, but age is one of the most important when an athlete wishes to have a long career. (Häkkinen et.al 2007, 256; Page 2003.)

Athletes and trainers believe that training with free weight is more advantageous in comparison to using machines. This belief stems from that fact that training with free weights requires athletes to recruit more motor units, control their entire body, and stabilize the weight lifted. Most athletes have tendency to exercise using free weights. Today, elastic resistance training with rubber bands has become popular in normal fitness and athletic training. Elastic resistance training is versatile and does not rely on gravity, enabling exercises to be performed in many planes. Hence, it allows athletes to train sport specific exercises. (Costill et al. 2008, 195; Page 2003.)

Young children and adolescents can use all these methods safely, just like adults as long as there is a strong focus on the importance of proper technique. Positive training effects have been noted with all of these methods in children. (Faigenbaum & Westcott 2009, 19-24.)

6.1 Machines

Weight machines used in resistance training force an exerciser to use a fixed movement pattern for each exercise. Therefore, these machines are easy to use and provide support for the body. An advantage of weight training machines is that trainers can train specific muscle groups or isolate certain muscles that are prone to injury. (Faigenbaum & Westcott 2009, 73-74.)

Exercises with machines do not place notable demands on balance or overall body control. Further, the selection of exercises and mechanical variation is very limited. Since adaptations are specific to the muscles trained, including the intensity, metabolic demands, and the joint angles of the sport performance, the selected exercises should replicate the requirements and the neuromuscular coordination of the sport performance. Therefore, the transferability of a training effect from practice to a game situation is relatively low. The exercises performed using machines occur mainly in a single plane and are not stimulating the sport performances effectively. However, weight machines are often necessary in order to complete a training session. (Hoffman 2002, 72; Stone et al. 2007, 245- 253.)

For a long time, machines were made merely for adults. People have differences in limb length as well as body size and consequently it is very unlike that one particular weight machine could match the mechanical needs of every individual. Especially young weight trainers were far too small and this meant they were unable to perform a majority of the exercises throughout their full range of motion. Only some large teenagers were able to use those machines. Fortunately, youth strength training machines are now available. (Faigenbaum & Westcott 2009, 73-74; Hoffman 2002, 83.)

6.2 Free weights

Standard free weights consist of adjustable barbells and dumbbells that come in various shapes and sizes. Different type of benches and racks are also included to free weight training. (Faigenbaum & Westcott 2009, 36.)

According to observations, a great majority of athletes execute resistance training using free weights for several reasons. Free weight training has great metabolic demands and it has shown to consistently produce greater strength improvements in comparison to machines. Since training with free weights can occur in multiple planes, the variation possibilities of exercises are unlimited. Training with free weights is considered to be functional, as it requires balance and steady control of the entire body while controlling the direction of the movement. In addition, free weights can develop greater intramuscluar and intermuscular coordination and stimulate mechanically daily sport performance tasks effectively. Therefore, the transferability of training effects from training to sport performance is very likely to occur. For these reasons, resistance training programs often emphasize the use of free weight exercises. (Gamble 2010, 48-49; Stone et. al. 2007, 245-253.)

As long as the focus is on proper exercise technique, children and adolescents can use free weights in training. Regardless of the body size, all children can use free weights and execute many different exercises throughout their own full range of motion, including multi-joint exercises. These multi-joint total body exercises contribute to children's improvements in muscle coordination and balance. (Faigenbaum & Westcott 2009, 24-37.)

6.3 Elastic resistance

Elastic resistance bands are popular, and have been a widely used tool for over 100 years in fitness and conditioning programs. Recently, therapists and trainers have started using them in rehabilitation as a way to strengthen muscles. Elastic resistance training is popular method because it is convenient, portable, inexpensive, versatile, and simple to use. Due to its versatility, it is ideal for a wide variety of patients. However, research has proven that elastic resistance can provide similar properties that free weights or weight machines can, making it an ideal device for anyone to use. With elastic resistance devices, trainers can strengthen their core, upper, and lower body by using single or multi-joint movements. A major advantage of elastic training is that it does not rely on gravity; allowing individuals to perform movements in various places and situations, for example at home or while travelling. In addition, elastic resistive devices can be sued to execute virtually any training movements, making it ideal for sport specific resistance training. (Ellenbecker & Page 2011, 1; Hughes & Page 2003.)

According to research, elastic resistance training is effective across ages, from young children to older adults, as well as from sedentary people to elite athletes. Using elastic bands when training young athletes is an easy and very effective method of initiating resistance training. Also, it provides a very good foundation for future resistance training with big loads. Additionally, elastic resistance exercises are suitable for independent training, by using safe attachment points, or with a partner stabilizing the elastic material. An individual strength program using elastic resistance exercises can be easily tailored to meet the needs of an individual. These programs are suitable for weight loss, general strength and conditioning, and for improving speed, power, and agility for sports. This can be done by simply varying the level of resistance, number of repetitions, and the velocity of the exercises. For instance a low resistance and a high amount of repetitions will improve strength endurance, whereas a higher resistance and fewer repetitions will increase muscle size and power. By using different platforms the exercises become more challenging and improve balance. (Ellenbecker & Page 2011, 1-11,169; IIHCE.)

Elastic resistance training is unique. Since resistance training with elastic bands does not rely on gravity, it not only allows trainers to isolate muscles, but to also perform the same movements in a totally different way. Movements can be much more functional in comparison to using other methods, for instance weight machines. Although elastic resistance provides similar physiological benefits as other methods, it does not display the typical characteristics of standard exercise classifications (isotonic, isokinetic, isometric). The variability in force and rate when an elastic band is stretched prohibits classification as either an isokinetic or isotonic exercise. (Ellenbecker & Page 2011, 11; Hughes & Page 2003.)

6.3.1 Biomechanics of elastic resistance

Regular weight machines and free weights rely on gravitational forces against the weights unlike elastic resistance devices. The biomechanics of elastic training are relatively simple. Resistance increases as the elastic band is stretched. The resistance depends on how much the band has been elongated. Elongation rarely exceeds 300% during elastic resistance exercises. The force-elongation curve, which is a characteristic of every elastic product, is typically three-phased. During the first 25% of the elongation-curve, the increase is exponential and from 25% to 500% the elongation increases linearly. After 500%, a sharp exponential increase in elongation occurs before failure. The general recommendation is to work between 25% and 250% elongation. If resistance needs to be increased further, trainers should progress to the next color rather than increase the stretch of the elastic band. Progressive stimulus contributes to maximal muscle activation and increases in muscle mass. Increasing the elongation on the elastic band to increase the force before exercising may change the biomechanics of the exercise. (Ellenbecker & Page 2011, 3; Page 2003.)

The amount of elastic material affects the resistance provided by the elastic band; thinner bands provide less resistance than thicker ones. Physical characteristics of force-elongation are similar regardless of the form of the elastic training material. Regardless of the initial length, the force of elastic resistance is dependable on the percentage of elongation. For instance, when a 1-ft length of elastic band is stretched 100%, to 2 ft, the force exerted would be exactly the same when a 2 ft- length of the same elastic material is stretched to 4-ft. (Page 2003)

The manner in which human muscles contract and produce force is the opposite of elastic bands function. A unique force position curve during the full range of motion of any limb is caused by the overlap of actin and myosin crossbridges, and the mechanism of the sliding filament theory of muscle contraction. The shape of an inverted "U" illustrates the length-tension relationship of human muscles. Maximal force production occurs somewhere in the middle of the full muscle length. Force production is least in full extension and least at full flexion because overlap of crossbridges is least in full extension, maximized at full flexion with no length left to contract. For instance, a bicep curl movement with a constant load gets easier as the arm and weight move from the parallel stance to the floor. The leverage of the elbow contributes to the exercise, negating some of the weight's power. In contrast, an elastic band has a length-tension relationship that is linear because it does not rely on gravity to produce force. With elastic bands, resistance increases throughout the exercise and the resistance is greatest when the movement nearly complete. This demonstrates that the elbow's leverage effect is offset with the use of elastic bands. Additionally, individuals generally complete a smoother exercise through the entire range of motion when using elastic bands. (Findley 2004, 68-69; Lillard 2009, 22-23.) The objective of any resistance training exercise is to activate the maximum number of muscle fibers. Maximal muscle fiber activation and greater strength gains should be achieved with elastic training because it loads muscles to the limit throughout the range of motion. (Page 2003.)

Resistance training with elastic devices is a unique method. Similar physiological benefits of free weights or machines can be achieved using elastic training. However, elastic resistance training does not display the same characteristics of typical exercise classifications (isotonic, isokinetic, isometric). Since force changes as the elastic band is stretched and the accompanying change in stretch velocity is variable, it prohibits classifying elastic exercise as form of isotonic or isokinetic training. (Page 2003.)

Muscular strength gains occur in the muscles that are activated during an exercise. In any elastic resistance exercise, positioning should be considered carefully. Positioning is important because it has a major effect in developing resistive torque. Improper positioning will hamper the optimal muscular strength utilization ratio and therefore, it can lead to inadequate torque production. In regards to proper positioning, several biomechanical variables need to be taken into consideration. For instance, the distance from the starting point to the axis, and the angle of the starting point to the axis affect the resulted torque curve of the exercise. (Page 2003.)

6.3.2 Training options of elastic resistance

In the past, elastic resistance has only been used for muscle strengthening purposes. Through clinical use, the inherent properties of elastic resistance training were found. Today, elastic resistance training has proven to be ideal for a variety of training applications and for achieving different training goals. Therefore, elastic resistance is used very often in fitness programs. Elastic resistance training can be used to increase muscle mass, lower body fat, and increase power and endurance. The ability to perform virtually any training movement makes elastic resistance an ideal method for sport specific exercises. Due to the resistive qualities at high exercise speed, elastic devices are also a very effective tool in plyometric and speed training. Additionally, balance can be improved by using elastic resistance training.(Ellenbecker & Page 2003, 117; Ellenbecker & Page 2011.) According to research, improvements in strength, force, power, and speed achieved with elastic resistance training appear to be, in most cases, superior to the results achieved by traditional resistance training methods (MgGuigan, Wallace & Winchester 2006, 268-272).

Resistance training with elastic devices can lead to remarkable strength improvements in the entire body (Fernandez-Silva, Leese & Newsam 2005, 35-47). Elastic exercises can be single or multi-jointed movements. The upper body, core, and lower body muscles can be trained separately or simultaneously with these exercises. Pushing and pulling exercises are particularly effective for the shoulder joints, upper back, and chest. The elbow joint and wrists can also be trained with elastic resistance. Resistance training for lower body joints such as the hip, knees, and ankles, can be achieved with single-joint exercises and with different squats and lunges. Although elastic training is used mostly for the upper and lower body, it provides effective and safe resistance for core muscles too. Combining different exercises makes the movements more functional and challenges the whole body. Probably the easiest way to make the training more challenging is to perform traditional strength training exercises in a standing position, as this causes the activation and stabilization of core muscles. (Ellenbecker & Page 2011, 3.)

Probably the most popular application of elastic training is for sport specific activities. Elastic resistance makes it possible for muscles to be strengthened along sport specific patterns throughout the motion. (Ellenbecker & Page 2003, 189.) Because elastic resistance does not relying on gravity, it allows for several movements and directions of motions to be performed, such as side-to-side movements. Further, multiple-joint movements while standing up can be done in many planes with elastic resistance. Thus, sport specific movements can be developed to replicate the same range of motion used in regular sport performances. Elastic training is very effective especially in sports requiring the rotation of the body or high speeds. Biomechanical characteristics and the ability to include both concentric and eccentric resistance enables to combination of both acceleration and deceleration muscular training that are an essential part of rotational sports. Due to these inherent characteristics, elastic resistance is suitable for plyometric and high-speed exercises. Therefore, elastic resistance training is incorporated to the training programs of sports requiring high speeds and power. (Ellenbecker & Page 2011.) Research found a 17% to 24% increase in shoulder strength and serving velocity among collegiate tennis players who used elastic resistance training. The duration of the research was 4 weeks and the subjects performed a variety of exercises with elastic band completing two sets of 20 repetitions at two different speeds. (Treiber et al. 1998.)

Elastic resistance training can be used to enhance sport specific elements of power and speed. Virtually all general sports performances and common physical activities like running, throwing, kicking, swinging, and jumping require both of these elements. In addition, success in most cases depends on the speed at which the muscular force is generated. For instance, a sport like tennis requires players to perform explosive multidirectional movements repeatedly and thus, power and speed are emphasized in their training program to achieve their full potential. These important aspects can be improved very specifically by using elastic resistance. Elastic resistance offers several exercise applications to improve power and speed. For instance, dynamic movements are an effective way to improve speed and power especially in the upper body. However, plyometric training is particularly one of the most successful methods used to improve speed and power. Plyometric exercises are defined as quick powerful movements that stimulate the elastic properties of the body to generate maximal force output in a short period of time. Plyometric movements involve an eccentric contraction that is followed immediately by an explosive concentric contraction. Regardless of the position in relation to gravity, mechanical properties of elastic resistance provide eccentric and concentric resistance inherently. Elastic resistance is ideal for plyometric training because of the inherent mechanical properties and lack of inertia in elastic resistance. (Davies & Matheson 2003; Ellenbecker & Page 2011, 133.)

Functional elastic movements can improve balance and coordination effectively because these movements require more skill and coordination, than for example weight training machines, when controlling a movement pattern (Faigenbaum & Westcott 2009, 101). Balance may improve simply from performing resistance training of the extremities. Elastic resistance applied around the trunk while performing bilateral or unilateral jumping exercises is an effective way to improve dynamic balance. Progression can follow several strategies, such as closing the eyes, using an unstable surface or a combination of both. (Orzehoskie & Thein-Nissenbaum 2003.)

6.3.3 Applicability for different age groups

Elastic resistance training is used as a part of a well-rounded physically active life to improve strength. The effectiveness of elastic training has been proven to be beneficial for a wide range of people, from children to older adults, and from sedentary people to professional athletes. (Ellenbecker & Page 2011, 1-16.)

Because several children can work simultaneously and perform variety of exercises, elastic training is used often in youth fitness classes. In addition, when appropriate instruction and guidance are provided, children do not need spotting while performing these exercises. As children get stronger, the amount of resistance needs to be added progressively. Additional resistance can be provided by using thicker bands or by adjusting the amount of pre-stretch in the band. (Faigenbaum & Westcott 2009, 99.)

It is best to start an elastic training program with relatively easy single-joint exercises, when children are 7 to 10 years old. More advanced exercises can be incorporated gradually for children between the ages of 11 and 14 because they usually have adequate coordination to stabilize their bodies. Children should use thinner bands or reduce the prestretch if correct technique cannot be maintained throughout the movement. Elastic resistance training is certainly safe and effective for the age group of 15 to 18 year olds. (Faigenbaum & Westcott 2009, 183-195.)

Research has proven that elastic resistance training is also effective for middle-aged and sedentary people. Strength improvements of 10 to 30 percent were noticed in older adults after only 6 weeks of following an elastic training program. Programs should start by using a lighter resistance to emphasize correct movements. (Ellenbecker & Page 2011, 5; Lillard 2009, 22-23.)

6.3.4 Advantages of elastic resistance

Elastic resistance provides several advantages in comparison to free weights and weight machines. Most of the benefits are related on the fact that elastic resistance training does not rely on gravitational forces. (Ellenbecker & Page 2011, 6-7.)

Portability and versatility are the greatest benefits provided by elastic resistance training. Free weights and machines rely on gravity and for that reason the exercises are limited by the direction of movements which gravity dictates. Thus, resistance is provided only in a vertical plane. Instead, elastic resistance relies on increasing tension. Therefore, it allows exercises in multiple planes and offers resistance for isolated single- joint and functional multi-joint movements. There is evidence that elastic resistance is ideal for functional training and it has a high potential to replicate a variety of sport –specific movements. (Ellenbecker & Page 2011, 6-7.)

In comparison to other resistance training methods, elastic resistance allows a user to change the emphasis placed on muscles during certain exercises. This is attributed to the possibility to change the origin of the attachment point of the elastic device. This maneuver changes the direction of the pull and shifts the emphasis of the elastic exercise. This is an important feature for athletes who want to target their training to specific muscles and want to enhance their sport performance. Another group of people taking advantage of this are those with injuries. Weak muscles can be strengthened and specific joints protected more effectively by shifting the emphasis to a certain muscle. (Stoppani.)

Another benefit provided by elastic resistance is the linear variable resistance throughout the range of motion. Since continuous tension is provided, muscles need to recruit more motor units to complete the motion. For instance, when performing a biceps curl with free weights, the tension on the biceps will be removed at the end of the motion. This is because the free weights are literally falling towards the shoulder at the end of the movement. Thus, the biceps muscles are not lifting the weight up against gravity anymore in that phase of the motion. However, when performing the same movement using elastic resistance, the tension in the biceps is present and increases throughout the entire range of motion. Research indicates that individuals can feel a stronger burn and greater fatigue with elastic resistance training. This is attributable to the fact that a greater number of muscle fibers are activated during exercises. Finally, for the same reason, greater results in muscle strength can be achieved. (Stoppani.)

An additional benefit of elastic training is that individual cannot "cheat" by using momentum to complete the exercise. Cheating is referred to the physics of moving weights. During the movement, the activation of muscle fibers is not at a maximal level because the physics of momentum takes over to move the weight. Since elastic training is based on elongation, the use of momentum is not possible. The only option in elastic resistance training is for the individual to complete the motion by utilizing more muscle fibres to make the band stretch. (Ellenbecker & Page 2011, 6-7; Hughes & Page 2003.)

6.3.5 Instructions

Elastic resistance replicates the common strengthening exercises performed with traditional strength training equipment. Almost all of the elastic exercises can be performed in just about any location, at home or while travelling, for example in a hotel. Elastic resistance exercises enable it so that everyone can easily tailor an individual strengthening program to meet the personal needs. Regardless the goal, whether it is to lose weight, tone the body, increase strength, improve speed, power, or agility for a sport, the objectives can all be achieved simply by varying the level of resistance, number of repetitions, and the speed of the exercise. The focus of training can be easily shifted to emphasize either the upper, lower, or middle body by using single-joint exercises that isolate different muscles. However, workouts can be made more challenging by performing exercises while standing or by using functional multi-joint exercises that cover the entire body. (Ellenbecker & Page 2011, 59.)

An elastic training program should start with the use of a light resistance in order to concentrate on proper technique. Also, a lighter resistance allows for individual to focus on and maintain proper posture, which is a very important part of training. In the beginning, it is better to perform movements slowly, emphasizing the eccentric (returning) part of the movement and not letting the band snap back abruptly to the resting position. Injuries are commonly attributed to improper technique. Just as with any physical activity, a proper warm-up and cool down are highly recommended. (Ellenbecker & Page 2011, 11-12, 59.)

When using elastic bands, it is important to always grasp the band at the same place before progressing to a more advanced resistance. If a shorter or longer section of the band is taken than in the previous session, resistance will be decreased or increased relative to the previous session. Therefore, movement can be too easy or hard and might mislead players and coaches to think that progression or a setback has occurred. (Hughes & Page 2003.)

An important part of training is progression. Exercise programs need to be modified as improvements in strength, stabilization, and coordination occurs. Resistance can be added easily by using thicker bands. After performing isolated single-joint exercises, individual can progress to compound movements that require the co-operation of more than one joint, such as the bench press. Next, functional movements that involve multiple joints such as side jump or throwing movements can be incorporated into a program. The final progression is involves adding sport-specific movements to enhance performance. (Ellenbecker & Page 2011, 11–13.)

The resistance provided by the elastic devices is based on the amount of elastic material, regardless of the form of the elastic material. Higher resistance can be provided with thicker bands. Therefore, the easiest way to increase strength is to progress to use thicker bands. Usually, different colored bands represent the variety of thickness. However, there are two other methods to increase the magnitude of elastic force even more. The first method is to combine and use several elastic units. The second involves reducing the initial length of the elastic device. With these strategies it is possible to provide a significant increase in resistance. Altering the training surface can also provide additional progression and challenges. For instance, the use of a pillow, blanket, or a rolled towel will improve balance. (Aboodarda, George, Mokhtar & Thompson 2011, 635-636; Ellenbecker & Page 2011, 169; Hughes & Page 2003.)

Elastic bands come in various strengths as well as sizes and are typically color-coded, thus everybody can start training safely and progress easily by increasing resistance. Elastic resistance products are available in fitness equipment stores, the Internet, and they can also be made at home out of an adequate length of elastic material. (Ellenbecker & Page 2011, 11–12; Faigenbaum & Westcott 2009, 99.)

7 Ice hockey specific strength training with elastic rubber bands

During the past several years, the use of elastic resistance exercises as a part of a hockey player's strength training program has increased in Finland among both juniors and adults. Elastic devices can be used to improve a player's endurance and speed strength, which are important qualities in ice hockey. Resistance can be increased simply by increasing the amount pre-stretch or by folding an elastic band in two, this makes it possible to use it as a maximal strength training tool for young players. According to Lehto (2012), similar elastic resistance exercises have been used as a supplement and support to strength training in speed skating since the 1970s. (Kärki 2012.)

The exercises can be focused to training muscles of the upper body, core, lower body or the entire body. Since the movements are not fixed or controlled in the same way as movements are when using weight machines, it is up to the players to control the movement paths. This means that the players need good motoric control, coordination and balance. Using these devices, players can perform exercises that support game performance demands by activating the exact same muscles and muscle groups. Further, another benefit is that the portability of elastic devices means that teams can complete these exercises almost anywhere, alone or with a partner. (Kärki 2012.)

According to Hakkarainen (2008), in ice hockey practices, elastic bands are used to provide resistance in certain gait exercises to train muscles used in skating. Due to the eccentric phases of the movements, these exercises help players recognize the muscles that are activated during optimal skating strides. The exercises also support skating by to activating muscles in the correct sequence and by teaching the timing required in an optimal performance. (Lehto 2012.)

During the season 2010-2011, the Lahti Pelicans C-juniors (15 year-olds) completed all of their resistance training using elastic devices. One of the main goals of the season was to develop each player's the forward skating technique and skating endurance. The exercises focused mainly on the lower body and included various stride and one-legged squat movements, which also activated core stabilization. Muscle endurance and skating technique were improved by performing long sets with lots of repetitions. The incorporation of sport specific exercises with elastic resistance strength training proved to be a very effective combination as the entire team reached the goal. According to the coach, the skating technique and endurance of each player improved significantly during the season. (Niemelä 2012.)

Additionally, elastic resistance training has also been used during the last couple seasons as a part of Helsinki IFK's first team's strength training program. The players have concluded that it is an effective tool to develop skating. By the means of these elastic device exercises, they have a better awareness of the muscles used in skating and have learned to activate them in the correct sequence. The main objective of these exercises was to improve their curve skating technique and to strengthen the required muscles. In addition, the device was used to develop ice hockey specific speed strength, which enhances the use of the hip joint during the skating strides. The movements were done both individually and in pairs, they included one-legged squats and various stride movements, which support in-game executions. During the summer, the main focus was on muscle and strength endurance, thus the sets were much longer than during the regular season. Since the season contains so many games, the aim is to maintain the qualities obtained during the summer. Elastic bands are also used for player rehabilitation. Each player on the team has his own elastic device and they are used daily. However, specific use by individuals depends on their own needs. (Lehto 2012.)

Elastic resistance training has played a central role in the off-ice training of Finnish U16 national ice hockey team during the 2011-2012 season. During the summer, the team performed longer sets of certain exercises to develop strength endurance, and switched to fewer repetition amounts when the season started. On several occasions, the elastic bands were used in speed and maximal strength training. Throughout the tournaments, elastic bands were primarily used to train only the upper body and core areas because the lower body received more than enough stress from games and other sport specific drills. All lower body elastic band exercises performed during the season mainly focused on supporting the muscles. (Kärki 2012.)

Today, elastic resistance training is a method, which is implemented into coaching seminars and events by the Finnish Ice Hockey Association. For example, this year elastic resistance exercises were used for the first time during off-ice practices at the annual Pohjola camp, from which the U16 national team is chosen. (Kärki 2012.)

8 The aims of the project

A wide selection of elastic band exercises can already be found in numerous books and other sources. The aim of the project was not to produce something completely new, rather to modify existing to make them more sport specific and to come up with new focused on working muscles and muscle groups that are important for hockey players. In addition the descriptions were made clear so that ice hockey coaches could easily understand them. Another goal of the project was to provide a safe, easy-to-use and effective training tool that can be used anywhere by individual ice hockey players, especially youth players, or by entire ice hockey teams to work on strength training.

The material will be uploaded to the Hockey Centre's online database, which is accessible by ice hockey coaches. In essence, the material is created for the coaches, so that they could develop each individual's strength training from an ice hockey specific perspective. Since the elastic band does not rely on gravitational forces, it offers great possibilities for sport specific and functional strength training at many different levels.

Primarily, the produced elastic band exercises will be geared towards adolescent ice hockey players and adult athletes. With this tool and these exercises, an adolescent ice hockey player can begin strength endurance training and learn proper technique safely. Following adolescence, more sport specific methods can be added to training, which is easy to do using elastic bands. At the same time, the intensity can be increased and a transition to maximum and speed strength training, given that the athlete has learned the correct technique and his muscles are groups are in balance. (Hakkariainen 2009, 209-210). An elastic band offers a safe and effective way to start sport specific speed strength training because it does not stress the spine and core nearly as badly as a barbell with weights on an athlete's shoulders. Elastic band training methods can still be used to strengthen muscles in both the core and hip region. (IIHCE.)

9 Project planning and implementation of the project

The idea and request to gather all the material for this project came from the International Ice Hockey Centre of Excellence (IIHCE). Ice hockey specific strength exercises should provide the same stimulus as a game situation, which will lead to improved game performance. Strength training with elastic bands suits this purpose extremely well. The mentor for the entire project was Tuomo Kärki, the Head of Training at the IIHCE.

The Head of Training, Tuomo Kärki prepared the first stage and it involved getting to know and using the exercise tool. During this phase, we went through familiar exercises with the elastic bands, and started to experiment with them to see what other movements could be possible. Following this, we took a closer look at materials, which displayed various different elastic band movements. The exercises deemed most relevant and useful for this project were then chosen. The most important selection criteria were that the exercises had to be applicable to on ice performance; they had to strain the same muscles and follow similar movement paths. We agreed that both of the participants in the project would practice with the tool and strive to develop new exercises for the project. A deadline was set by which time all the exercises had to be listed, this meant that all new moves were quickly noted when they were deemed to be effective in practice. The aim was to be able to practice and develop the new moves as a team, as soon as possible. During the next meeting, all the new exercises were discussed, critiqued and tested out in practice. In these meetings, more brainstorming was done to try and come up with even more ideas. In addition, note worthy points were written down as well as desired changes. For example, some note worthy points were, required filming angles for certain moves, lighting, and any additional tools that might be needed. On the last functional testing day, all the film worthy exercises were listed and divided into the following categories: upper body, core and lower body movements.

Following the practical sessions, the movement list was modified to better suit the filming phase of the project. The filming dates were decided upon and the shoot location was booked from the Vierumäki Arena. It was estimated that three or four filming sessions would be required to film all the material. The first exercises to be filmed were the lower body movements, followed by the core movements and finally the upper body movements. An introduction to the elastic band as a strength training tool was filmed during the second session. All movements were filmed from three different angles, which meant that execution repetitions quickly added up. Regardless of this, we wanted to progress calmly and cautiously, which provided the opportunity to come up with new ideas. In the process of filming, several new movements were added, and as a result some others were not filmed. All of this was done to ensure the best outcome for the project. Despite making effective progress during the first three filming sessions, an additional session had to be booked so that all the movements were shot properly. All the filming was done by Tuomo Kärki, and Jesse Welling assisted in movements which required two participants.

Following the last filming session, the planning and composition of the video descriptions was started. The layout and style used for the descriptions followed the caption format that is used for similar videos already in the Hockey Centre's database. A suitable description and basic instructions were written up for each movement so that it could be executed easily, correctly and safely. Also, the end of filming marked the beginning of the editing process. After this the movements with the descriptions were added one at a time to the Hockey Centre's Internet resource.

The International Ice Hockey Centre of Excellence both established and maintains the online Hockey Centre resource, which includes a material and drill bank, feedback, assessment and communication tools, and a training diary service. The Hockey Centre resource offers most of its material and drills in a video library. Both a video and illustrative descriptions are available for almost all of the on-ice and physical drills on the server. The most important and current hockey related seminar videos are also available for home viewing on the Hockey Centre server. (Saarinen, 2010.)

The Hockey Centre was established to work as a functional educational tool to help the Finnish Ice Hockey Associations share information and updates as well as to guide player development. The tools provided are an essential part of talent assessment, individual player development, and in communication between national teams, clubs, players and coaches. Overall, the main aim of the Hockey Centre is to improve the level of both coaches and players. (Saarinen, 2010.)

10 Description and results of the project

The produced elastic band material has been added to the IIHCE's Hockey Centre, as a part of the off-ice physical drills. More precisely, the material can be found in the off-ice section, under strength training where they have been further categorized as lower body, core, upper body and full body exercises.

All the movements have been designed to support ice hockey game performance. Special focus has been placed on sport-specific power production, movement ranges and paths, and posture control. Elastic band exercises activate the stabilization muscles of the optimal skating position. Most of the exercises are hockey-specific but some are traditional resistance training exercises. Still, these traditional movements are performed in a manner, which uses sport-specific elements, such as using a hockey specific rhythm for the arms and legs while performing a not so hockey specific movement. Further, many movements are performed in a prone position adding more strain to the core.

All of the movements were filmed using a video camera. Each exercise is accompanied by a video (attachment 1) and an explanatory description (attachment 2). The descriptions cover the key points of the exercise and the effects of the movement—the muscles that are strained.

The tool itself, the elastic band, has been introduced fully in a separate video, and it can be found under the off-ice practices section. In the same section, the combination tool of a hockey stick and the elastic band is also demonstrated, and its purpose is to enhance the ice hockey player's elastic band training. Since the ready-made tool is not readily available, an instruction video with the materials and construction has been included. In addition, tips about acquiring the tools and materials are also included for coaches.

The same section also includes in depth information about elastic bands, including its suitability in training different ice hockey attributes. Also, some benefits of sport specific strength training and the benefits of elastic band training for hockey players are mentioned. Coaches are also instructed on the suitability of the tool for young hockey players in regards to strength training. The material gathered for the product includes 81 filmed exercises along with detailed descriptions and an introduction to elastic bands as a strength training tool.

10.1 Upper body exercises with elastic band

The main focus of the exercises is on the training the upper body muscles that are needed in skating, shooting, and battling. In addition to upper body conditioning, many of the movements also include balance control and the use of the lower body and core as a part of the movement's execution. (IIHCE, 2011.)

The upper body exercises have been subdivided further; upper back, chest, biceps, triceps, and shoulder exercises. Altogether there are 28 upper body movements.

10.1.1 Upper back

- Rowing with straight arms
- Single hand row
- Lateral pull down with stick
- Upper back row with stick

10.1.2 Chest

- Chest with both hands (cable crossover) - resistance from behind
- Chest with one hand (cable crossover) – resistance from behind
- Chest with both hands and weight transfer (cable crossover) - resistance from behind
- Push-up with stick in an upright position and weight transfer – resistance from behind

- Push-up with stick in an upright position – resistance from behind

10.1.3 Triceps

- French press in an upright position - resistance diagonally from behind and below
- French press in an upright position reciprocally – resistance diagonally from behind and below
- Skiing extension – resistance from the front and below
- Skiing extension reciprocally - resistance from the front and below

10.1.4 Biceps

- Biceps in an upright position reciprocally - resistance diagonally from behind and below
- Biceps with both hands in an upright position - resistance diagonally from behind and below
- Biceps in an sitting position with one hand – resistance diagonally from the front and below
- Biceps in an sitting position with both hands - resistance diagonally from the front and below
- Biceps in an upright position with both hands - resistance diagonally from the front and below
- Biceps in an upright position with one hand - resistance diagonally from the front and below
- Biceps in an upright position with both hands reciprocally- resistance diagonally from the front and below

10.1.5 Shoulder

- Upright row with stick – elastic band under feet

- Shoulder press with stick - elastic band under feet
- Shoulder pull behind with both hands reciprocally – resistance from the front
- Shoulder pull behind with both hands - resistance from the front
- Front raise with both hands reciprocally - resistance from behind
- Front raise with both hands - resistance from behind
- Single arm lateral raise diagonally backward – resistance diagonally from the front and side
- Single arm lateral raise - resistance from the side

10.2 Core exercises with elastic band

The main focus of the exercises is on the training the core muscles that are needed in skating, shooting, and battling. In addition to core conditioning, many of the movements also include balance control and the use of the lower and upper body muscles as a part of the movement's execution. (IIHCE, 2011.)

The core exercises have been subdivided further; abdominal, lower back, and rotation exercises. Altogether there are 15 core movements.

10.2.1 Abdominals

- Leg raises reciprocally when lying on a back
- Sit-up (legs supported)
- Sit-up and rotation (legs supported)
- Sit-up (without support)

10.2.2 Lower back

- Good morning with both legs – resistance from the front and below
- Good morning with single leg – resistance from the front and below

10.2.3 Rotation

- Body rotation in an upright position – resistance from behind
- Body rotation in an upright position – resistance from the side
- Body rotation in an upright position with stick – resistance from the backhand side
- Body rotation in an upright position with stick – resistance from the forehand side

10.2.4 Playing posture

- Straightening hands in front in a playing posture - resistance from the side
- Straightening hands above head in a playing posture - resistance from the side
- Playing posture - rotation - playing posture - resistance from the side
- Lower body rotation in a playing posture – resistance from the side
- Moving sideways back and forth in a playing posture (hands straight in front) – resistance from the side

10.3 Lower body exercises with elastic band

The main focus of the exercises is on the training the lower body muscles that are needed in skating, shooting, and battling. In addition to lower body conditioning, many of the movements also include balance control and the use of the core and upper body muscles as a part of the movement's execution. (IIHCE, 2011.)

The core exercises have been subdivided further; striding, hamstring, abduction, adduction, single leg squat, hip flexion and extension, and jumping exercises. Altogether there are 38 lower body movements

10.3.1 Striding

- Skating stride forward
- Striding forward – ice hockey
- Skating stride sideways (crossover)
- Skating stride backward
- Striding forward – track and field

10.3.2 Hamstrings

- Knee flexion (prone)
- Knee flexion with alternating leg (prone)

10.3.3 Abduction

- Leg abduction diagonally backward
- Leg abduction to the side
- Leg abduction diagonally forward

10.3.4 Adduction

- Leg adduction slightly from behind
- Leg adduction from the side
- Weight transfer squat - resistance from behind

10.3.5 Single leg squat

- Single leg squat - free leg diagonally in front – resistance diagonally from behind of working leg

- Single leg squat – free leg diagonally in front - resistance diagonally from the front of working leg
- Single leg squat - free leg diagonally backward – resistance from the side of free leg
- Single leg squat – free leg behind – resistance from the side of working leg
- Single leg squat - free leg behind – resistance from the front
- Single leg squat - free leg behind – resistance from behind

10.3.6 Hip extension

- Hip extension – pushing backward with straight leg in an upright position
- Hip extension - standing with one leg

10.3.7 Hip flexion

- Hip flexion – lying on a back
- Hip flexion – in an upright position

10.3.8 Jumps

- Skating jumps sideways - continuous
- Skating jumps backward - continuous
- Skating jumps forward - continuous
- Jumps forward alternating the leg - continuous
- Single leg jump sideways – resistance from the side of free leg
- Single leg jump sideways – resistance from the side of working leg
- Single leg jump from side to side – resistance from the side of free leg
- Single leg jump from side to side – resistance from the side of working leg
- Single leg jump from side to side – resistance from the front
- Single leg jump from side to side – resistance from behind

- Skating jump from side to side - resistance from the side
- Skating jump from side to side - resistance from the front
- Skating jump backward - resistance from the front
- Skating jump forward - resistance from behind

11 Discussion

As a result of this project, 81 hockey specific elastic band exercises were developed to help players improve various physical qualities, which will be beneficial during on ice performances. The exercise planning was approached from an ice hockey perspective, focusing on typical and essential positions and movements. The aim of the movements was to help hockey players develop various strength types such as endurance, explosiveness and general strength for young athletes. In addition, these exercises also improve coordination, balance and overall body control.

According to Hoffman (2002) movements for sport specific strength training should mimic the actual sport performance so that the activation sequence of muscles is the same. The different muscles must activate in the correct sequence to support and enhance the optimal sport performance. This means that a player needs certain motor abilities and must be able to combine them functionally. The exercises developed during the project support the movement chains of ice hockey, which will support the correct muscle activation sequences and range of motion. This range of motion will ensure that the exercise activates the correct muscle or muscle group. According to Gamble (2010) movement timing and direction needs to be focused on so that all the needed muscles are used during the specific exercises.

Directing power and speed into certain movements can serve to be problematic for hockey players when the force production is not maximal in the sport performance. This may be caused by incorrect direction of the movement, timing, or range of motion. All of the force mentioned aspects directly affect the technique and power of the movement. Also, a lack of strength in certain muscles may cause a movement chain to be inefficient and powerless. Many ice hockey players have increased their overall strength using rather simple strength training exercises. Due to this, some find it difficult to efficiently combine simple movements to powerfully conduct a certain movement chain. In order to make certain sport specific movement chains powerful and effective, it is crucial to practice entire movement chains in strength training and not just certain portions. Twist (2007), highly recommends this kind of strength training for ice hockey players. Elastic band resistance training offers exercises with support sport specific movement chains as it is based upon stretch resistance instead of gravity.

Training maximal strength and gaining muscle mass are an important part of an ice hockey player's strength training program, especially for adolescent players (Montgomery 1988, 116-118). It is very likely that more specific strength exercises are more effective than general kettle bell exercises. By using a more specified method, the load and strain can be directed to certain muscles, which may lead to faster muscle mass gains. With elastic devices, it is possible to obtain the required amount of resistance needed for young players to carry out effective maximal strength training. In terms of the effectiveness of more holistic strength training exercises, elastic resistance training works as a great additional support to the program.

During a game, a player should be in a game stance in which the knees are bent and the buttocks are low (Mennander 2011, 54-56). This skating position alone demands a certain level of endurance from the core and lower body. The lower body elastic resistance training exercises focus on improving a player's strength endurance so that they can maintain the proper stance throughout an entire game. Maintaining this stance is crucial for a hockey player because almost all of the power needed in game situations is initiated in the lower body. Poor skating technique and a lack of skating endurance, disables players from maintaining the correct hockey stance from which an ideal skating push-off is produced.

According to Montgomery (1988) and Haché (2003), during maximum skating velocity, the weight of an ice hockey player is balanced upon one leg at almost any given time. Weight transfers from one leg to the other as the player pushes off in the desired direction. To support this sport specific characteristic, most of the exercises are completed standing on one foot. In some of the exercises, the weight transfer motion of skating has also been incorporated. One-footed exercises demand control of the ankle, knee and core, to keep the centre of gravity in the optimal position for the movement. During these exercises, the muscles of the ankle work to keep the sole steadily attached on the surface below. In addition to strengthening the ankle, these exercises also strengthen the buttocks, hamstrings and adductors, all of which are used in skating.

Almost all of the exercises activate the deep stabilizing muscles of the core. This improves posture and overall movement control in functional and challenging exercises. Core control and the stabilization of the deep abdominal muscles are central aspects of properly executing complicated and challenging movements (Twist 2007, 74-77). In the ever-changing game situations, it is practically impossible to perform effectively if a player lacks basic core control. Due to the normal in-game disturbances, shooting, skating and the other hockey skills are much more difficult to perform and this raises the importance of good core strength to be able to maintain proper game posture. As said by Twist (2007), good core control and strength improve the power production of both the upper and lower body during an ice hockey game. An elastic band is an excellent tool for strengthening the core, which is particularly important for young players (Ellenbecker & Page 2011, 3; Hakkarainen 2008).

The aim of the project was to incorporate elastic devices into the training programs of hockey players through the Hockey Centre portal, and to provide exercises, which support sport specific skills. All the movements were presented in such a manner that they are easily applicable to ice hockey so that it would be easy for coaches see the benefits and use them in training. For coaches, these elastic device movements are a functional, diverse and effective alternative strategy for strength training. Simplified, the physics of hockey strongly centers on the efficiency of different movement chains. Elastic band exercises are especially suitable for the strength training of young athletes before they progress to a free weights strength training program (Faigenbaum & Westcott 2009, 73-74). Elastic devices are great for holistically and diversely training the entire body. Ice hockey players need a lot of variety in training and elastic devices provide a good tool for these demands. In addition, elastic resistance training can be performed in ice hockey specific ways, which support the skills needed in the game, especially skating. Practicing these movements accumulates motoric versatility and fluency to the constantly changing game situations in hockey. It is very favorable and important for a hockey player to be able to function effectively and intelligently even if the player's position is unfavorable at a given moment in a game. Elastic resistance training develops and supports the wide range of physical qualities needed by ice hockey players. I am pleased with the material and the final product and believe that it will be useful in practical strength training.

The device has been declared to be effective and beneficial in practical use and is being widely used in ice hockey practices. Moreover, it has had a central role in the coaching seminars held by the Finnish Ice Hockey Association (Kärki 2012.) Hopefully the material in the Hockey Centre server reaches as many coaches as possible, and that the exercises prove to be helpful in a sport specific manner in many strength training programs. Coaches should be patient and learn more about the device in their own time so that it is familiar to them when they introduce it to the players. This would make it more likely that the device is used as a supportive device in ice hockey specific strength training. In addition, it very applicable to general strength training while at the same time using ice hockey specific movement chains. By incorporating this device into off-ice training, the practices would become more diverse while better supporting sport specific performances.

The greatest problem with this project was writing the theory portion regarding elastic band training in ice hockey. As said by Ellenbecker and Page (2011), it has been established that elastic resistance training is a versatile and effective way to improve endurance, speed and sport specific characteristics. However, specific literary information regarding its benefits regarding ice hockey does not seem to exist. Due to this, it was necessary to interview professional ice hockey coaches whom have used elastic bands as a part of their strength training programs. In this sense, the project was approached in a backwards manner. It would have been much easier to first check the availability of theoretical information and only then start planning the project. Even though the final project was a success, it is likely that with better planning, the project could have been completed in a shorter time frame. On the other hand, this project will surely benefit other such projects and research in the future in both planning and execution.

Another problem was to writing the implementation part of the project. Since different stages of the project were not written down to a diary during the process, it was extremely hard to recall those stages afterwards. Due that the project planning and implementation chapter might be somewhat inadequate. However, main parts of the implementation of are certainly included into theory part but with a diary the result would have been probably better.

The most difficult process was completing the movements during filming. The exercises were filmed from several different angles, which meant that the repetition amounts were high and this caused fatigue. Further, regardless of the high repetition amounts, the movements had to be performed correctly which added another degree of difficulty; all the joint angles were precise, there was a lot of core stabilization and the knees and ankles had to be extended along exact pathways. The process would have been easier had there been more time to become acquainted with the tool and if there were more, shorter filming sessions. Despite all of this, all the necessary exercises were filmed and the final product was excellent.

Completing this project was very educational, as it taught a lot about sport specific exercises and what points should be focused on. Such details were often over-looked before. The training effect's transferability is extremely high when striving to improve specific performance aspects. Looking at certain details from a coach's point of view – angle of the knee joint, ankle and core control during a movement – really brought attention to the nuances of many things. The lessons learned during the project have already been useful in the coaching profession.

In the future it would surely be beneficial to research the specific benefits and the effects of elastic resistance training on ice hockey because such research has not been conducted before. According to Lehto (2012) it has already become clear that elastic resistance training is beneficial and support ice hockey performances, thus the results of such studies would surely raise interest among ice hockey coaches.

Future research could focus on holistic development, trying to find optimal training amounts and loads or the improvement of individual physical qualities. The studies should answer at least some of the following questions: what are the effects of consistent sport specific elastic training on the physical qualities of hockey? Can the sport specific strength qualities be trained more effectively with elastic resistance training than with the currently used methods (weight lifting, squats)? Can the sport specific techniques and movement control be improved following sport specific movements, such as a one legged elastic band squats? What is the ideal training amount needed to support on ice game performance?

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Attachments

Attachment 1. Picture of training video.

Attachment 2. Picture of training description

KUVA VIDEO

Askellus eteenpäin vastuskumilla - jääkiekko [REF# 1482]

- Katse ylhäällä ylävartalo etunojassa säären suuntaisesti
- Käsien ja jalkojen vastavuoroinen rytmitys tehostaen vartalon liikeketjua
- Liikeketju (pakara ojentaa lantion - reisi ojentaa polven - pohje ojentaa nilkan)
- Jalan palautus lähellä lattiaa vartalolinjan alta
- Painon siirtäminen astuvan jalan päälle
- Jalkaterä, polvi ja lantio samassa linjassa vartalon alla
- Harjoite kehittää alavartalon kestovoimaa
- Harjoite kohdistuu polven ojentaja-, lonkan koukistaja- ja pakaralihaksiin
- Variaatiot: Harjoitteen voi toteuttaa myös kuminauha vyötäröllä

Kategoriat: Oheis- / kuivaharjoite, Kestovoima, Alavartalo, Polven ojentajat, Lonkan koukistajat, Pakaralihakset, Vastuskumi