Haaga-Helia
University of Applied Sciences

# Off-ice training manual for U-18 ice hockey

Mitja Lievonen

Bachelor's Thesis
Degree Programme in Sports Coaching and Management
2020

**Author**
Mitja Lievonen

**Degree programme in Sports Coaching and Management**

| **Thesis title** | **Number of pages and appendix pages** |
| --- | --- |
| Off-ice training manual for u-18 ice hockey | **73 + 38** |

Abstract

Strength and conditioning is a vast field and the importance of a well-designed off-ice training program for ice hockey is extremely important. The goal of the off-ice training is to develop, not only better ice hockey players, but better athletes overall. The role of strength and conditioning in ice hockey seems to have increased in importance in the past years. Therefore, this manual got started. This product is an off-ice training manual, that includes an annual plan for the whole season, a program for strength training, speed and plyometric training, and endurance training. Also a monitoring system and testing battery are included to complement the product.

This product tackles the key areas of the off-ice training and key features of the age-specific needs for u-18 athletes. Sport analysis covers the key physical elements that are needed in the game. Strength development stands as a major building block for young athletes. Speed, agility, endurance training and mobility are other training modes addressed in the product. The effects of strength training seem to have an undeniable benefit for speed and agility performance. Scientific research and textbook materials regarding to developing these abilities are addressed. Training variables for each physical ability are covered and explained. The thesis reviews different periodization models and programming structures for various times of the season. Periodization is one of the major keys to creating a structured training plan and provides a window for the best adaptations of each training modality. Monitoring is an essential part of the periodization. It will allow individual changes to the program and can indicate overtraining. Testing can dictate the effectiveness of the training program. Physical testing should be done to determine individual weaknesses and strengths.

The annual plan of the off-ice training is the final product of the thesis. The training program includes an example of an annual plan and microcycle structure for the off-season, pre-season, competitive season, and transition phase. Actual training sessions of all training modes, strength, speed, agility, and conditioning are included and explained in the product. The program presents recommended testing battery and monitoring methods that can be used to evaluate the effectiveness of the training program and progress of the athletes performance.

The final product is intended for ice hockey coaches. Designing a well-rounded off-ice training program takes a lot of time. All the different training modes have their own intrigue variables, and with all the other responsibilities that head-coaches have, ready to use manual might be a much-needed help.

As in with any scientific review, no conclusion can be made as final. The field of strength and conditioning progresses every year and more information of developing skills is presented. Therefore, the information provided in this manual is a product of this time. Even though many training methods are proven efficient over years of experimenting and studying, it does not mean that new, more efficient training methods cannot be discovered.

**Keywords**
Ice hockey, strength and conditioning, periodization, manual.

## Table of contents

# 1 Introduction

Strength and conditioning seem to be an ever growing field in sports. In ice hockey, it will not only attempt to develop better ice hockey players, but better athletes. Ice hockey has multiple different physical demands. (Mero, Nummela, Kalaja & Häkkinen 2016, 564-565) Athletes need to be fast and strong and to have the ability to maintain these abilities for the duration of a 2+ hour event. The off-season in ice hockey is quite short compared to the competitive season. This does not provide a huge window to develop these physical attributes to a great extent. Especially athletes in the late adolescence should attempt to keep physical development throughout the entire season. Proper periodization for the off-ice training provides the necessary tool to ensure that constant progress can be made. Periodization provides structure to the training plan, when thought out thoroughly. It attempts to provide an optimal window of opportunity to develop specific adaptations when interference of other training modes are not present and to manage fatigue.

The objective of this thesis is to provide an inclusive training manual with a periodization of the annual plan. The annual plan is divided into mesocycles and further into microcycles. The structures for each microcycle and their contents are explained in the final product and explanations to each individual training session are included. The final product is intended for ice hockey coaches who need help with the planning of the off-ice training.

The thesis reviews physiological needs for ice hockey. Four major aspects speed, strength, endurance, and mobility are reviewed. Training variables for each component are discussed from a practical standpoint. Each part of the physical training should provide enough information to help create a practise plan. Different periodization models, and the practical applications of each are discussed. The theoretical part does not suggest a single periodization model to be used. However, mix of periodization models might be needed, especially during the competitive season. Testing and monitoring key elements to periodization. Testing provides information to the coaches whether the training program is producing desired adaptations. Is the performance increasing? Preferred and scientifically most reliable testing battery is provided in the final product. Monitoring is a method to ensure fatigue management during hard training phases and competitive season. Reliable monitoring methods to manage fatigue are discussed in the end of the theoretical part. All components of the thesis tie together in the final product. A complete off-ice training manual for u-18 ice hockey.

# 2 Sport Analysis

To perform at high level ice hockey requires multiple different skills and abilities. Stick handling and skating are extremely specific individual skills for the sport and take multiple years of practise to master. Along with individual skills player must have good on field positional awareness and ability to react to changing situations. On the psychological side ice hockey players should have determination, courage, and creativity. Good player must also have good co-operative skills on social skills perspective. (Mero, Nummela, Kalaja & Häkkinen 2016, 564-565)

For the goals of this thesis I am going to focus more on the physiological side of the sport analysis. In ice hockey, physiological abilities can be categorised into four different qualities. Strength, speed, endurance, and mobility.

## 2.1 Strength

Strength is a major distinguishing factor between pro and amateur hockey players. (Lorenz, Reiman & Naylor 2013) High force production is the best indicator for all types of skating ability (acceleration, stops, turns etc.) Strength training for ice hockey is done to build mass, to increase maximal strength (absolute and relative) and to increase fast force production, power. Absolute strength and muscle mass are needed in contact situations and they reduce injury risk because strength training improves bone, tendon, and other connective tissue durability. (Fleck & Falkel 1986; Hejna, Rosenberg, Buturusis & Krieger 1982; Lauersen, Andersen & Andersen 2018) In the early stages of strength training, training for hypertrophy is beneficial, because adding lean muscle mass is major a major indicator for strength. (Siahkouhian & Hedayatneja 2010; Brechue & Abe 2002)

## 2.2 Speed

Fast player is usually always first to get to the puck and breakaway from the defence. Therefore, speed is one of the most important qualities for an ice hockey player. Nature of the game is fast pace and situations are constantly changing. Ability to react, change direction and accelerate fast is for this reason more important than overall top speed. (Mero et al. 2016, 564-574; Domer 2005) Reactive agility and short accelerations seem to be essentials for ice hockey specific speed training. Development of these attributes should be a cornerstone of a hockey strength and conditioning program.

## 2.3 Endurance

Ice hockey is a high-intensity sport that is played in shifts. This makes the efforts interval style. Bouts within the interval are combined of multiple stops, changes of direction, battles, and maximal sprints. Duration and intensity of the intervals and recovery between them is varied. Number of shifts varies between 15 to 25 per game, each lasting 40 to 45 seconds on average. Duration of total time on ice varies between 14 to 28 minutes depending on the players role. Recovery between shifts is 2 to 5 minutes on average, making work to rest ratio 1:3,5 to 1:8 depending on the role. (Mero, Nummela, Kalaja & Häkkinen 2016, 567-569)

On average, each shift consists of 6% of high effort skating and 10% of battling for the puck and space on the ice. This means 5 to 7 high effort bouts, lasting 2 to 3,5 seconds each. 50% of total time spent on the ice is sliding on two feet and other light activity. Average intensity of the game is estimated to be between 70 to 80% of VO2 Max, with 69% of the total energy produced being anaerobic and the rest ~30% aerobic. (Mero et al. 2016, 567-569)

Due to intense, fast pace nature of the game, anaerobic power is a much-needed ability for ice hockey players. Especially the ability to produce power in repeated efforts. Therefore, anaerobic capacity is one of the most important quality for athletes. Intensity and duration of one individual shift determine which energy system body is using. Immediate energy sources (ATP and phosphocreatine) last up to 10 seconds, after that, if high-intensity activity continues, anaerobic glycolysis is the primary energy source.

Recovery during a light activity on ice (e.g. sliding) and between shifts is faster with good aerobic capacity. Good aerobic capacity improves recovery time from high-intensity bouts and allows athlete to work longer at high intensities. Good aerobic capacity creates the base for all later higher intensity training (Peterson et al. 2015).

## 2.4 Mobility

Mobility in lower body, especially in lower back, groins and hamstrings is important to maintain. Due to the skating position, which is similar to a half squat position, tightness in these muscles are not uncommon. (Mosenthal, Kim, Holzshu, Hanypsiak & Athiviraham 2017) The ability to achieve full hip, knee and ankle extension in skating can be limited by tight hamstring muscles and this may lead to injuries in groin and lower back area. Lower back can be prone to repetitive strain injuries due to constant tension in the area. Strength

training is shown to prevent injuries in these problem areas. Strength training done especially with eccentric overload, will strengthen the muscles and therefore protect them from injuries. (Askling, Karlsson & Thorstensson 2003)

# 3 Strength Training

As stated earlier, maximal strength and power are one of the most important abilities for elite level hockey player. Maximal strength training is shown to improve sprinting performance. Therefore, it seems to be essential to speed development. (Seitz, Reyes, Tran, de Villarreal, & Haff 2014) meta-analysis revealed that strength training had correlation to improved sprint performance regardless of the training variables (e.g. frequency, volume, intensity ect.). Lower body strength increases in, especially the squat, transfers positively into sprinting performance. Long-term resistance training aiming to improve one repetition maximum, concurrent with sport training, is shown to improve change of direction performance in young athletes (Keiner, Sander, Wirth & Schmidtbleicher 2014). It seems that strength training aimed towards increasing maximal strength is important for athletic development. The following chapter focuses on the training variables of strength training.

## 3.1 Strength training variables

Strength training can be divided into multiple different types of modes that are determined by load, repetition range and the speed of execution. (Bompa & Buzzichelli 2015, 229-310) All of these aspects have a role in designing a strength training program. Training variables concerning strength training programming covered in this chapter are specificity, overload, fatigue management, and variability. Variables for strength training on a single session of weekly level are training frequency, volume, intensity, tempo, rest periods, and exercise selection.

### 3.1.1 Specificity

Specificity in strength training comes down to goals that need to be achieved. In ice hockey athlete needs to be fast, powerful, and strong. Therefore, focus of training should aim to achieve maximum strength, and power. Training should be methodologically structured, goals being the main end goal, Training of all those adaptations at the same time should not be the focus. Periodization of the strength training divides the program into separate phases to focus on one individual adaptation. More on that later. (Israetel, Hoffmann & Wesley-Smith 2015, 28)

### 3.1.2 Overload

Overload is one of the oldest and most research-grounded strength training variables, It is one of the most critical variable to a well-designed strength training program. ”Overload is present in a program, when the stimulus is within the maximal threshold of the adaptive system, and the stimulus is on average greater than recent historical stimuli.” (Israetel et al. 2015, 72-73) Simply put, each training session, loads should get progressively heavier or same load should be lifted more times. Simple rule is to try increasing the weight lifted by 2,5 to 5kg from workout to workout, or to lift same weight as in previous session but for more repetitions.

### 3.1.3 Fatigue management

Strength training causes fatigue many ways in the body. Single session depletes glycogen stores, nervous systems fatigues over weeks of heavy lifting, micro-tears develop in connective tissues, such as tendons, ligaments, bones, and muscle fascia. If training is done hard over prolonged period of time testosterone levels begin dropping and cortisol levels start rising (Israetel et al. 2015, 76-86). Therefore, ways to manage fatigue are important to avoid hampered performance on ice.

Glycogen stores restore in few days, at most, when carbohydrate is consumed adequately. Lighter training days and rest day’s work in promoting faster recovery. These two can be implemented on a weekly basis. Programming at least one or two days for recovery and emphasize high quality nutrition to the athletes should be considered. Nervous system takes a longer time to get fatigued, however avoiding CNS-fatigue from rising high is best way to play it safe. Deloads or lighter training weeks prevent CNS-fatigue from rising too high. Programming of the deloads is discussed in the periodization chapter. Finally, active rest phases or transitional phases of training should be programmed to give time for connective tissues to heal properly. This time of the season is usually right after the last games of the spring season. (Israetel et al. 2015, 105-115)

### 3.1.4 Variety

Variety in strength training refers to the changing of the training variables such as volume and intensity. This can be done every microcycle or mesocycle. More on micro- and mesocycles in the periodization chapter. Poliquin (1988) suggests that resistance training program should be varied every 2 to 4 weeks since body starts to adapt to training stimulus and therefore the effectiveness of the program starts to decrease. Poliquin suggests five

ways to varying strength training: by varying muscular contractions (concentric, eccentric, and isometric), intensity and volume, exercise selection, and velocity of the movements. Poliquin suggests exercise selection variation in short-term (within a microcycle) by varying e.g. grip placement and different movement angles. Velocity of the movement comes in a form of tempos. For example, slower velocities in the eccentric portion during hypertrophy block and fast movements in a form of plyometrics.

### 3.1.5 Training volume and frequency

In strength training volume can be calculated by multiplying sets, repetitions and the weights used (sets x repetitions x load), also known as volume load. (Helms 2019, 47) Volume can be easily be determined by the number of working sets performed per movement pattern or muscle group per week. (Helms 2019, 47) Movement patterns are discussed more thoroughly on page 12. Simply put, if an athlete does 4 sets of squats (bilateral or unilateral) on a Monday and 5 sets of squats (bilateral or unilateral) on a Thursday, total volume for that movement pattern during that week is 9 sets.

In the early stages of strength training lower training volumes generate enough stimulus to allow positive adaptations and are more likely ensure adequate recovery between training sessions. In the beginning of the season when loads are lower, higher volumes are easier to manage. During anatomical adaptation and hypertrophy phase training volume is best to start at lower effective volume of 10 to 12 sets per movement pattern per week. (Helms 2019, 62) As a beginner training volume doesn´t need to be increased since strength is gained through technique and neural improvement. However, for more experienced athlete’s volume should slowly increase every one or two microcycles to create progressive overload. (Helms 2019, 62)

When it comes to strength training 16 to 17-year-old hockey players are most likely total beginners. Some level of strength training is almost always done in younger age groups, at least by Finhockey standards (at Finhockey). However, starting at lower volume is best to way to play it safe since the quality of training and coaching can vary massively.

Strength training volume is best to be kept at lower effective volumes during all types of strength training (hypertrophy, maximal strength and power) at 10-12 sets per muscle group and movement per week. After athletes reach intermediate training level, around 6 months to 1 year, can volume be increased up to 13-15 sets per muscle group and movement per week. (Helms 2019, 208)

Training three sessions per body part per week is a good starting frequency for beginners. Less experienced lifters seem to get the best benefit from higher training frequency. First several months of strength training cause strength improvements that far outpace muscle size additions. This is because the nervous system is both learning to enhance its force output per individual neuron and groups of neurons as well as coordinate muscle timing better to produce higher forces. Higher training frequencies give the nervous system more practice to improve its abilities and have been shown to result in more rapid improvement in strength levels of beginners (Israetel et al. 2015, 213) Two sessions per body part per week works for more experienced athletes because they need more time to recover.

### 3.1.6 Training intensity

Intensity can be determined by loads used on the bar in relation to one repetition maximum (1RM), for example 85% of 1RM. Intensity can also be determined by RPE scale, based on repetitions in reserve (RIR) on a given repetition scheme (Helms 2019, 62-66). For example, set of 10 repetitions, RIR 8, means two more repetitions could be performed. However, estimating how many repetitions an individual can do is difficult, especially as a beginner. (Steele, Endres, Fisher, Gentil & Giessing 2017) Beginners do not have similar understanding how much they can actually lift. For this reason, coach needs to have a keen eye on athletes and ask questions to estimate their RIR.

Determining training intensity by percentages can be difficult in practice. Percentages can differ by a quite big margin on a given day (Poliquin 1988). This can sometimes make the working set feel too hard or even lead to failure. Or on the opposite hand given percentage can feel too easy on some days. For this reason, better approach is to determine the load, by letting the repetitions indicate the load. For beginner athletes working on lower intensity (7-9 RIR) will give enough stimulus (Mäennenä et al. 2019, 277-278). This will lead to each workout being effective and the athlete will be working on high end of their performance on that day.

Autoregulatory progressive resistance exercise (APRE) method has shown to be more effective compared to linear progression based on percentages (Mann, Thyfault, Ivey, & Sayers 2010). APRE-method allows athletes to regulate their own training volume and intensity on a daily and weekly basis. This way they have more autonomy of their training and can improve at their own individual pace. However, this method should be used, and was studied, with more experienced lifters, (2,5 years training age) not with beginners.

Maximal strength training can be roughly divided into two categories. Hypertrophic and neural strength training. Hypertrophy training is generally done at 60 to 85% of max 1RM intensity and the main goal is to increase lean muscle mass (Mero et al. 2016, 250). Neural strength training is done 85 to 100% of 1RM max and the goal is to increase maximum force development. Bompa and Buzzichelli (2015, 239-249) categorize hypertrophy training to 60 to 80% of 1RM, with repetition range between 8 to 15 repetitions per set. Maximal strength is divided into intermuscular maximal and intramuscular maximal strength. Intermuscular coordination refers to the ability to coordinate all muscles involved in the kinetic chain and is done at 40 to 80% of 1RM. This would hit the hypertrophy zone. Intramuscular coordination refers to the ability to recruit maximum amount of motor units voluntarily at high intensity, at 80-90% of 1RM. In both, intermuscular and intramuscular coordination, intent is to maximally accelerate through the concentric phase of the lift.

### 3.1.7 Rest periods

Commonly there has been a clear-cut difference in rest periods between hypertrophy and maximal strength training (Bompa & Buzzichelli 2015, 141). Studies noted, that 30- to 60-second recovery periods spiked anabolic hormone levels, growth hormone and testosterone, immediately after workout, whereas this effect was blunted (or non-existent) when resting two minutes or longer. (Kraemer et al. 1990; Kraemer et al. 1991; Kraemer & Ratamess 2005; de Salles et al. 2009) These results lead to shorter rest periods being commonly used for hypertrophy training. However, it has been studied that using longer rest periods result in more weight lifted and more repetitions performed on heavy weights compared to short rest periods. While the effect on hypertrophy remaining similar (Schoenfeld et al. 2016; Henselmans & Schoenfeld 2014; Senna et al. 2016; Grgic, Schoenfeld, Skrepnik, Davies & Mikulic 2018; Morton et al. 2016). Whether athletes need more muscle or more strength, longer rest periods, 2 to 5 minutes, will give the best benefit. Less trained, neurologically less efficient athletes need less rest in maximal strength training compared to stronger individuals (Grgic et al. 2018).

In a practical sense, this might lead to some issues. If a team only has 45 minutes of gym time before next team kicks in, 2 to 5 minutes of rest between sets will not give a lot of time to do different exercises. Exercises can be paired by using antagonist paired sets (APS) (e.g. bench press and pull-ups) or pairing upper body and lower body exercises (e.g. lunges and dumbbell bench press). This method allows to keep rest periods long enough for single exercise, while still the ”flow” of the training is faster and there is room for more exercises (Helms 2019, 177-181). However, while using antagonist paired set method with smaller muscle groups and single joint movements do seem to lead to higher

training volumes compared to traditional training (one exercise at a time) (Robbins, Young & Behm 2010). Pairing big compound lifts like heavy squats with bench presses seems to lead to a performance decrease (Ciccone, Brown, Coburn & Galpin 2014). Therefore, favour traditional training during maximal strength and power phases for main lifts. During anatomical adaptation and hypertrophy phase, when lots of unilateral movements are performed, APS or upper and lower pairing can be done.

### 3.1.8 Tempo

In strength training tempo refers to the speed of the movement. Each lift can be divided into three different types of muscle contraction: eccentric, concentric, and isometric. Eccentric part is the lowering part of each movement, for example in the squat, when you begin to squat down. Concentric part is the actual pushing or pulling of the resistance, in the squat, pushing up from the bottom position. Isometric contraction is when no movement happens, for example, the pause in the bottom of the squat.

Slowing down the tempo in resistance training seems to cause increased mitochondrial and sarcoplasmic protein synthesis immediately after exercise, and delayed stimulation of myofibrillar protein synthesis (Burd et al. 2011). This could indicate higher rates of hypertrophy. Another reason why slowing down eccentric portion of the lift can cause great hypertrophy is due to the increased time under tension. When it comes to power and maximal strength training slow eccentric is not beneficial since it has shown in decreased rates of force development (Suchomel et al. 2019)

Eccentric training is shown great increases in strength and hypertrophy (Roig et al. 2009). Downside to eccentric training is greater delayed onset muscle soreness (DOMS) and delayed recovery. Possibly, because eccentric training generates the highest levels of muscular tension (Komi & Buskirk 1972). Fast eccentrics (plyometrics) have shown to result in higher rates of force development. On the other side, slow eccentrics have been associated with decreased rates of force development (Häkkinen & Komi 1986). Therefore, slow eccentrics are recommended to be used during the off-season because of the decreased RDF in slow eccentrics training for power and maximal strength training slow eccentric may not be beneficial. Barisik suggests slowing down the eccentric part of the lift can be useful for technique learning (Barisik 2020, 74). Eccentric supramaximal (+100% of 1RM) training is very taxing to the body. Poliquin (1988) suggested it to be used with more experienced athletes with more than 2 years of strength training.

10 to 15 percent of more force can be produced by isometric contractions. Therefore, isometric training can be used to break through plateaus in lifts. This can be done by adding pauses in various points of range of motion or by pushing against immovable resistance (Poliquin 1988). Concentric training with maximal intent to accelerate the bar is shown to result in better strength gains compared to slower concentric (González-Badillo, Rodríguez-Rosell, Sánchez-Medina, Gorostiaga & Pareja-Blanco 2014). Therefore, accelerating with maximal intent is recommended during all phases of resistance training, hypertrophy, maximum strength, and power training.

Lifting tempo can be prescribed as a 3-digid or a 4-digid way. In the three-digid method the first number refers to the eccentric portion of the lift, second to the isometric between eccentric and concentric, and the final number is for the concentric portion. For example, 3-2-1 tempo in a squat would mean 3 second lowering, 2 second pause in the bottom and 1 second concentric (Suchomel et al. 2019).

Charles Poliquin's 4-digid tempo is an edit from the 3-digid prescription adding fourth number to the end to denote a pause in the contracted position. As in the example above, just add fourth number. 3-2-1-1 would be 3 second lowering, 2 second pause in the bottom, 1 second concentric and 1 second at the top of the squat (Barisik 2020, 70-71). Tempo descriptions are commonly added in the resistance training program to provide accurate information for performing the exercises as intented.

### 3.1.9 Exercise order

The priority of the training goal should determine the exercise order. If the goal is to increase power, power exercises should be performed primarily. This is because greater increases in strength are done for the first exercise in a workout (Simão, de Salles, Figueiredo, Dias & Willardson 2012). Exercises performed later at fatigued state leads to less repetitions performed compared to if they were performed earlier in the workout (Simão, Farinatti, Polito, Viveiros & Fleck 2007). Furthermore, when exercise involving larger muscles is performed in the end of the session, 1RM test results seem to be slightly lower compared to when performed in the primarily in the session. This suggests that the training program should begin with exercises that are particularly important for the training goals (Simão et al. 2010).

Power exercises such as power cleans and snatches should be performed first, since they require highest level of skill and concentration. Also, power exercises performed while fatigued do not reach similar force outputs compared to while trained in a fresh state

(Beachle & Earle 2008, 390-392). Therefore, performing power exercises early in a workout provide the best results. Secondly, because of greater increases in strength are developed in the beginning of the workout, main lifts such as squats and bench presses are commonly preferred to be performed after power training. After these multi-joint movements, isolation, or single joint movements, such as dumbbell rows or triceps extensions can be performed in the end of the workout (Beachle & Earle 2008, 390-392).

### 3.2 Exercise selection

Australian strength coach Ian King wrote the ”Lines of movement” concept in the early 1990’s (at Kingsports). He categorized six different movement patterns. This concept gives a great foundation to build a strength training program that hits all needs for muscle and strength development. Six movement patterns are as follows: quad dominant (squat) and hip dominant (deadlift and hip hinge) for lower body. Horizontal pushing and pulling, and vertical pushing and pulling for upper body.

Quad dominant movements consist of squatting and lunging patterns. Bodyweight and barbell squats, and bodyweight, dumbbell and barbell lunges and split squats. Hip dominant movements consist of deadlift and its variations (e.g. romanian deadlift), hip thrusts, glute bridges and back extensions, and direct hamstring exercises such as leg curls. Horizontal pushing is any movement where you push either your bodyweight or weights off your chest away from your body. For example, bench pressing and its variations, and push-ups. Horizontal pulling is the opposite action. Pulling your bodyweight or external resistance towards your chest. For example, bent over rows and inverted rows. In vertical pushing is you are either moving weight directly or slightly in front overhead, e.g. push press or dumbbell presses. Vertical pulling is done pulling resistance or bodyweight from directly overhead towards your clavicles. Chin-up and pull-up are best examples of this.

While squats, deadlifts, bench presses and Olympic lifts allow to move the most weight. Vertical and horizontal pulls with vertical pushes are equally as important and should be done with similar volumes as the formerly mentioned. (Picture 1)

| Joint | Strength training | Ratio |
|---|---|---|
| Ankle | Plantar flexion (gastrocnemius, soleus) to dorsiflexion (tibialis anterior) | 3:1 |
| Ankle | Inversion (tibialis anterior) to eversion (peroneus) | 1:1 |
| Knee | Extension (quadriceps) to flexion (hamstrings) | 3:2 |
| Hip | Extension (spinal erectors, gluteus maximus, hamstrings) to flexion (iliopsoas, rectus femoris, tensor fascia latae, sartorius) | 1:1 |
| Shoulder | Flexion (anterior deltoids) to extension (trapezius, posterior deltoids) | 2:3 |
| Shoulder | Internal rotation (subscapularis, latissimus dorsi, pectoralis major, teres major) to external rotation (supraspinatus, infraspinatus, teres minor) | 3:2 |
| Elbow | Flexion (biceps) to extension (triceps) | 1:1 |
| Lumbar spine | Flexion (abdominals) to extension (spinal erectors) | 1:1 |

Picture 1 Agonist-to-antagonist ratios for slow concentric isokinetic movements (Bomba & Buzzichelli 2015)

Picture 1 presents ratios which agonist – antagonist muscles are suggested to be trained. The volume of strength training should be balanced between the two. In many sports some muscle groups are naturally more involved in the action. For example, in ice hockey quadriceps and glutes do much of the work during skating action, while hamstrings are much less involved. By only focusing on developing certain muscle groups involved in the sport, while deglecting the opposing ones, can lead to muscle imbalances and even injuries. Balancing agonist – antagonist muscle groups during anatomical adaptation phase is common (Bompa & Buzzichelli 2015, 178-179). Especially upper back muscles (trapezius and posterior deltoids) are suggested to be exercised at higher volume (3:2 ratio) compared to anterior deltoids.

Squat pattern, deadlift or hip hinge pattern, bench press, and Olympic weightlifting variations give a wide variety for exercise selection. Squats to depth are greater in building stronger, more athletic players (Hartmann, Wirth, Klausemann, Dalic, Matuschek & Schmidtbleiche 2012; Kubo, Ikekuburo & Yata 2019). Mobility issues can be avoided by elevating the heels with small plates or varying squat selection. For example, barbell back squats can be substituted with front squats or by using special equipment, such as safety squat barbell (SSB). SSB relieves some pressure from the lower back which can, in some occasions, be a limiting factor (Hecker, Carlson & Lawrence 2018).

Deadlift might be safest to start with regression of the full off the floor deadlift. Using blocks under the weights reduces the range of motion (ROM) and is easier to perform given the athlete has limited flexibility. Progression here can be later made by doing full ROM deadlifts (Barisik 2020, 187-190). Conventional deadlifts can be substituted to sumo deadlift variations or by using special equipment such as trap bar deadlifts. These two variations result in less strain on the lower back, (Belcher 2017) which can be an eliminating

factor for other training. Trap bar also allows to lift slightly more weight, around 6-8% compared to conventional deadlift (Lake, Duncan, Jackson & Naworynsky 2017).

Bench press can be varied with many other forms of horizontal pressing movement pattern. However, bench press is the number one strength builder compared to all of these because of full range of motion and loads can be higher compared to other variations, such as incline presses and floor presses (diminished ROM) or dumbbell presses (lower loads).

There is a huge variety Olympic lifts to choose from. For this reason, choosing the best one for hockey players can be a tough task. Block and hang variations are usually the easiest to teach and take the least time to learn. Full snatches to squat are technically more difficult than power variations. Therefore, favouring said variations is the smartest approach. Block power snatches and block power cleans, and hang power snatches and hang power cleans are great ways to develop starting strength and explosiveness. Which can be seen in the first few steps on ice (Ayers, DeBeliso, Sevene & Adams 2016; Hackett, Davies, Soomro & Halaki 2015). Power clean and snatches can be substituted with hang pulling exercises. These variations have shown to produce similar power production with power cleans (Comfort, Dos'Santos, Thomas, McMahon & Suchomel 2018) and are easier to learn. Another upside to hang pulls is that they can be beneficial if an athlete has injury of some sort in the shoulder region.

### 3.3 Lifting technique

Number one priority in making the athletes stronger is ensuring that lifting is done safely and with correct techniques. Improper lifting form may lead to injuries and force time away from training (Dahab & McCambridge 2009). When beginning strength training loads should be kept light and rate of perceived extortion (RPE) should be low (Zwolski, Quatman-Yates & Paterno 2017; Sadres, Eliakim, Constantini, Lidor & Falk 2001). Meaning that each set should be quite far away from failure. Loads around 40 to 80% of estimated 1RM, beginning with lower intensity. Repetition range between 5 to 12 repetitions. While lifting skills improve so does strength due to neural adaptations. When lifting technique is deemed adequate, can loads and RPE be increased even up to 1RM testing (Faigenbaum, Milliken & Westcott 2003). Complexity of the lift affects the amount of time needed to teach given lift. For example, Olympic lifts, like clean and snatch variations take longer to master compared to, for example overhead pressing.

### 3.4 Core training

Strong core muscles ensure that athletes can maintain proper skating position, shoot harder and are able to maintain balance in the battle situations. Role of the core is to isometrically support and restrict rotation of the lower lumbar spine. To stabilize the body. Core training can be divided into three parts: anti-extension, anti-rotation, and anti-lateral flexion. (at Faneille.com) These categories can be further divided into isometric and dynamic movements. Strongman movements, such as farmer's walks are great form of isometric core movements. Isometric anti-rotational movements could be pallof press's and pallof holds. Dynamic movements for extension are commonly used abdominal movements, such as lying leg raises. Dynamic rotational movements can be trained with medicine balls (Boyle 2016, 85-127). This can also work in improving power production of the core.

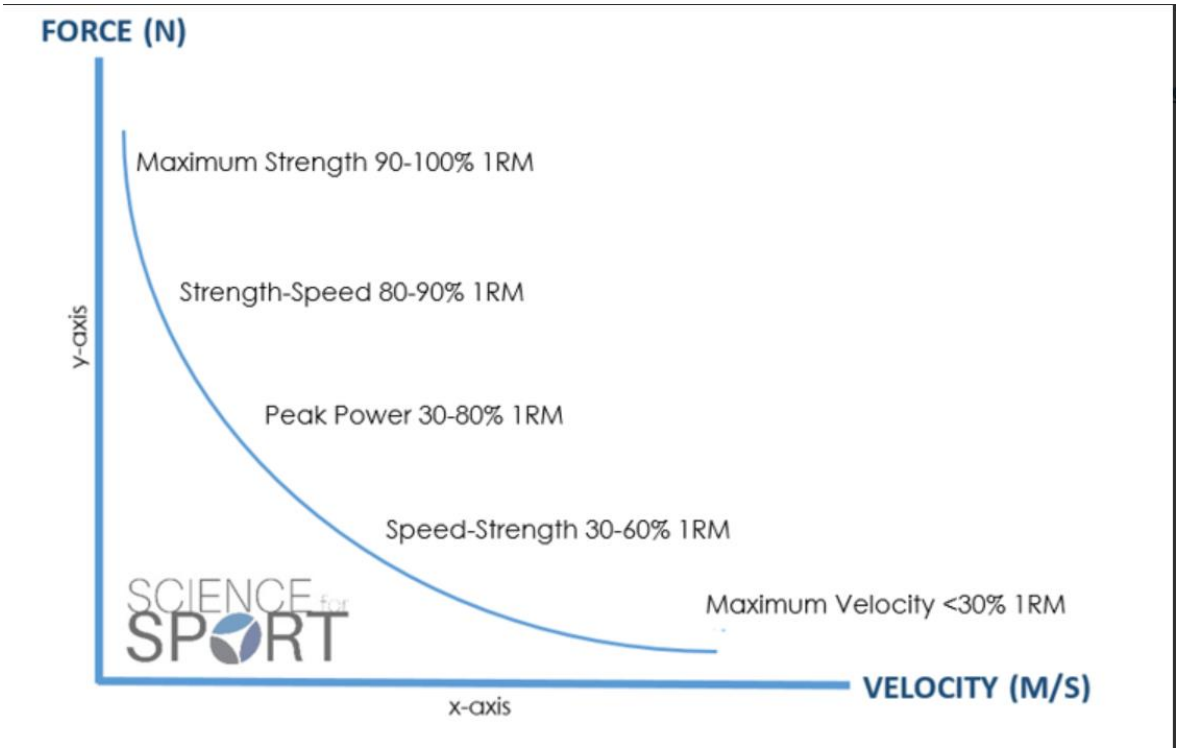
### 3.5 Anatomical adaptation and hypertrophy training

This type of strength training is where young athletes should spend most of their time when beginning strength training (Bompa & Buzzichelli 2015, 134). During anatomical adaptation (AA), training is focused on strengthening the core, muscles, tendons, and other connective tissues. This will prepare their body to deal with heavier loads and more neuromuscular strength training in the future. This time of training is also focused on fixing muscle imbalances, which are not uncommon for hockey players. Exercise selection in anatomical adaptation consists of more unilateral movements, such as split squats and dumbbell presses. Core strength is another major training point in this phase (Bompa & Buzzichelli 2015, 229-239).

Repetition range during the AA phase starts with moderate to high repetition ranges from sets of 6 to 20 repetitions, intensity between 60 to 80% (Bompa & Buzzichelli 2015, 239-249). Variety of repetition ranges should depend on muscle groups worked and total time under tension of the working set.

# 4 Power training

Power = Force x Velocity. This means that the ability to produce power consist of the ability to produce force in fast movements, such as throwing and jumping. High force outputs are generally produced slowly (0,6 – 0,8 seconds), while majority of the athletic movements, such as sprinting and kicking are done at fast velocities (0,3 seconds) (Turner et al. 2020). In force-velocity curve (Picture 2) high force movements, e.g. heavy (90% of 1RM) back squats, are performed slowest of all the other modes on the curve. On the opposite end high velocity movements, e.g. sprints, are the fastest (~0,1 seconds). Strength-speed movements consist of e.g. Olympic lifting movements. Peak-power movements e.g. Olympic-lifting variants and bench throws. Speed-strength consist of slower plyometric drills, e.g. countermovement jump and light loaded jumps.




Picture 2. Force-Velocity curve (from Science for sport)

## 4.1 Force-Velocity curve

As the purpose of training for ice hockey is to develop powerful and fast athletes, all aspects of the force-velocity curve should be trained. Increasing maximum strength levels has been shown to improve short sprinting performance (Seitz, Reyes, Tran, Sáez de Villarreal & Haff 2014) and rate of force development (RFD) (Taber, Bellon, Abbott & Bingham 2016). Maximum strength training increases athlete's ability to exert force, therefore, it potentiates the power ability (Turner et al. 2020).

Olympic lifting and its variants result in great RFD and therefore improved first step quickness (Hackett, Davies, Soomro & Halaki 2016). Same study noted that plyometric training (speed-strength and maximum velocity) had the same results in countermovement jump as Olympic weightlifting. Greatest power production is not bound to a specific load but rather loads for best force production can vary between different exercises (Soriano, Jime ´nez-Reyes, Rhea & Marı ´n 2015). Soriano et. al. (2015) showed that optimal loading for power production at heavier loads (>70% of 1RM) is done with Olympic lifts, power clean and hang power clean. Moderate loads (30 to 70% of 1RM) however, work greater with squat exercises. Finally, lighter loads (<30% of 1RM) are best with power production for the squat jump.

## 4.2 Plyometric training

Plyometric training consists of movements that elicit stretch-shortening cycle (e.g. jumping, bounding, hopping) (Bompa & Buzzichelli 2015, 282-289). However, not all jumping exercises are inherently plyometric. For example, box jumps don´t have the fast-eccentric component and short ground-contact times that define plyometric training. Regardless, jump training is included in this section.

Plyometric training can be very taxing to the body due to the high forces it produces (Wallace et al. 2010). Plyometric training intensity might be best programmed individually by lower body strength levels. Athlete with two times bodyweight squat is much more capable of handling high forces compared to an athlete with a one-time bodyweight squat strength. More on this on page 18.

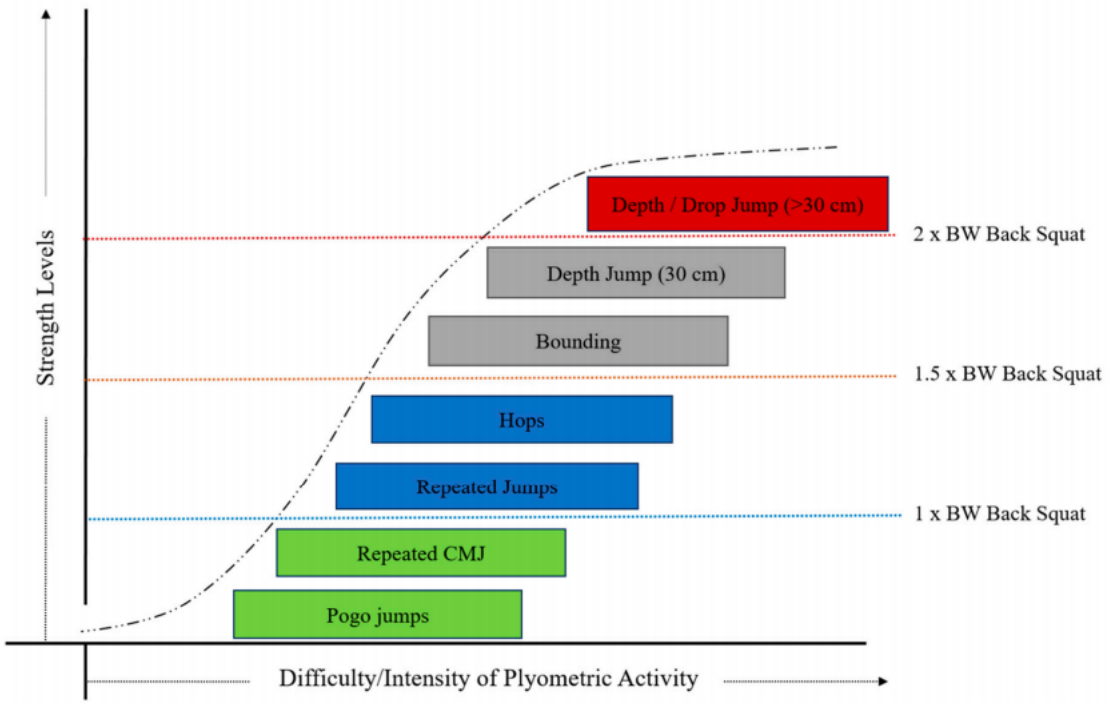
### 4.2.1 Plyometric training frequency

Plyometric training is a neurally taxing method. To achieve full nervous system recovery between workouts, 48-72 hours of rest between sessions is advised (Potach & Chu 2015, 414-426). This gives an opportunity for two to four training sessions per week.

Countermovement jump and 20m sprint performance gained similar results in a study between high (4 sessions per week) and moderate (2 sessions per week) training volume groups (de Villarreal, González-Badillo & Izquierdo 2008). If similar results can be gained with half the work, it seems, that training at lower frequency and volume is a better option. Two training sessions per week during off-season. Even one session is enough to improve speed and power during the competitive season.

### 4.2.2 Plyometric training volume

Training volume can be counted as ground contacts or jumps during a training session. For example, 3 sets of 5 hurdle jumps equals to 15 ground contacts. Total volume for the week, as above mentioned, is better kept rather low than too high. In their book Potach and Chu (2015, 414-426) have a volume guideline for 80-100 repetitions per week for beginner athletes (no plyometric training experience) and 100-120 total repetitions per week for intermediate athletes (some experience). In the study by (de Villarreal et al. 2008) highly effective volume performed in the 2 sessions per week group did 120 ground contacts per week. Renowned strength coach Michael Boyle recommends even slightly lower volumes. Roughly 25 ground contacts per workout and 100 contacts per week to be done in controlled manner to avoid overuse injuries (Boyle 2016, 145-158).




Picture 3. Plyometric progression, (Suchomel et al. 2019)

### 4.2.3 Plyometric training intensity

In order, to produce maximum amount of power, should power and plyometric training be done with maximal intent (Potach & Chu 2015, 414-426). Lower repetition range in plyometric training allows to keep the intensity and force production high and may reduce injury risk. Because each repetition should be done at maximum intent, exercise progression makes the difference in intensity (Picture 3). Depth jumps put higher forces on the body compared to vertical jumps (Wallace et al. 2010). Therefore, starting at lower impact exercises should be considered. Suchomel et al. (2019) suggest that the progression of the

plyometric exercises can be aligned with athlete's lower body strength levels. Stronger athletes with two times bodyweight squat can start with higher intensity exercises, e.g. depth jumps, while weaker individuals need to focus more on lower intensity so they can focus more on the landing mechanism and to develop eccentric strength.

Boyle (2016, 145-159) suggests progression for plyometric training is better started with adding landings ("stick") in between jumps. This adds more emphasis on injury prevention since landings focus more on the eccentric component of plyometrics and on stability. Jumping drills like hurdle jump, hops, with lateral bounds, hops and box jumps can be used. Just add stick landing with clear "pause" between repetitions. After two to three weeks exercises can be progressed to plyometrics without pauses.

### 4.2.4 Plyometric training rest periods

Full neural recovery should be achieved between sets for maximal power outputs. Since training should be done for maximal anaerobic power, individual sets should last no more than 10 seconds. Rest periods between sets can be easiest to determine by work-to-rest ratio. Between 1:12 to 1:20 work-to-rest ratio for most plyometric exercises (Potach & Chu 2015, 414-426). For example, for a set of hurdle jumps lasting 5 seconds, 60-100 seconds of rest should be adequate. However, higher the intensity, longer rest may be needed. Plyometric training should not have similar effect as a cardiorespiratory conditioning. Shortened rest periods can be cause such effect and therefore should be avoided.

### 4.2.5 Plyometric training exercise selection

Unilateral plyometric training produces better improvements in single-leg and double-leg power compared to bilateral exercises (Bogdanis, Tsoukos, Kaloheri, Terzis, Veligekas & Brown 2019). However, using bilateral plyometric exercises result in longer lasting gains in power performance (Makaruk, Winchester, Sadowski, Czaplicki & Sacewicz 2011). We can conclude from this that both unilateral and bilateral plyometric exercises belong in a solid training program.

Horizontal force production seems to be important key for enhancing sprint performance (Zweifel 2017; Buchheit et al. 2014). For greater horizontal power production plyometric exercises such as broad jump, forward bound and forward hop are great exercises. Horizontal drop jumps can be reliable in improving reactive strength when brief contact times are not required (Ball & Zanetti 2012).

Adding extra resistance to jumps can improve force production. Especially using 30% of 1RM resistance in squat jumps leads to improvements in strength, power, and speed performance (McBride, Triplett-McBride, Davie & Newton 2002). Positioning of the load makes some difference to power production. Study by (Weakley et al. 2018) examined difference between hexagonal (trap bar) and straight barbell. Hexagonal bar led to higher jumps and generated greater force, power, velocity, and RFD compared to straight barbell.

### 4.3 Ballistic power training

Ballistic training is a dynamic motion when applied resistance or athlete's body is projected. Medicine balls, barbells, kettlebells, track-and-field shots can be used as training tools and Olympic lifts to some extent. Ballistic training is generally advised to increase RFD and it has been effective for increase of power performance in resistance trained non-elite athletes (Newton, Kraemer & Häkkinen 1999). Combined with heavy resistance training ballistic method with loads of 50 to 60% of 1RM lead to significant increase in jump squat and bench press (Mangine et al. 2008).

Ballistic movements can be performed in the beginning of the workout or in the end. Depending on the goal or what else is practised on that day. If technical and tactical development is the goal, ballistic power exercises are better performed in the end of the session. If speed and power are the primary goals, ballistic training can be done after the warm-up, prior the speed session, especially in the pre-season. Ballistic, and power training in general has stimulatory effect of the nervous system and can be used as post activation potentiation portion of the warm-up (Bompa & Buzzichelli 2015, 278-280).

Strength and conditioning coach Michael Boyle spoke about using medicine-balls for torso training. Especially improving coordination and power on the torso. In sports, role of the torso is to stabilize and rotate, rather than flexion and extension. For example, slap shot in ice hockey involves huge rotation of the trunk and taking a hit involves the ability to stabilize the torso to avoid bending of the spine. Medicine ball training for torso, or core strength, has advantages in allowing sport-specific movements being done for power development and for intermuscular coordination through the kinetic chain (Boyle 2016, 85-88, 120-126). Boyle's recommendations for medicine ball training is to do 3 sets of no more than 10 repetitions. Starting from double leg throws and progressing to rotational throws and from there to single leg medicine ball training.

Key to all ballistic training is the velocity of the movement in order to generate maximum amount of force and to project the object (Bompa & Buzzichelli 2015, 278-280). Recommended training variables for ballistic method are presented in picture 4.

| | |
|---|---|
| **Load** | Load that allows projection of the body or implement |
| **No. of exercises** | 2–6 |
| **No. of reps per set** | 5 or 6 |
| **No. of sets per session** | 2–6* |
| **Rest interval** | 2–3 min. |
| **Speed of execution** | Explosive |
| **Frequency of training** | 2–4 |

*Lower figure for the higher number of exercises; higher figure for the lower number of exercises.

Picture 4. Training parameters for the ballistic method, (Bomba & Buzzichelli 2015)

### 4.4 Olympic weightlifting

Compared to the squat and the deadlift, Olympic lifts have higher power outputs and larger range of motion (Garhammer 1993). In both, Olympic lifting and powerlifting (squat, bench, deadlift), power output diminishes as the weights approach 100% of 1RM. However, in Olympic lifts, power output can be twice as high at 90% of 1RM compared to powerlifts (Garhammer 1993). Olympic lifting also is a great tool for improving balance, coordination, flexibility, and overall athleticism (Hedrick & Wada 2008).

It is not smart to program Olympic lifts for more than six repetitions. Power output has been studied to drop after six repetitions (Baker & Newton 2007). Since the goal of training Olympic lifts is to improve power, weights should be lifted at high velocities with repetition range between one to six.

#### 4.4.1 Olympic weightlifting variations

Highest power outputs in Olympic lifts are recorded in the so called “second pull”, where the bar has cleared the knees (Stone, Pierce, Sands & Stone 2006). This means, that for team sport athletes, full lifts off the floor are not necessary. Full lifts are technically more difficult, and the highest power is still generated from above the knee. Another aspect for choosing most beneficial Olympic lifting variation is deciding between full squat or power variation. Highest power outputs are measured between 70 to 80% in the hang power clean (Stone et al. 2006; Kilduff et al. 2007; Kawamori et al. 2005). For example, cleaning to full squat requires only pulling up to navel level and rapidly dropping under to catch. Then again power clean requires athlete to pull much higher, which maximizes the power

production. Block power snatches, block power cleans and hang power snatches and hang power cleans are great ways to develop starting strength and explosiveness (Ayers, DeBeliso, Sevene & Adams 2016; Hackett et al. 2015). Power clean and snatches can be substituted with hang pulling exercises since they produce similar power production (Comfort, Dos'Santos, Thomas, McMahon & Suchomel 2018). Pulling variations are easier to learn and can be beneficial if an athlete has injury of some sort.

### 4.4.2 Training variables for Olympic weightlifting.

Like mentioned earlier, lifts are not recommended to be done for more than six repetitions. Intensity (of 1RM) can range from 50 to 90%. Even maxing out on Olympic lifts with single repetitions is acceptable. However, high bar velocities should be sustained to elicit maximal power outputs.

Number of sets may depend on intensity used (Bompa & Buzzichelli 2015, 275-278). At higher intensities lower number of repetitions are performed, therefore more sets can be performed to obtain adequate volume. Three to six sets depending on repetition range. For example, 3 sets for sets of 5 repetitions and 5 sets for sets of 2 repetitions. Tempo in the exercises should be maximal for maximal type II muscle fiber (fast-twitch) recruitment. Rest periods should allow full neural recovery, so 2 to 4 minutes between sets will be enough. Higher the load, longer recovery may be needed and less recovery for lower loads (Bompa & Buzzichelli 2015, 275-278). Training frequency for Olympic lifts can be at two to three sessions per week. Or even in the beginning of each strength session.

# 5 Speed and Agility training

Speed training can be divided into three different parts. Acceleration, maximum velocity, and speed endurance. In ice hockey, maximum velocities are hardly ever reached since sprint efforts are quite short (Domer 2005). Speed endurance is useful only at longer distances (+10 second sprints or after maximum velocity is reached) (Sheppard 2003). Therefore, training for speed endurance is more anaerobic endurance and is not discussed in this chapter.

Resistance training with explosive emphasis may enhance athlete´s ability to generate high force outputs since these types of exercises utilize rates of force development (RFD) with near maximal or maximal values (Haff & Potteiger 2001). Therefore, potentiates the ability to generate high rates of acceleration. Since ice hockey shift consist multiple accelerations, improving acceleration performance via explosive exercises (power training) is advised.

It is suggested that maximum strength levels should be high so that speed training produced maximal effects. (Suchomel, Nimphius & Stone 2016) suggests that athletes should reach two times body weight in the back squat. Increasing maximum strength in the lower body has been shown to improve sprint performance (Seitz, Reyes, Tran, Sáez de Villarreal & Haff 2014). However, speed training should not be on the background completely. Two times bodyweight squat is very hard to achieve and putting speed training on hold for one whole year would not be smart. Speed training should be as a second priority in the program.

Agility refers to the athletic ability to swiftly accelerate and decelerate, to quickly change direction, and to rapidly vary movement patterns (Bompa & Buzzichelli 2015, 270). Change of direction (COD) training goes hand in hand with speed training in ice hockey. Long consistent training periods of strength training (two years according to this study) increased COD performance significantly. By 5-10% increase in 10m sprint times, respectively (Keiner, Sander, Wirth & Schmidtbleicher 2014). Reactive strength seems to have some importance to change-of-direction speed (Young, James & Montgomery 2002). Therefore, plyometric training exercises such as drop jumps can improve COD performance.

It seems to be that strength training has an undeniable affect to speed and agility performance, but how can acceleration and agility be drilled on the field?

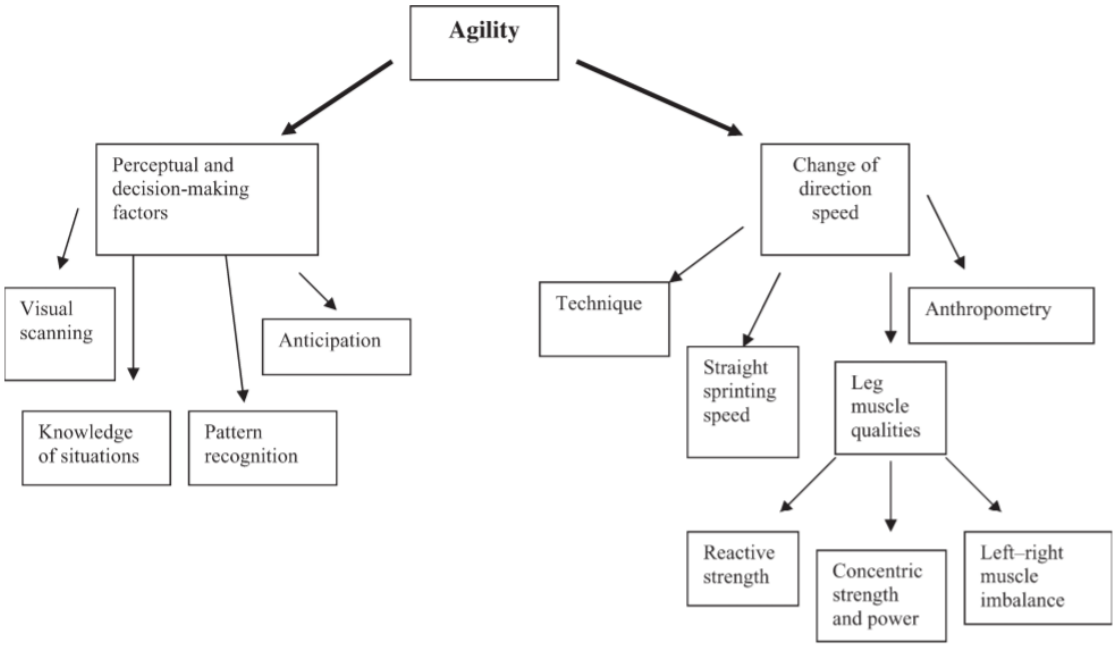
### 5.1 Sprint training

Acceleration can be trained with short 10-30m sprints (Joyce & Lewindon 2014, 145-165). 40 yrd (36.9m) sprint test showed significant correlations with skating speed (Behm, Wahl, Button, Power & Anderson 2005). Therefore it seems that improving short <40m sprints times by training short sprints would correlate on ice. Best training effects was observed at 31+ m sprint distances (Rumpf, Lockie, Cronin & Jalilvand 2016).

Heavy sled sprint training using 80% of athletes body weight is shown to improve acceleration times and especially horizontal force production (Morin et al. 2017). Heavy sled sprinting involves aggressive forward lead during the motion which is highly correlative to skating position (Robert-Lachaine, Turcotte, Dixon & Pearsall 2012). Sled sprint training can be effectively done at lighter loads (5-30% of athletes BW). However, optimal load for resisted sprint training is yet to be defined (Petrakos, Morin & Egan 2016).

Short-to-long approach is generally used method for developing speed in team sports (Joyce & Lewindon 2014, 145-165). Athletes initiate program with shorter acceleration sprints of 5 to 10 m and gradually increase to longer sprint distances. Sprints are done at maximal intensity of a 95-100% of maximal speed. Recovery between repetitions should be full 2 to 6 minutes depending on the distance (Haugen, Seiler, Sandbakk & Tønnessen 2019) or one minute of rest per one second of work (Bompa & Buzzichelli 2015, 44). Number of repetitions in training session can be between 5 to 10 total repetitions. Sprint training is recommended to be done at a ”fresh” state, meaning that sprint training is best done after rest day or easier training day (Bompa & Buzzichelli 2015, 157-172).

## 5.2 Agility training




Picture 5. Components of agility (Sheppard & Young 2006)

Agility training is commonly separated into two components. Change of direction (COD), and perceptual and decision-making factors. COD can be trained with so called closed agility drills, where the distances and the direction changes are known beforehand. Perceptual and decision-making factors can be trained with open agility drills, where the athlete changes direction based on outside signals, like visual or auditive signals. Training variables in agility training can be similar as to sprint training. Allow full recovery between sets and perform each repetition with maximal speed (95-100%).

Closed drills can be good in the early phases of agility training. Closed agility drills are drills where the pattern is previously determined. Point of the drills is to focus on change of direction mechanics, acceleration, and deceleration. COD training should incorporate movement patterns in various planes of movement, forward, backward and side-shuffling at various angles (Joyce & Lewindon 2014, 185-199). Get athletes familiar with the pattern and increase velocity of the drills.

Open drills include perceptual and decision-making factors into training. This is very similar to the sport event since actions on ice cannot be predicted. It is suggested that agility training needs to become more challenging as adolescents approach adulthood (Lloyd et al. 2013). Greater training focus should be on reactive agility training (RAT) in post-pubertal athletes. Only 15 minutes per day twice a week of RAT was shown to improve agility

performance significantly over three-week period in a study by (Serpell, Young & Ford 2011).

# 6 Endurance training

Anaerobic and aerobic energy systems are the main energy systems in use during an ice hockey game. Long duration running, jogging, and biking are traditional methods used to improve endurance. However, they may not be the best methods to improve conditioning for ice hockey. Long duration running or jogging are quite straining to the body and they require the use of slow-twitch muscle fibers. An ice hockey player should have good anaerobic power and speed qualities, and training for slow, long duration is quite contradictory. Long distance, slow endurance training at high volumes can be harmful since it hampers strength performance, can lead to muscle loss due its catabolic nature and fatigue cumulation (Wilson et al. 2012).

Aerobic conditioning might better be improved through other training methods. Tempo runs are an aerobic conditioning tool developed by a Canadian sprint coach Charlie Francis. Tempo runs are described to be an alternative method to long distance running by renowned strength and conditioning coach Michael Boyle. They are also discussed by (Joyce & Lewindon 2014, 153) especially for speed athletes. For ice hockey, developing conditioning by playing the sport is a proficient method. Especially during the competitive season additional endurance training might be harmful rather than advantageous, since added volume affects recovery (Stone & Kilding 2009).

## 6.1 Endurance training variables

Endurance training can be divided into aerobic and anaerobic training modalities (Baechle & Earle 2008, 93-140). Aerobic training has the most benefits for increasing maximal oxygen consumption (VO2max) and works as a base for all higher intensity aerobic and anaerobic training (Seiler & Tønnessen 2009).

Aerobic training can be monitored by using heart rate measurements. Setting exercise intensity by using heart rate zones is well suited to prolonged and submaximal exercise bouts. However, its effectiveness may be limited for controlling or adjusting the intensity of a HIT session (Buchheit & Laursen 2013). Rate of perceived extortion (RPE) method can be a useful tool for measuring high-intensity training sessions. RPE scale is simple and versatile to use and athletes can give immediate feedback of the set and of the training session. While more research with trained athletes is needed to confirm the efficacy of RPE method, it has been shown to promote the same physiological adaptations as an

HR-based programme. Especially repeated sprint training (RST), which is prescribed to be performed ‘all-out’, can be monitored efficiently by RPE-scale (Buchheit & Laursen 2013).

Bompa & Buzzichelli (2015, 44-48) present physiological characteristics of energy systems training and its six intensity zones. Intensity zone 1 is the alactic system which is in use during speed and power training. Those training variables are discussed in the speed and power training chapters. Intensity zone 2, the lactic system is in play when ATP and CP start to wear off and lactic acid starts to build up. Zone 2 training increases athlete’s ability to perform during lactic efforts and tolerate lactic acid build up. Training is done with short (3 to 10 sec) and long (20 to 60 sec) efforts with inadequate recoveries. Since ice hockey shift consist of short 3 to 7 second spurts of action training this intensity zone off-ice would simulate close to a sport performance. Intensity zone 2 training is often done as the competitive season approaches. Zone 2 training can be done in sets or in series. Set consists of multiple repetitions and is separated by similar rest periods. Series consists of multiple sets and are separated by longer rest periods.

Zone 3, maximal oxygen consumption, aims to improve athletes VO2max. Training in this zone improves between shift recovery for ice hockey players. High-intensity interval training is popularly used method for zone 3 training. Intensity zone 4, anaerobic threshold training is usually used along with zone 2 training. Training at anaerobic threshold is done at an intensity in which the rate of lactic acid diffusion in the blood equals the rate of removal. The objective of training in this zone is to maintain intensive work without accumulating excessive lactic acid and to raise the intensity of that work. This type of training works well with zone 2 training, since it improves the athlete’s ability to tolerate lactic acid build up. Intensity zone 5 is your typical long-distance running zone. Goal is to improve increase aerobic capacity. Intensity zone 6, aerobic compensation is most beneficial for recovery and can be done during recovery training sessions.

Table 1: A typical five-zone scale to prescribe and monitor training of endurance athletes.

| Intensity zone | $VO_2$ (%max) | Heart rate (%max) | Lactate ($mmol.L^{-1}$) | Duration within zone |
|---|---|---|---|---|
| 1 | 45-65 | 55-75 | 0.8-1.5 | 1-6 h |
| 2 | 66-80 | 75-85 | 1.5-2.5 | 1-3 h |
| 3 | 81-87 | 85-90 | 2.5-4 | 50-90 min |
| 4 | 88-93 | 90-95 | 4-6 | 30-60 min |
| 5 | 94-100 | 95-100 | 6-10 | 15-30 min |

The heart rate scale is slightly simplified compared to the actual scale used by the Norwegian Olympic Federation, which is based primarily on decades of testing of cross-country skiers, biathletes, and rowers.

Picture 6. Intensity scale for endurance training, (Seiler & Tønnessen 2009)

Seiler and Tønnessen (2009) define endurance training into five-zone scale (Picture 6). Zones one and two are zones below anaerobic threshold (zone one 45 to 65% of VO2max and zone two 66 to 80% of VO2max). These two zones are typically used to build the conditioning aerobic base and elite endurance athletes commonly spend ~80% of their total training time in these two zones. Zone three training consists of the anaerobic threshold training (81 to 87% of VO2max) and zones four and five the maximal oxygen consumption training zones done near the VO2max (90-100% of VO2max). Studies show that high-intensity training (94-100% of VO2max) done with repetitions of three minutes and up result in best adaptations in the increase of the VO2max. However, these studies mostly apply to elite endurance athletes. Nevertheless, using this information with junior ice hockey players could be applied. If the goal of the training is to increase VO2max of the athletes, maximal efforts >3 minutes should provide the best results.

### 6.2 Small-sided games

Small-sided games can be used to improve VO2 max and repeated sprint ability (RSA) during the off-season (Halouani, Chtourou, Gabbett, Chaouachi & Chamari 2014; Eniseler, Şahan, Özcan & Dinler 2017; Hammami, Gabbett, Slimani, & Bouhlel 2017). Small-sided games result in similar or even higher values of heart rate responses as with blood lactate concentrations and distances covered compared to a full game.

Generally, small-sided games involve three main kinds of alterations: Number of players used, field dimensions and task constraints. Intensity of the game can be altered by reducing the number of players used on field. Low number of players on each side has been shown to increase heart rate up to 87-91% of HR max compared to more players (83-88%

of HR max). Studies report an increasing tendency of %HR max, blood lactate concentration and rate of perceived extortion (RPE) when larger dimensions of the field are used for small-sided games. Finally, adjusting the rules and goals of the small-sided games can alter the intensity of the game. Lower intensities can be achieved without goal keepers result in lower intensities and limitations of touches increase the intensity. Task constraints keep players perception on a specific goal of the task, thus helping them in learning process and improving their performance (Clemente, Martins & Mendes 2014).

It is suggested to start small-sided games training with an aerobic approach in the beginning of the off-season. Use small to medium field sizes and more players on the field. 30 to 60-minute sessions consisting of 4 to 5 sets of 5 to 15 minutes with 1 to 2 minutes of rest in between. When approaching the start of the pre-season games can become higher in intensity. Larger field dimensions with fewer players and more rule restrictions can be used. When training to improve VO2max via SSG the overall workload should be from 10 to 30 minutes. The sessions consisting of 4 to 8 sets of 3 to 6-minute repetitions with work-to-rest ratio of 0.5:1 (Clemente et al. 2014).

SSG has shown weakness in improving VO2max especially in fitter athletes and within-player responses are highly variable (Buchheit & Laursen 2013). Therefore, adding some high-intensity interval training (HIIT) to training program should be considered. With that said, SSG along with playing the sport itself can work extremely well for improving conditioning. Above mentioned examples of SSG training recommendations are based for soccer training, but the sport used for SSG during the off-season in ice hockey can be any dryland sport e.g. handball, basketball. SSG can also be done during the ice sessions.

### 6.3 High-intensity Interval Training and Repeated sprint training

HIIT has been shown to be an excellent method to improve endurance (Buchheit & Laursen 2013). HIIT for young athletes results in slight increase in peak oxygen uptake (VO2peak), running performance, repeated sprint ability and submaximal heart rate (Engel, Ackermann, Chtourou & Sperlich 2018).

HIIT consists multiple different variations which are determined by duration of the interval and total work time and intensity (Buchheit & Laursen 2013). Long HIT intervals (>60 sec) working at 80-90% VO2max improve ability to recover between efforts by increasing lactate threshold and VO2max (Bishop, Girard & Mendez-Villanueva 2011). Sprint interval training (SIT) is done at sub-maximal to maximal sprint speeds with main goal in improving repeated sprint ability.

Repeated sprint training (RST) can improve VO2max, but this method is mainly aimed towards the improvements in lactic capacity and repeated sprint performance (Bishop et al. 2011). Compared to interval-based training, RST produces greater improvements in best sprint time and mean sprint times. However, high-intensity interval training seems to result in lesser decrease in the sprint times. Therefore, combining said two training methods might give the best results for improved repeated sprint ability. RST training can be used for zone 2 training to improve lactic capacity. RST can be done in series of maximal sprints (30-40m), with short ~30 second recoveries between sets, and longer 3 to 4-minute rest between series.

In a study by (Medbø & Burgers 1990) short (20 seconds) sprint training at submaximal speeds resulted in increase in anaerobic capacity after a six-week training periods. Compared to endurance training this method was far more efficient. It seems that even short training period for anaerobic endurance can elicit significant performance increases. Anaerobic endurance training via repeated short sprints seems to be a viable method and it can improve sustained power output. Volume between 8 to 15 short sprints is commonly used, but various rest periods can be applied.

# 7 Mobility and Warm-up

## 7.1 Stretching and mobility training

Static stretching is lengthening and holding of a muscle 10-60 seconds (even longer) at a mildly uncomfortable position. Dynamic stretching uses active muscular effort and momentum to lengthen the muscle. Proprioceptive neuromuscular facilitation (PNF) stretching involves isometric contraction and relaxation of both agonist and antagonist muscles that are stretched (Joyce & Lewindon 2014, 61-70).

Static and PNF stretching prior to strength- or power-sport seems to have mostly negative effects of a performance (with stretches longer than 60 seconds), while dynamic stretching is more favourable option out of the three (Peck, Chomko, Gaz & Farrell 2014). Dynamic stretching has been shown to promote positive effects with no negative effects on speed and agility performance. Static stretching seems to cause negative effects with stretches longer than 60 seconds. However, stretches less than 45 seconds seem to make little to no difference (Kay & Blazevich 2012).

For athletes with flexibility issues limiting the performance, a stretching program might be needed. However, timing of said training need to be taken into consideration. Post-exercise stretching is good place to improve mobility since muscle temperature is increased. Mobility training can be also done as a separate session on a recovery day (Joyce & Lewindon 2014, 299).

## 7.2 Warm-up

Goal of the warm-up is to prepare the athlete to exercise or competition by increasing muscle and core temperature, and blood flow, and to disrupt transient tissue bonds (Joyce & Lewindon 2014, 296). These effects can have following impacts on a performance: Faster muscle contraction and relaxation of agonist and antagonist muscles, improved RFD and reaction time, improvements in muscle strength and power, lowered viscous resistance in muscles, improved oxygen delivery due to the Bohr effect, increased blood flow to active muscles, and enhanced metabolic reactions. Warm-up does not seem to prevent injuries altogether (Fradkin, Gabbe & Cameron 2006; Shrier 1999). However, increased muscle temperature can increase the resistance to muscle tears.

Warm-up can be divided into two components. A general warm-up, where the goal is to increase blood flow, heart rate, deep muscle temperature, respiration rate and perspiration, and to decrease viscosity of joint fluids. This can be done by low intensity sport-specific actions or by slow activity such as jogging and jumping rope. Second part of the warm-up is a specific warm-up. It incorporates movements similar to movements of the athlete's sport. Specific warm-up can begin with dynamic stretching followed by increasingly higher intensity activities relative to activity. The point of the dynamic stretching in a warm-up is to activate major muscle groups involved in the training session. Activating gluteal muscles in a warm-up may give slight improvement for explosive exercise (Parr, Price & Cleather 2017). Speed and power session may need longer time to warm-up (National Strength and Conditioning Association Journal, 1984).

The final part of the warm-up is considered to be a neural preparation (Joyce & Lewindon 2014, 99-108). It involves post-activation potentiation (PAP) that acutely enhances muscular-force output. Commonly used methods are plyometric and so-called quick feet exercises on agility ladders. For resistance training, warm-up sets can work as PAP. Picture 7 presents effective guidelines for warming-up to resistance training.

| Working Set Rep Target 1–5 | | | Working Set Rep Target 6+ | | |
|---|---|---|---|---|---|
| | Reps | Load | | Reps | Load |
| Set 1 | 5–10 | Bar if applicable (optional) | Set 1 | 8 | 50% Working Weight |
| Set 2 | 5 | 50% Working Weight | | | |
| Set 3 | 4 | 60% Working Weight | Set 2 | 4 | 70% Working Weight |
| Set 4 | 3 | 70% Working Weight | | | |
| Set 5 | 2 | 80% Working Weight | Set 3 | 2 | 90% Working Weight |
| Set 6 | 1 | 90% Working Weight | | | |

Picture 7. Warm-up sets for strength training (Helms 2019)

### 7.3 Cool-down and post-exercise stretching

Common reasons for post-exercise stretching are to reduce muscle soreness and stiffness (Herbert & de Noronha 2011). Static stretching (30 to 60 seconds) might be good to use post-training since it increases blood flow, and range of motion (flexibility), and also

has shown a very little, but positive effect on muscle-soreness. Static stretching seems to be a useful tool for increasing parasympathetic nervous system activity and therefore, better relaxation done post-exercise (from Science for Sport).

# 8 Training age and maturation

16 to 18-year-old athletes can be at very different stages in maturing process. Most of the athletes have most likely already reached peak height velocity (PHV) and are at the end of the puberty (Lloyd et al. 2015). However, some athletes can be still in the midst of PHV since maturation rates can vary from 2 to 4 years (Mero et al. 2016, 85-87).

Plyometrics put high forces on the body (Wallace et al. 2010) and should be done at lower intensity during PHV. Considerations should be made to training programs for athletes in the middle of PHV, but most 16 to 18-year-olds can be trained similar to adults (Lloyd et al. 2015). Production of anabolic hormones, such as testosterone, increases strongly. Therefore, training for hypertrophy during late adolescence or post-PHV years is most beneficial (Mero, Nummela, Keskinen & Häkkinen 2007, 274). Resistance training during and post-PHV is shown to promote strength gains, with increased muscle mass (Moran et al. 2017).

Athletes can have differences in training age. Training age has affects to overall volume and intensities in the training plan. Especially strength training and plyometric training should not be progressed too soon. Therefore, defining training age must be done so that training program is adequate for each individual (Bompa & Buzzichelli 2015, 282-289; Scince for Sport 2016).

Defining training age and status can be done by the number of training years and months or by maximal strength numbers. Both methods have their advantages. Defining training age by strength numbers can be tricky since some people build strength faster (Timmons & James 2010) and therefore, can seem more trained even though amount time spent in training is the same as with a weaker individual. On the other hand, strength numbers set clear standards that define training status. Barisik (2020, 165-167) presents strength standards for six different strength movements aimed especially for ice hockey players. Standards are set for beginner (0-2 years of training), intermediate (two to four years of training) and advanced athletes (Pictures 9-11). These standards are set and apply to athletes that have been following a competent resistance training program and have received qualified coaching the whole time. These numbers will not necessarily be reached with once or twice per week random lifting.

- Trap Bar Deadlift: 2 x BW
- Barbell Squat: 1.5 x BW
- Split Squat: 1 x BW for 5 reps
- Bench Press: 1 x BW
- Weighted Chin-Up: 0.33 x BW
- Power Clean from Hang: 1 x BW

Picture 9. Beginner strength standards. (Barisik 2020, 165)

- Trap Bar Deadlift: 2.5 x BW
- Barbell Squat: 1.8 x BW
- Split Squat: 1.5 x BW for 5 reps
- Bench Press: 1.25 x BW
- Weighted Chin-Up: 0.5 x BW
- Power Clean from Hang: 1.25 x BW

Picture 10. Intermediate strength standards (Barisik 2020, 165-166)

- Trap Bar Deadlift: 3 x BW
- Barbell Squat: 2.2 x BW
- Split Squat: 1.75 x BW for 5 reps
- Bench Press: 1.5 x BW
- Weighted Chin-Up: 0.7 x BW
- Power Clean from Hang: 1.5 x BW

Picture 11. Advanced strength standards (Barisik 2020, 166)

Keiner (et al. 2013) have suggested a timeline model for strength development by training years. The model suggests that after four to five years of structured strength training, relative strength numbers should have reached a minimum of two times bodyweight back squat. This applies to 16 to 19-year-old adolescents. Is this model was followed, athletes should have started a structured strength program at the age of 11 to 15 years. Regardless, it seems that a 2 times BW squat should take at least four years to achieve.

Defining training age by training years presents its own issues. All time spent training might not be equal, like mentioned with strength training. The standard of coaching or the effort in training might lack in skill or intensity. Therefore, looking at both training years and strength numbers need to be taken into consideration when defining athletes training age.

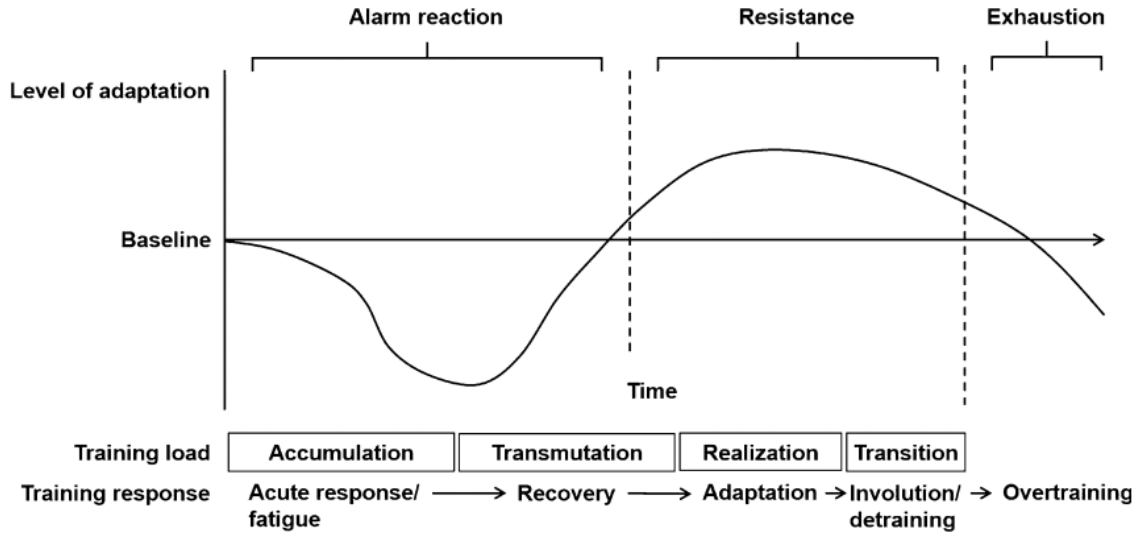
# 9 Periodization

The concept of periodization actualizes Hans Selye's model of the general adaptation syndrome (GAS) (Picture 12). GAS attempts to explain the biological process that stress induces in the organism. GAS model theorizes that initial stress response results in fatigue and to a drop in performance. This can also be described as an accumulation period. When enough time is devoted to recovery, or transmutation phase, positive adaptations can take place, which leads to increase in performance. This period of increased performance is referred as realization. In case of subsequent stressor is not provided, this leads to a transition phase, or detraining, which leads to a decrease in performance. On the other hand, if enough time is not devoted to the recovery phase, overtraining happens. Which also leads to decrease in performance. In the concept of sports training, stress usually refers to training session or multiple sessions within a training phase (Cunanan et al. 2018). Recovery phase attempts to reach supercompensation effect. A reduced potential for overtraining and increased potential for adaptations. This can be achieved through "deload" or unloading microcycle.

Michael Stone conceptualizes periodization as the overall concept of a training process, and it builds the foundation for the program design (Stone & Stone 2012). Periodization is a program design strategy to promote long-term performance improvements. Programming in short term with higher intensity can result in rabid gains in performance. However, compared to long-term program, that increases intensity slower manner, performance increases are higher in long-term program and the peak performance is maintained for a longer amount of time (DeWeese, Hornsby, Stone & Stone 2015).

Periodization allows program to fluctuate volume, intensity, and specificity of training in training cycles or periods in overall program (Joyce & Lewindon 2014, 508). Periodization done for a one-year plan is called an annual plan or a macrocycle. An annual plan is divided into three main phases of training: preparatory season (also known as pre-season), competitive season and transition. Ice hockey has only one competitive season within a calendar year. Therefore, ice hockey annual plan can be described as a monocycle. The main phases can be further divided into sub-phases e.g. general preparatory and specific preparatory. The sub-phases are further divided into mesocycles, lasting one to two months. Lastly, mesocycles are built of microcycles, usually lasting a week (Bompa & Buzzichelli 2015, 175; Helms 2018, 126).

Multiple periodization models suggest that training should begin with general training and move towards more sport specific actions and movements nearing the competitive season. During general preparatory phase goal of the training is to increase overall work capacity, fix possible muscle imbalances and aerobic conditioning. Hypertrophy and muscular endurance are typically performed in strength training. Poliquin (1988) suggests that strength training is done in 2 to 4-week accumulation and intensification phases. Accumulation phase is devoted to building muscle with higher volume and intensification phase to building maximal strength with higher intensities and lower volumes. Specific preparation phase is generally devoted to peaking sport specific qualities, such as power in ice hockey (DeWeese, Hornsby, Stone & Stone 2015). Periodization is cyclical by nature. Therefore, after the peak, the process can be repeated. The peak is usually timed to the most important times of the competitive season. In ice hockey the peak is usually timed to the beginning of the competitive season and into the play-offs. The annual plan should always include the time for active rest. Transition phase work as a time for active recovery (Stone & Stone 2012). This time is usually immediately after the end of the competitive season. Transition phase allows connective tissues to heal from microtears, and psychological and emotional recovery from the stress of the competition. This phase should always include some type of light activity. Usually these activities include low intensity aerobic compensation, stretching and other recovery methods.




Picture 12. General adaptation syndrome (Cunanan et al. 2018)

## 9.1 Issues with the concept of periodization

First issue with the concept of periodization arises from the Selye's GAS model. The theory assumes that all biological organisms respond similarly to stress. While biological responses are closely similar, inter-individual differences to similar training volume and intensity can vary massively (Kiely 2012). Genetics play a big role in athletic development. For example, they influence which type of muscle fibers are predominant for each individual. Fast twitch or slow twitch (Ahmetov, Egorova, Gabdrakhmanova & Fedotovskaya 2016). This raises the issue for the periodization of an ice hockey team. Each individual will respond differently to training stimulus. Along with genetics, the training background, and other factors in life cause stress, such as work, school, relationships etc. Therefore, all training variables need to be altered individually. In order to produce maximal potential from each individual, the training process needs to be monitored. Monitoring training indicates the effectiveness of the program and allows individual changes to be made (Stone & Stone 2012). More on monitoring on page 38.

Even though the GAS model itself does value the rest and recovery from stress, it does not suppose periods devoted to the rest and recovery for resistance training programs (Cunanan et al. 2018). This issue of the GAS is further resolved by more recent periodization models and theories. The concept of periodization makes the assumption that future training could be forecasted, and that previous training supports and potentiates the following phase. However, future training plan almost always needs adjustments to injuries, possible competitive schedule changes, and to other changes in life (Kiely 2012).

## 9.2 Periodization models

The most common periodization models are linear periodization, block periodization and undulating periodization models. Linear periodization model increases intensity over micro- and mesocycles as the volume of the training decreases. High-volume hypertrophy and muscular endurance training is typically performed in the early phases of the linear periodization model and more sport specific training is done in the later phases nearing the competitive season.

Block periodization focuses on developing one or two adaptations for the length of one mesocycle. While training focuses on one or two goals, e.g. maximal strength and VO2max, other training modes are kept at maintenance status. Evidence suggests that sequenced training, such as block periodization, results in greater performance increases especially in speed and power. This might be a result of a phase potentiation effect.

Phase potentiation model suggests that the previous training potentiates the effect for next phase of training. For example, hypertrophy training potentiates maximum strength gains, and maximum strength training potentiates the effect of power training (DeWeese, Hornsby, Stone & Stone 2015). Block periodization has shown to work greatly for improving VO2max and maximal strength (Rønnestad, Øfsteng & Ellefsen 2019). Shortcoming with the block periodization model might be that since training only has one or two main focus points, adaptations might not be maintained in the following blocks. For example, VO2max can decrease within 4 weeks of detraining (Mujika & Padilla 2000; Bosquet & Mujika 2012). However, beginners can take longer time off from strength training without strength gains lost compared to more experienced lifters (Ogasawara, Yasuda, Sakamaki-Sunaga, Ozaki & Abe 2011). This is hardly going to be relevant, since strength training will be major focus point for young hockey players. Detraining or loss of adaptations can be negated by doing maintenance training. For example, one session per week is enough for beginner lifters to maintain strength adaptations (Tavares et al. 2017; Rønnestad, Nymark & Raastad 2011).

Undulating periodization varies different loadings and intensities during a microcycle or a mesocycle. Daily undulating periodization (DUP) model thrives to improve multiple different skills during a single microcycle. Weekly undulating periodization has the same goal, but skills are developed one microcycle at the time. Undulating periodization model was developed to avoid detraining of adaptations achieved in the previous training blocks (Helms 2019, 126-129). DUP could be deployed to allow variation to heavy and light training days because it varies between relative intensities (% of 1RM). However, this might not be effective since this does not account for RPE of the session. Relatively light intensity of 60% of 1RM, might be highly fatiguing when performed at high volume, for example 3 sets of 12 repetitions at 60% of 1RM. (Stone & Stone 2012). DUP model could be taken into consideration during in-season training if the goal of the training is to keep the training adaptations at maintenance. For example, during play-offs, when the main focus is mostly at the games and recovery.

### 9.3 Designing an annual plan for off-ice training

Planning of the annual plan begins with the release of the game schedule. Competitive, pre-competitive and transition phases are determined next to support the schedule (Turner 2011, 34-44). Once the schedule is set, the main goal for the off-ice training should be decided. Development of maximal strength to 16 to 18-year-olds is most likely going to be the most important aspect because of its transfer effect to speed, change-of-direction, and power performance. Next, periodization model is included into the annual

plan. Block periodization seems to be the most effective for increasing power and speed performance. Blocks should be arranged so that each training phase potentiates the training effect of the following: hypertrophy, maximal strength, power. Periodization should aim for peaking the performance in a long-term. Therefore, avoiding rabid increases in volume and intensity is suggested. Each training mode strength, speed and endurance should be arranged within each block of training. More on microcycle structure in the following subchapter. The overall training volume of all training modes should be considered. Begin with lower volumes and increase progressively. Incorporate phases of active recovery into the program. Deloads of light training weeks can work in order to produce supercompensation effect. Once the initial plan is created, monitoring and testing programs need to be placed into the periodized plan. More on testing and monitoring in the following chapters. Training plan should be monitored throughout the program and adjustments should be made on an individual level and on a team level when needed (DeWeese et al. 2015).

The length of the competitive season can create issues to periodization. Especially, if the traditional model (linear periodization) is followed. Due to focus being on the games, training may taper considerably, and therefore lead to detraining and a loss of lean body mass (Gamble 2006). This is not desired especially with youth athletes. Therefore, strength training should be concurrent with sports training throughout the annual plan. Undulating nonlinear periodization approach might seem like a viable option for team sports during the competitive season. It will allow fluctuations in intensity and volume within a microcycle. However, it is not clear whether this is the best option for developing strength and power during the season.

Ice hockey players need to develop multiple different qualities. This raises difficulties in periodization. The training program might need to vary and shift systematically the emphasis of the program at different phases of training. However, rather many training modes can be trained concurrently while supporting each other. For example, combined maximum strength and endurance training is shown to lead in greater adaptations in endurance performance (Rønnestad et al. 2019). However, meta-analysis by Wilson et al. (2012) showed that concurrent training of endurance and strength does not lead to as high adaptations as strength training alone in hypertrophy, maximal strength, and power. Therefore, the main priority of the training should be considered closely. According to phase potentiation model hypertrophy, maximum strength and power are trained consecutively for best adaptations. Hence, concurrent training of separate strength training modes is not necessary.

Physical training should be carried out so that the technical development is not disturbed. Especially during the competitive season physical training may need to be diminished to only the essential modes. For example, conditioning training, such as interval training, is most likely not necessary at all during the season. Sport training itself can improve sport specific conditioning (Stone & Kilding 2009). Hence, majority of off-ice training during the season may need to consist of strength, speed, and power training, with aerobic compensation training for active recovery.

### 9.3.1 Microcycle structure

Designing a microcycle structure should be done to maximize desired training outcomes. For example, speed and agility are commonly suggested to be done at fresh state. Therefore, speed session done directly after highly fatiguing ice-practice would be counterintuitive. Bompa and Buzzichelli (2015, 158-173) suggest that alactic (speed and power), lactic (HIT intervals, RST ect.) and aerobic training should be done on differing days (Picture 13). For example, a seven-day microcycle with 5 training days could look like following: Alactic-Lactic-Aerobic-Alactic-Lactic-Rest-Rest. Therefore, Bompa and Buzzichelli suggest dividing training days into three main energy system categories (Picture 13).

| Anaerobic alactic day | Anaerobic lactic day | Aerobic day |
|---|---|---|
| 1. Technical skills (1–10 seconds)<br>2. Tactical skills (5–10 seconds)<br>3. Acceleration and maximum speed<br>4. Maximum strength and power | 1. Technical skills (10–60 seconds)<br>2. Tactical skills (10–60 seconds)<br>3. Speed endurance (10–60 seconds)<br>4. Power endurance, muscle endurance short | 1. Long-duration technical skills (>60 seconds)<br>2. Long- and medium-duration tactical skills (>60 seconds)<br>3. Aerobic endurance<br>4. Muscle endurance medium and long |

Picture 13. Categorizing Energy systems training within a micro-cycle, (Bomba & Buzzichelli 2015)

Speed and agility can be trained on same day with maximal strength. Maximal strength can also be trained on a same day with lactic endurance but needs to be done prior to endurance portion. Prefer short technical and tactical skill drills on alactic days. When lactic capacity is trained, longer technical and tactical skills training can be done.

Volume and intensity of technical training, strength training, speed and conditioning need to be taken into account when structuring the total training volume of a microcycle

(Deweese et al. 2015). Training volume and intensity may need to undulate for each individual quality during each microcycle. Manipulations of these volumes on daily basis depend on the main goal of the day. If technical development is the main priority of the session, for example during the competitive season, strength training volume may need to be reduced. This is essential in maintaining the overall workload so that fatigue is managed. When heavy strength training is the main priority, conditioning and technical training needs to be at lower volume. During the competitive season games need to be taken into equation when total stress of training. Strength training should depend on the competitive schedule (Bompa & Buzzichelli 2015, 158-173). Planning of the strength training few days prior a game should provide enough time for recovery.

### 9.3.2 Integrating microcycles into mesocycles

Progressive overload within a mesocycle provides room for consistent progression of training loads and time for adequate recovery (Bompa & Buzzichelli 2015, 173-174; Turner 2011). Increasing loads within a mesocycle from microcycle to microcycle is a commonly used method. 3:1 loading paradigm is done by increasing loads for three microcycles in a row with one unloading microcycle in the end. Goal of the unloading phase is to reduce fatigue and thereby allow adaptations to take place. Unloading week can be also referred as a deload, taper or a light week (Helms 2019, 103-106). Deloading is done by decreasing volume by roughly 50% compared to previous cycle. Intensity is decreased by roughly 10% (Helms 2019, 103-106; Bompa & Buzzichelli 2015, 173-174).

In strength training, introductory weeks can work as an unloading cycle. Introductory week can be placed in the beginning of the mesocycle, rather than in the end of the cycle, contradictory to conventional unloading cycle models. During an introductory week, new movements are introduced to athletes and volume is planned around 75% of total volume planned for the cycle. This method can be used when moving from an intensification block (e.g. maximum strength) to an accumulation block (hypertrophy). Therefore, this could help prepare in handling the transition to the higher volume of training (Helm 2019, 103-106).

### 9.3.3 Combining various training

Phase of training and desired adaptations determine how to combine various training, such as speed and strength training. Periodization can determine how to progress in for example, agility training, and what training complements agility training best. As a rule,

each training phase should be planned so that activities would stress the same energy system. This will force the body to train one system at a time, so that other energy systems can stay ”fresh” for other training days.

Bompa and Buzzichelli (2015, 49) suggest combining strength training and energy systems training as follows: In the early preparatory phase, anatomical adaptation and hypertrophy are combined with aerobic capacity and aerobic and alactic power training. Energy system zones 5, 4, 3 and 1 can be trained. In the mid-preparatory phase, during maximal strength and power training phase, combine resistance training with lactic capacity, and aerobic and alactic power training. Energy system zones are pretty much the same as previous but zone 2 can be introduced. During the late-preparatory (pre-season) and competitive season alactic and lactic power short, and aerobic power is trained in combination with strength training. Energy system zones 1, 2, 4 and 6.

Speed training is not suggested to be began in the early off-season. Rather begin speed training with accelerations during the maximal strength training phase. After the first phase of acceleration, speed training can become more complex, with addition of agility training, maximum speed, and sled sprints (Picture 14).

| | | General preparation | | | Specific preparation | |
|---|---|---|---|---|---|---|
| Periodization of strength | | AA | MxS | MxS | MxS (maint.), P | MxS (maint.), PE |
| Periodization of speed | Nonspecific | — | — | Acceleration (uphill and flat) | Acceleration (flat), maximum speed quickness, agility | — |
| | Specific | — | — | — | — | Action–reaction, quick direction changes, stop-and-go agility, max velocity in different directions |

Key: Maint. = maintenance, MxS = maximum strength, P = power, and PE = power endurance.

Picture 14. Periodization of speed training, (Bompa & Buzzichelli 2015, 57)

Agility training is neither suggested to begin directly in the beginning of the off-season (Picture 15). After the first block of anatomical adaptation can old and new agility drills be introduced. Velocity of the agility drills is suggested to increase throughout the first phase of training to the following phases. It is suggested that agility drills become more complex throughout the off-season. Training should begin with closed drills and progress towards open drills, with decision making aspect (Joyce & Lewindon 2014, 185-199).

| Training phase | Preparation | | | Competitive | Transition |
|---|---|---|---|---|---|
| Periodization of strength | Anatomical adaptation | Maximum strength | Conversion to power | Maintenance: maximum strength, power | Compensation training |
| Periodization of agility | No agility drills | Learning phase: repeating known agility drills, learning new ones | Increasing velocity of agility drills | Increasing velocity of agility drills | No agility drills (not in scope of training for this phase) |
| Benefits to agility | Low | Good to high | Maximum | | Low |

Picture 15. Periodization of agility, (Bompa & Buzzichelli 2015, 270)

Training stress and loading may need to undulate from day to day within a microcycle (DeWeese et al. 2015). This provides an opportunity for recovery and can ensure that variety of power outputs will be used. Undulation can happen in a form of light and heavy training sessions. A heavy training day consisting of heavy strength training and followed by interval training is most likely highly fatiguing. To ensure enough recovery the following training day should involve active recovery and possibly more emphasis on technical development. For strength training, light / heavy day method may not be adequate with beginner athletes, since their maximum strength level can be instable, and intensity cannot be accurately determined. Therefore, progression in strength training may be better kept constant from session to session.

### 9.4 Monitoring

Michael Stone suggests that the goal of the periodization is fatigue management (Stone & Stone 2012). Proper monitoring program will allow coaches to adjust the training program on a microcycle and a mesocycle level. Monitoring program should incorporate not only performance markers, but also sleep, diet, nutrition, and other lifestyle factors that affect training. If training is carried on for a long period of time without enough emphasis on recovery overtraining syndrome may occur (Kreher & Schwartz 2012). Even though it takes a long time and massive negligence to recovery to occur, monitoring the training and recovery should always be utilized.

Methods for monitoring the training response can be done by monitoring heart rate variability (HRV), using neuromuscular performance tests such as countermovement jump (CMJ), and by training diaries (Joyce & Lewindon 2014, 71-84). HRV test is done to calculate training load from metabolic training. Maximal heart rate and resting heart rate need to be measured. If resting HR is higher than usual, more emphasis on recovery should be

considered. Overtraining is thought to have a negative influence to cardiovascular autonomic control. However, correlation with HRV testing is yet unclear (Sandercock, Bromley & Brodie 2005). CMJ test at fresh state works as a baseline for neuromuscular performance test. Drop in CMJ performance could be a sign of fatigue and if performance keeps decreasing overtime, more recovery may be needed. Session RPE scale and mood state questionnaires can indicate training readiness and desired effectiveness of the training session (Joyce & Lewindon 2014, 71-84). RPE scaling has been shown to be reliable tool for assessing difficulty of training session in young athletes (Ciolac et al. 2015).

No test alone indicates overtraining syndrome since single performance value can fluctuate from day to day However, if test results show a drop in performance, and RPE and mood scaling results show undesired outcomes over a long period of time. Along with declined performance on-ice, more emphasis on recovery may be needed. (Joyce & Lewindon 2014, 71-84). Calculating the total training volume for each training session can be done by multiplying the RPE and the duration of the session. For example, a 60-minute hard strength training session could have an RPE of 8. We can calculate that training load for that session is 60 x 8 = 480. This format can be used for any training session, speed, endurance, or ice practices (Foster 1998).

# 10 Testing

Off-ice testing should be done to assess whether strength and conditioning program is efficient or not. Sprint tests, jump tests and 1RM strength tests are commonly used methods. 1RM strength testing does have a moderate correlation to on-ice performance and can be done to adjust training loads. 1RM testing is safe method for maximal strength testing when technique is adequate, even in young children (Faigenbaum, Milliken & Westcott 2003). Planning the 1RM tests into the strength training program might be best.

When considering off-ice testing for ice hockey, validity of the tests should be considered. Does off-ice test have any correlation to on-ice performance? (Behm, Wahl, Button, Power & Anderson 2005) showed that 40-yd sprint and balance test had correlations to on-ice performance in young hockey players. Horizontal power tests, 30-meter sprint and 3 hop jump, have shown high correlation with on-ice speed test (Zankovets & Popov 2015; Farlinger, Kruisselbrink & Fowles 2007). While absolute (static) strength test has shown only moderate correlation. In a study by (Janot, Beltz & Dalleck 2015) vertical jump test was a significant predictor of on-ice performance. Same study concluded that 1,5 mile (2,4km) run and Windgate anaerobic power tests were significant predictors of skating performance incorporating recovery aspect in repeated skate performance. However, it is to be noted, that neither of the off-ice power tests vertical jump and Windgate tests correlated with on-ice repeated shift performance. They could only predict single bout acceleration and top speed (Peterson et al. 2016).

Aerobic capacity has shown correlation to repeated shift performance (Peterson et al. 2015). Aerobic capacity was tested on a skating treadmill to volitional exhaustion. VO2peak correlated with decrement of the sprint times in the repeated skate test. However, it is unclear whether VO2peak test done, for example by running, has a similar correlation to on-ice performance, since skating technique has an effect on performance. Athletes with better skating technique will be more efficient and therefore will place less stress on their metabolic system. (Durocher, Guisfredi, Leetun & Carter 2010) found no correlation between on-ice and off-ice VO2peak values done by cycle-test with collegiate athletes. It seems unclear which off-ice aerobic capacity test is the most practical option. However, testing VO2max via any method may be beneficial.

## 11 Aims of the project

The aim of this thesis was to provide a periodized off-ice training manual with direct guidelines to program design for u-18 ice hockey. For what I have heard during my work placement and internships, strength and conditioning in ice hockey seems to be quite poor in Finland. For this reason, I decided to do this manual. My aim was to write in such manner that creating a program after reading the product would be as clear as possible. All material gathered for the product was based on a scientific evidence and some material is based on well-known strength and conditioning coach's materials. However, even the latter has some scientific backup and has been deemed effective through years of coaching. Program is based on the theoretical part of the product and does not involve anything that is not mentioned previously. It is meant for ice hockey coaches and for teams that do not have a strength and conditioning coach. Program itself will not be enough. Knowledge of proper techniques is essential. Especially strength training and sprinting exercises should be executed with proper mechanics. The program includes a movement bank for resistance training. Pictures, videos, or other descriptions are not included into the program.

## 12 Project planning

Project plan

Material search

First version of the periodization

Writing

Consultation

The final product

The project plan was first created in the spring of 2019. The primary purpose of the thesis was to create guidelines of overall athletic development of u-18 junior ice hockey. The plan was to include sport analysis that undergoes the physical demands of ice hockey and takes into consideration age specific needs for off-ice training. Lastly, plan was to introduce how to combine off-ice and on-ice training in a manner that could produce best possible results.

Material search was aimed towards periodization and sport analysis literature. I also wanted to find out which physical qualities were best to be developed at this age and maturation stage. First version of the annual plan was completed prior to start of the writing process. It was developed during my work placement during the fall of 2019 and the spring of 2020. Around the same time I was still searching for materials. Writing process was deliberately left towards the end of the project once I knew I had enough knowledge and material. Final steps of the project were possible consultations about the final product and finetuning the overall work. The final product was finished during the fall of 2020.

## 13 Project implementation

The project began in May 2019 when I began my work placement for KooKoo-juniors. I worked with u-18 and u-16 teams and I was in charge of the strength and conditioning practises. I needed to create a periodized plan for off-ice training. I was interested in u-18 athlete development because it is the time for semi-professional training and 17-year-olds can be trained very much like adults. I began my material search about training variables and periodization and my goal in the beginning of the project was to gather as much information as possible. Most of the early material was based on literature, such as (Bompa & Buzzichelli, 2015), and later in the project lots of research papers and studies were gathered. Studies were used to back up any information I could to further prove the effectiveness of certain training methods.

I got a chance to use lot of the knowledge in action while doing my work placement in KooKoo-juniors, in Kouvola and while gathering more material I got to try out what works and what not. Learning curve was steep, I can say that. During the summer of 2020 I got a chance to do an internship for Yunus Barisik, who has been coaching young prospects and professional players for several years and has been interning under Ben Prentiss, one of the NHL's top strength and conditioning professionals. Learning curve found even steeper angle during this time. I got loads of useful material to use and got to see young pro-players off-season training in action, and how to combine strength and speed training in order to produce powerful and fast ice hockey players.

After the summer in internship I began writing the product. Vast majority of the material was already gathered, so the writing process began quite effortlessly. More and more studies and research papers were added at the midst of writing to further complement my reasoning. A large portion of the program was already completed because I had already designed an annual plan for strength and conditioning for KooKoo juniors. Further editing to the program was made during research and writing the theoretical part.

Majority of the theoretical part is based on international research papers and textbooks. Small amount of information is in fact from Finnish books or studies. Big reason for this was that I found it easier to read materials and write the product with the same language. Another factor was that most of my own research was done in English, that naturally resulted in English material. Finnish texts needed translation into English, and I saw that this took unwanted extra time. This also gave me an opportunity to search from much wider pool of information. Ice hockey specific studies were few and far between. For this reason,

majority of the research material used is rather based on specific topic, for example, resistance training. Not resistance training in ice hockey. I believe this results in more reliable content. If all material is based on ice hockey related research, there would not be enough reliable data to be used. Furthermore, research based on a specific training modality is far more reliable since it focuses on a single topic, for example, the rest periods in resistance training. However, ice hockey specific research should not be completely disregarded. For example, ice hockey related studies on testing gives valid picture of demands of the sport.

The final step to the project was consultation. I consulted with Yunus Barisik, who I had done an internship earlier. He made points about my work that needed corrections and gave his opinions about the product. I made the changes I saw necessary regarding his opinions. After the consultation I finished the final product with assistance from my tutor teacher Mika Vähälummukka.

## 14 The product

The final product of this thesis is an annual plan for u-18 ice hockey team. The annual plan is divided into four main phases: off-season, pre-season, competitive season, and transition. The annual plan is based on 2020-2021-season and it begins on week 14 of 2020. Each training phase is divided into blocks, lasting mainly four weeks each. Strength training uses block periodization model throughout the season. However, during the competitive season the periodization might need to be more undulating due to the amount of games. The game schedule was not released while planning the periodization, therefore, undulating model was difficult to add.

The main priority of this program is to increase maximum strength of the athletes. Along with strength training for hypertrophy, maximum strength and power, the plan includes training for speed, agility, and endurance. Each training mode is varied from block to block and from phase to phase. Each block includes a deload or an intro week. The purpose of this week is to achieve supercompensation effect and devote time for active recovery.

Strength training attempts to achieve phase potentiation through sequencing training from hypertrophy to maximum strength, and finally to power training. Endurance training follows linear model from higher volume, low intensity training for aerobic capacity, to maximal oxygen consumption, and prior to the start of the competitive season, peaking with lactic capacity training. In-season endurance training is mainly performed on ice. Speed and plyometric training begin at lower volume and intensity and progresses towards higher intensity drills and more complex agility drills towards to beginning of the season. During the competitive season speed, agility, and plyometrics are performed once per week.

The product includes methods for monitoring the training process. According to Michael Stone this is a key element to successful periodization plan (Stone & Stone 2012). Monitoring process includes testing battery. The purpose of testing is to monitor training process from a performance standpoint. Testing allows coaches to seem whether the program is working or not. After testing, changes can be made on an individual level to tweak the training program. Along with testing, monitoring process includes strength training diary and guidelines for RPE-scaling system, heart-rate variability (HRV) measures and a countermovement jump (CMJ) test. RPE-scaling can be used to monitor internal evaluation of the training session. HRV measurement can be administered to monitor recovery from hard training and games. CMJ test can be applied to monitor neural recovery prior to power or speed session.

# 15 Discussion

The final product is periodization of an annual plan for u-18 ice hockey team. The product itself is quite compact package and it is written in a very straight forward manner. Training variables or methods are not justified in the product. However, the theoretical part should reason all the methods within the product.

A vast amount of the materials I used is from scientific studies of different training methods. I believe this way I was able to dig a little bit deeper into all the aspects of training. From minor details, such as rest periods in resistance training, to bigger picture on a macrocycle structure. I was able to provide information of the training variables in each training modality. After all, the training variables construct the training program and can be major factor between effective and ineffective training program. If some variable is left uncovered and is misused, the effectiveness of the training can be diminished.

Periodization is a major key for athletic development. It provides structure to the training and provides time for recovery. When used correctly, training adaptations can reach their full potential. I hope that the information I collected can provide the necessary information to create and modify the training program. Even though periodization has deep roots in sports practise dating back to the 1950's, it has raised lots of dispute of which model of periodization would be the best. However, it seems that power sports favour certain periodization models, and team sports favour other types. Seems that everything comes down to the main goal of the training. If some periodization model seems to fit better to certain training goal, it might be best practised. Individual differences may also affect periodization modes used. Beginner lifters can make rabid gains in strength and can follow quite linear model of periodization. However, more advanced lifters need more variation and manipulation of the training variables.

I wanted to keep sport analysis part short and compact. Explanations of each physiological component needed in the sport, without digging too deep into specifics in each segment. I simply wanted to present the qualities that seem to be the most essential. Four major physiological characteristics needed in ice hockey were selected from (Mero et al. 2016). Speed, strength, endurance (energy-systems) and mobility.

For what I have learned, strength training is an essential component in athletic development during late adolescence. For this reason, strength training has a big emphasis in the program. My goal was to dig deep into all training variables in strength training, while still, keeping the content as short and as practical as possible. Yet I feel lot of the knowledge

was left uncovered. If I had spilled out every detail I know about strength training the product might get too confusing to read. So clear path needed to be chosen. I my own opinion strength training requires expert coaches because proper lifting techniques need to be taught and monitored at all times. Especially in the early stages of strength training. I suggest coaches who choose to use this manual do some research on correct lifting techniques and coaching cues.

Speed seems to be essential component that separates athletes on the ice. The ability to reach the puck first and break through make offensive players a lot more dangerous. Converting strength to power and speed via training intrigued me. At first, I discovered that maximal strength was a major factor in speed development. As a result, I began favouring strength training even too much. While using trial and error in my work placement year in KooKoo-juniors I noticed that speed, while it improved with my athletes, did not reach a desired gain during the year. After I interned in the summer-2020 I saw how speed training can be involved in training almost throughout the season while progress can still be made with no downside to strength development.

Endurance training was a bit controversial topic throughout my one and a half years of creating this product. Ice hockey in Finland seems to still have, to some extent, outdated idea of the development of endurance. High workload is put into running and jogging and endurance test results are being pointed out in testing battery. This is contradictory to all evidence I came across in developing of conditioning in team sports. Ice hockey is a sport with a big emphasis on power and to the ability to maintain it. Endurance is traditionally trained via long distance, slow running. However, it may not be the best method if maximum strength and power are the main priorities in training. Evidence suggests that for maximal strength development, concurrent endurance and strength training does not lead to as high adaptations as strength training alone. Therefore, choosing the conditioning method can be tricky. I had a goal to find research on endurance training for different muscle-fiber types. However, I could not find any, even though I had listened to a podcast where a strength and conditioning coach Andy Galpin, with a PhD on sports science, speaking about the subject. I guess research is not yet reached that level. In the end, I managed to put together a product that is supported by research and is a good fit for ice hockey athletes.

I deemed mobility training least important out of the four. I recognize that many, even 15-year-old hockey athletes, have major limitations in their mobility. Especially in the thorasic spine and hips. However, mobility can be improved along with other training without too much interference and major issues to, for example, strength training can be avoided by

exercise selection. It needs to be said that mobility training should not be the primary training goal for any 16-18-year-old athlete. That should be obvious.

The final result of this thesis was to produce an off-ice training manual that covers off-season and in-season training. Goal of the program is to provide tools for year-round development of the physical skills. The program should be easy to interpret and to deploy. I believe these goals were met in the final product. As in with any scientific review, no conclusion can be made as final. The field of strength and conditioning progresses every year and more information of developing skills is presented. Therefore, the information provided in this manual is a product of this time. Even though many training methods are proven efficient over years of experimenting and studying, it does not mean that new, more efficient training methods cannot be discovered.

Like mentioned learning curve during the project was steep. In the beginning I got to test lots of the methods in the field and during the end of the project I gathered loads of information that has made my expertise in the field is much deeper. I feel I can be confident in applying this product in my own work in the future. However, this does not mean that further research would not be needed, but I will intend to keep on expanding my knowledge and experimenting with different training methods.

Since the goal was to present as easy to understand guidelines as possible, my main issue in writing was to present the information in a such way. I had quite a lot of material collected. There was a lot of contradicting evidence in training methods with differing points of views and this may have made my points seem unclear at times. Another issue I had was in making sure that any training methods with no evidence base was not presented as truth. As an example, I did not find any studies about tempo runs, which have been popular method to improve aerobic conditioning with speed athletes, to support them to be an effective conditioning tool.

Strength and conditioning is a vast field and methods are many. Deciding on what training method is chosen to this program is influenced by my own experiences as a strength and conditioning coach, and by internships and work placements. I personally believe that training methods mentioned in the product are well enough proven and will work with committed athletes and coaches.

Development object for the program in the future could be more specific programming for position specific goals and addition of the more complete movement bank. It is obvious

that defensive and offensive players have different needs regarding the movement patterns and energy-systems. For example, defensive players do more moving backwards compared to offensive players and generally have higher average playtimes. This could be addressed in the off-ice training. However, I did not see this as such important issue. Rather spend more energy to developing better athletes overall. Goalies are another story completely. Their on-ice movement is completely unique compared to the field players. Loads of lateral movement and good overall hip mobility are needed qualities. These individual tweaks to programming could be a future development focus.

Movement bank could include images, videos, and movement descriptions to assure that all movements could be performed at high standards and in the similar manner. Even though quick google search will help in finding proper movement mechanics and none of the movements presented are nothing new, general coherence will be missing.

Injury rehabilitation is my final idea for future development of the program. While it can fall on strength and conditioning coach’s hands in less severe cases. Athletes with major injuries should be pointed to the direction of doctors or physiotherapists. Minor injuries, like groin pain, which is not uncommon for hockey players, can be dealt by without previously mentioned.

## References


Ahmetov, II. Egorova, ES. Gabdrakhmanova, LJ. & Fedotovskaya, ON. 2016. Genes and Athletic Performance: An Update. Medicine of Sport Science, 61, p. 41-54

Askling, C. Karlsson, J. & Thorstensson, A. 2003. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. Scandinavian Journal of Medicine & Science in Sports. Vol. 13, 4, p. 244-50

Ayers, JL. DeBeliso, M. Sevene, TG. & Adams, KJ. 2016. Hang cleans and hang snatches produce similar improvements in female collegiate athletes. *Biology of sport*, *33*(3), p. 251–256

Ball, NB. & Zanetti, S. 2012. Relationship between reactive strength variables in horizontal and vertical drop jumps. Journal of Strength and Conditioning Research. 26, 5, p. 1407-1412.

Baker, DG. & Newton, RU. 2007. Change in power output across a high-repetition set of bench throws and jump squats in highly trained athletes. Journal of Strength and Conditioning Research. 21, 4, p. 1007-1011

Barisik, Y. 2020, Strength training for ice hockey, Espoo

Brechue, WF. & Abe, T. 2002. The role of FFM accumulation and skeletal muscle architecture in powerlifting performance. European Journal of Applied Physiology. 86, 4, p. 327-336

Beachle, TR. & Earle, RW. 2015. Essentials of strength training and conditioning, Human kinetics

Behm, D. Wahl, M. Button, D. Power, K. & Anderson, K. 2005. Relationship Between Hockey Skating Speed and Selected Performance Measures. Journal of strength and conditioning research / National Strength & Conditioning Association. 19, p. 326-331

Belcher, D. 2017. The Sumo Deadlift. Strength and Conditioning Journal. 39, 4, p. 97-104

Bishop, DJ. Girard, O. & Mendez-Villanueva, A. 2011. Repeated-Sprint Ability – Part II Recommendations for Training, Sports Medicine 41, 9, p. 741-756

Bogdanis, GC. Tsoukos, A. Kaloheri, O. Terzis, G. Veligekas, P. & Brown, LE. 2019. Comparison Between Unilateral and Bilateral Plyometric Training on Single- and Double-Leg Jumping Performance and Strength. Journal of Strength and Conditionig Research. 33, 3, p. 633-640

Bompa, TO. & Buzzichelli, CA. 2015. Periodization training for sports - Third edition, Human Kinetics, London

Bosquet, L. & Mujika, I. 2012. Chapter 10, Detraining, Endurance training: science and practice. p.100-106

Boyle, M. 2016. New functional training for sports, Second Edition, Human Kinetics, Inc. London

Buchheit, M. Laursen, PB. 2013. High-Intensity Interval Training, Solutions to the Programming Puzzle, Sports Medicine, 43, p. 313–338

Buchheit, M. Samozino, P. Glynn, JA. Simpson B, M. Al Haddad, H. Mendez-Villanueva, A. & Benoit Morin, J. 2014. Mechanical determinants of acceleration and maximal sprinting speed in highly trained young soccer players, Journal of Sports Sciences, 32, 20, p. 1906-1913

Burd, N. Andrews, R. West, D. Little, J. Cochran, A. Hector, A. Cashaback, J. Gibala, M. Potvin, J. Baker, S. & Phillips, S. 2011. Muscle time under tension during resistance exercise stimulates differential muscle protein sub-fractional synthetic responses in men. The Journal of physiology, 590, p. 351-362

Ciccone, AB. Brown, LE. Coburn, JW. & Galpin, AJ. 2014. Effects of traditional vs. alternating whole-body strength training on squat performance. Journal of Strength and Conditioning Research, 28, 9, p. 2569-2577

Ciolac, EG. Mantuani, SS. Neiva, CM. Verardi, C. Pessôa-Filho, DM. & Pimenta, L. 2015. Rating of perceived exertion as a tool for prescribing and self regulating interval training: a pilot study. Biology of sport, 32, 2, p. 103–108

Clemente, FM. Martins, FML. Mendes, R. 2014. Periodization Based on Small-Sided Soccer Games: Theoretical Considerations, National Strength and Conditioning Association, 36, p. 34-43

Comfort, P. Dos'Santos, T. Thomas, C. McMahon, JJ. & Suchomel, TJ. 2018. An Investigation Into the Effects of Excluding the Catch Phase of the Power Clean on Force-Time Characteristics During Isometric and Dynamic Tasks: An Intervention Study. Journal os Strength and Conditioning Research, 32, 8, p. 2116-2129

Cunanan, AJ. DeWeese, BH. Wagle, JP. Carroll, KM. Sausaman, R. Hornsby, WG 3rd. Haff, GG. Triplett, NT. Pierce, KC. & Stone, MH. 2018. The General Adaptation Syndrome: A Foundation for the Concept of Periodization. Sports Medicine, 48, 4, p. 787-797

Dahab, KS. & McCambridge, TM. 2009. Strength Training in Children and Adolescents: Raising the Bar for Young Athletes? Sports Health. 1, 3, p. 223-226

de Villarreal, ES. González-Badillo, JJ. & Izquierdo, M. 2008. Low and moderate plyometric training frequency produces greater jumping and sprinting gains compared with high frequency. Journal of Strength and Conditioning Research. 22, 3, p. 715-725

de Salles, BF. Simão, R. Miranda, F. Novaes, Jda S. Lemos, A. & Willardson, JM. 2009. Rest interval between sets in strength training. Sports Medicine. 39, 9, p. 765-777

DeWeese, B. Hornsby, G. Stone, M. & Stone, M. 2015. The training process: Planning for strength—power training in track and field. Part 1: Theoretical aspects. Journal of Sport and Health Science 4, p. 308-317

DeWeese, B. Hornsby, G. Stone, M. & Stone, M. 2015. The training process: Planning for strength–power training in track and field. Part 2: Practical and applied aspects. Journal of Sport and Health Science, 4, p. 318-324

Domer, S. 2005, Off-Ice Speed and Quickness for Ice Hockey. NSCA's Performance Training Journal. 4, 5, p. 18–23

Durocher, JJ. Guisfredi, AJ. Leetun, DT. & Carter, JR. 2010. Comparison of on-ice and off-ice graded exercise testing in collegiate hockey players. Applied Physiology, Nutrition, and Metabolism. 35, 1, p. 35-9

Engel, FA. Ackermann, A. Chtourou, H. & Sperlich, B. 2018. High-Intensity Interval Training Performed by Young Athletes: A Systematic Review and Meta-Analysis. Frontiers in Physiology. 9, 1012

Eniseler, N. Şahan, C. Özcan, I. & Dinler, K. 2017. High-Intensity Small-Sided Games versus Repeated Sprint Training in Junior Soccer Players, Journal of Human Kinetics, 60, p. 101-111

Faigenbaum, A. Milliken, L. & Westcott, W. 2003. Maximal Strength Testing in Healthy Children. Journal of strength and conditioning research / National Strength & Conditioning Association. 17, p. 162-166

Farlinger, CM. Kruisselbrink, LD. & Fowles, JR. 2007. Relationships to skating performance in competitive hockey players. Journal of Strength and Conditioning Research. 21, 3, p. 915-922

Finhockey, 10-14-vuotiaat, http://www.finhockey.fi/index.php/pelaajalle/leijonanpolku/10-14-vuotiaat, read, 10.8.2020

Fleck, SJ. & Falkel, JE. 1986. Value of resistance training for the reduction of sports injuries. Sports Medicine. 3, 1, p. 61-68.

Foster, C. 1998. Monitoring training in athletes with reference to overtraining syndrome. Medicine and Science in Sports and Exercise, 30, 7, p. 1164-1168

Fradkin, AJ. Gabbe, BJ. & Cameron, PA. 2006. Does warming up prevent injury in sport? The evidence from randomised controlled trials? Journal of Science and Medicine in Sport, 9, 3, p. 214-220

Gamble, P. 2006. Periodization of Training for Team Sports Athletes. Strength & Conditioning Journal, 28, 5, p. 56-66

Garhammer, JA. 1993. Review of Power Output Studies of Olympic and Powerlifting: Methodology, Performance Prediction, and Evaluation Tests. Journal of Strength and Conditioning Research. 7, 2, p. 76-89

González-Badillo, JJ: Rodríguez-Rosell, D. Sánchez-Medina, L. Gorostiaga, EM. & Pareja-Blanco, F. 2014. Maximal intended velocity training induces greater gains in bench

press performance than deliberately slower half-velocity training. European Journal of Sport Science, 14, 8, p. 772-781

Grgic, J. Schoenfeld, BJ. Skrepnik, M. Davies, TB. & Mikulic, P. 2018. Effects of Rest Interval Duration in Resistance Training on Measures of Muscular Strength: A Systematic Review. Sports Medicine, 48, 1, p. 137-151

Hackett, D. Davies, T. Soomro, N. & Halaki, M. 2016. Olympic weightlifting training improves vertical jump height in sportspeople: a systematic review with meta-analysis. British journal of sports medicine, 50, 14, p. 865-872

Hackett, D Davies, T. Soomro, N. & Halaki, M. 2015. Olympic weightlifting training improves vertical jump height in sportspeople: a systematic review with meta-analysis. British Journal of Sports Medicine, 50, 14, p. 1-9

Haff, GG. & Potteiger, A. 2001. A Brief Review: Explosive Exercises and Sports Performance. Strength and Conditioning Journal, 23, 3, p. 13-20

Halouani, J. Chtourou, H. Gabbett, T. Chaouachi, A. & Chamari, K. 2014. Small-sided games in team sports training: a brief review. Journal of Strength and Conditioning Research, 28, 12, p. 3594-3618

Hammami, A. Gabbett, TJ. Slimani, M. & Bouhlel, E. 2018. Does small-sided games training improve physical-fitness and specific skills for team sports? A systematic review with meta-analysis. The Journal of sports medicine and physical fitness. 58, 10, p. 1446-1455

Hartmann, H. Wirth, K. Klusemann, M. Dalic, J. Matuschek, C. & Schmidtbleicher, D. 2012. Influence of squatting depth on jumping performance. Journal of strength and conditioning research, 26, 12, p. 3243-3261

Haugen, T. Seiler, S. Sandbakk, Ø. & Tønnessen, E. 2019. The Training and Development of Elite Sprint Performance: an Integration of Scientific and Best Practice Literature. Sports Medicine - Open. 5, 1, p. 44

Hecker, KA. Carlson, LA. & Lawrence, MA. 2018. Effects of the Safety Squat Bar on Trunk and Lower-Body Mechanics During a Back Squat. Journal of Strength and Conditioning Research. 33, Issue, p. S45-S51

Hejna, WF. Rosenberg, A. Butrusis, DJ. & Krieger, A. 1982. The prevention of sports injuries in high school students through strength training. National Strength Coaches Association Journal. Feb, p. 28-31

Hedrick, A. & Wada, H. 2008. Weightlifting Movements: Do the Benefits Outweigh the Risks?. Strength & Conditioning Journal, 30, 6, p. 26-35

Helms, E. Morgan, A. Valdes, A. 2019, Muscle and Strength Pyramid Training 2.0

Herbert, RD. de Noronha, M. Kamper, SJ. 2011. Stretching to prevent or reduce muscle soreness after exercise. The Cochrane database of systematic reviews, 7, John Wiley & Sons, Ltd, p. 1465-1858

Henselmans, M, & Schoenfeld, BJ. 2014. The Effect of Inter-Set Rest Intervals on Resistance Exercise-Induced Muscle Hypertrophy. Sports Medicine. 44, 12, p. 1635-1643

Mero, A. Nummela, A. Kalaja, S. & Häkkinen, K. 2016. Huippu-urheiluvalmennus Teoria ja käytäntö päivittäisvalmennuksessa, VK-Kustannus

Häkkinen, K. & Komi, PV. 1986. Training-induced changes in neuromuscular performance under voluntary and reflex conditions. European journal of applied physiology and occupational physiology, 55, 2, p. 147-155

Israetel, M. Wesley-Smith, C. & Hoffmann, J. 2015. Scientific Principles of Strength Training,

Kay, AD. & Blazevich, AJ. 2012. Effect of acute static stretch on maximal muscle performance: a systematic review. Medicine and science in sports and exercise, 44, 1, p. 154-164

Janot, JM. Beltz, NM. & Dalleck, LD. 2015. Multiple Off-Ice Performance Variables Predict On-Ice Skating Performance in Male and Female Division III Ice Hockey Players. Journal of sports science & medicine, 14, 3, p. 522-529

Barisik, Y. Jääkiekkoilijan keskivartalon voimaharjoittelu, https://faneille.com/latka/jaakiekkoilijan-keskivartaloharjoittelu/, 15.10.2020

Keiner, M. Sander, A. Wirth, K. Caruso, O. Immesberger, P. & Zawieja, M. 2013. Strength performance in youth: trainability of adolescents and children in the back and front squats. Journal of Strength and Conditioning Research, 27, 2, p. 357-362

Keiner, M. Sander, A. Wirth, K. & Schmidtbleicher, D. 2014. Long-term strength training effects on change-of-direction sprint performance. Journal of strength and conditioning research, 28, 1, p. 223-231

Kawamori, N. Crum, AJ. Blumert, PA. Kulik, JR. Childers, JT. Wood, JA. Stone, MH. & Haff, GG. 2005. Influence of different relative intensities on power output during the hang power clean: identification of the optimal load. Journal of strength and conditioning research, 19, 3, p. 698-708

Kilduff, LP. Bevan, H. Owen, N. Kingsley, MI. Bunce, P. Bennett, M. & Cunningham, D. 2007. Optimal loading for peak power output during the hang power clean in professional rugby players. International journal of sports physiology and performance, 2, 3, p. 260-269

Kraemer, WJ. Marchitelli, L. Gordon, SE. Harman, E. Dziados, JE. Mello, R. Frykman, P. McCurry, D. & Fleck, SJ. 1990. Hormonal and growth factor responses to heavy resistance exercise protocols. Journal of applied physiology, 69, 4, p. 1442-1450

Kraemer, WJ. Gordon, SE. Fleck, SJ. Marchitelli, LJ. Mello, R. Dziados, JE. Friedl, K. Harman, E. Maresh, C. & Fry, AC. 1991. Endogenous anabolic hormonal and growth factor responses to heavy resistance exercise in males and females. International journal of sports medicine, 12, 2, p. 228-235

Kraemer, WJ. & Ratamess, NA. 2005. Hormonal Responses and Adaptations to Resistance Exercise and Training, Sports Medicine, 35, 4, p. 339-361
Kreher, JB. & Schwartz, JB. 2012. Overtraining syndrome: a practical guide. Sports health, 4, 2, p. 128–138.

Kingsports, Lines of Movements, https://kingsports.net/lines-of-movement-the-origin-and-intent/, 15.10.2020

Komi, PV. & Buskirk, ER. 1972. Effect of eccentric and concentric muscle conditioning on tension and electrical activity of human muscle. Ergonomics, 15, 4, p. 417-434

Kubo, K. Ikebukuro, T. & Yata, H. 2019. Effects of squat training with different depths on lower limb muscle volumes. European Journal of Applied Physiology, 119, 9, p. 1933-1942

Lake, J. Duncan, F. Jackson, M. & Naworynsky, D. 2017. Effect of a Hexagonal Barbell on the Mechanical Demand of Deadlift Performance. Sports, 5, 4, p. 82

Lauersen, JB. Andersen, TE. & Andersen, LB. 2018. Strength training as superior, dose-dependent and safe prevention of acute and overuse sports injuries: a systematic review, qualitative analysis and meta-analysis. British Journal of Sports Medicine, 52, p. 1557-1563

Lloyd, RS. Oliver, JL. Faigenbaum, AD. Howard, R. De Ste Croix, MB. Williams, CA. Best, TM. Alvar, BA. Micheli, LJ. Thomas, DP. Hatfield, DL. Cronin, JB. & Myer, GD. 2015. Long-term athletic development- part 1: a pathway for all youth. Journal of strength and conditioning research. 29, 5, p. 1439-1450

Lloyd, R. Read, P. Oliver, J. Meyers, R. Nimphius, S. & Jeffreys, I. 2013. Considerations for the Development of Agility During Childhood and Adolescence. Strength and Conditioning Journal, 35, p. 2-11

Makaruk, H. Winchester, JB. Sadowski, J. Czaplicki, A. & Sacewicz, T. 2011 Effects of unilateral and bilateral plyometric training on power and jumping ability in women. Journal of strength and conditioning research, 25, 12, p. 3311-3318

Mangine, GT. Ratamess, NA. Hoffman, JR. Faigenbaum, AD. Kang, J. & Chilakos, A. 2008. The effects of combined ballistic and heavy resistance training on maximal lower- and upper-body strength in recreationally trained men. Journal of strength and conditioning research, 22, 1, p. 132-139

Mann, JB. Thyfault, JP. Ivey, PA. & Sayers, SP. 2010. The effect of autoregulatory progressive resistance exercise vs. linear periodization on strength improvement in college athletes. Journal of strength and conditioning research, 24, 7, p. 1718–1723

McBride, J. Triplett-McBride, T. Davie, A. & Newton, R. 2002. The Effect of Heavy- Vs. Light-Load Jump Squats on the Development of Strength, Power, and Speed. Journal of strength and conditioning research / National Strength & Conditioning Association, 16, p. 75-82

Medbø, JI. & Burgers, S. 1990. Effect of training on the anaerobic capacity. Medicine and Science in Sports and Exercise, 22, 4, p. 501-507

Mero, A. Nummela, A. Keskinen, K. & Häkkinen, K. 2007. Urheiluvalmennus. VK-Kustannus. Lahti.

Moran, J. Sandercock, GRH. Ramírez-Campillo, R. Meylan, C. Collison, J. & Parry, DD. 2017. A meta-analysis of maturation-related variation in adolescent boy athletes' adaptations to short-term resistance training, Journal of Sports Sciences, 35, 11, p. 1041-1051

Morin, JB. Petrakos, G. Jiménez-Reyes, P. Brown, SR. Samozino, P. & Cross, MR. 2017. Very-Heavy Sled Training for Improving Horizontal-Force Output in Soccer Players. International Journal of Sports Physiology and Performance, 12, 6, p. 840-844

Morton, RW. Oikawa, SY. Wavell, CG. Mazara, N. McGlory, C. Quadrilatero, J. Baechler, BL. Baker, SK. & Phillips, SM. 2016. Neither load nor systemic hormones determine resistance training-mediated hypertrophy or strength gains in resistance-trained young men. Journal of Applied Physiology, 121, 1, p. 129-138

Mosenthal, W. Kim, M. Holzshu, R. Hanypsiak, B. & Athiviraham, A. 2017. Common Ice Hockey Injuries and Treatment: A Current Concepts Review. Current Sports Medicine Reports, 16, 5, p. 357-362

Mujika, I. & Padilla, S. 2000 Detraining: loss of training-induced physiological and performance adaptations. Part II: Long term insufficient training stimulus. Sports Medicine, 30, 3, p. 145-54

Mäennenä, J. Olli, J. Puputti, J. Roininen, T. Haverinen, M. Kuukasjärvi, K. & Parkkinen, J. 2019. Voimaharjoittelu – Teoriasta parhaisiin käytäntöihin, VK-Kustannus, Lahti

Roundtable. Flexibility. 1984. National Strength and Conditioning Association Journal, 6, 4, p. 10-22)

Newton, R. Kraemer, W. & Häkkinen, K. 1999. Effects of ballistic training on preseason preparation of elite volleyball players. Medicine and Science in Sports and Exercise, 31, p. 323

Ogasawara, R. Yasuda, T. Sakamaki-Sunaga, M. Ozaki, H. & Abe, T. 2011. Effects of periodic and continued resistance training on muscle CSA and strength in previously untrained men. Clinical physiology and functional imaging, 31, p. 399-404

Parr, M. Price, P. & Cleather, DJ. 2017. Effect of a gluteal activation warm-up on explosive exercise performance. BMJ open sport and exercise medicine, 3, 1, p. 1-8

Peck, E. Chomko, G. Gaz, DV. & Farrell, AM. 2014. The effects of stretching on performance. Current Sports Medicine Reports, 13, 3, p. 179-85

Peterson, BJ. Fitzgerald, JS. Dietz, CC. Ziegler, KS. Ingraham, SJ. Baker, SE. & Snyder, EM. 2015. Aerobic capacity is associated with improved repeated shift performance in hockey. Journal of Strength and Conditioning Research, 29, 6, p. 1465-1472.

Peterson, B. Fitzgerald, J. Dietz, C. Ziegler, K. Baker, S. & Snyder, E. 2016. Off-Ice Anaerobic Power Does Not Predict On-Ice Repeated Shift Performance in Hockey. Journal of Strength and Conditioning Research, 30, 1, p. 2375-2381

Petrakos, G. Morin, JB. & Egan, B. 2016. Resisted Sled Sprint Training to Improve Sprint Performance: A Systematic Review. Sports medicine, 46, p. 381-400

Poliquin, C. 1988. Five steps to increasing the effectiveness of strength training program. National Strength and Conditioning Association Journal, 10, 3, p. 34-39

Robbins, DW. Young, WB. & Behm, DG. 2010. The effect of an upper-body agonist-antagonist resistance training protocol on volume load and efficiency. Journal of Strength and Conditioning Research, 24, 10, p. 2632-2640

Robert-Lachaine. X. Turcotte, R. Dixon, PC. & Pearsall, DJ. 2012. Impact of hockey skate design on ankle motion and force production. Sports Engineering, 15, 4, p. 197-206

Roig, M. O'Brien, K. Kirk, G. Murray, R. McKinnon, P. Shadgan, B. & Reid, WD. 2009. The effects of eccentric versus concentric resistance training on muscle strength and mass in healthy adults: a systematic review with meta-analysis. British Journal of Sports Medicine, 43, 8, p. 556-568

Rumpf, MC. Lockie, RG. Cronin, JB. & Jalilvand, F. 2016. Effect of Different Sprint Training Methods on Sprint Performance Over Various Distances: A Brief Review. Journal of Strength and Conditioning Research, 30, 6, p. 1767-1785

Rønnestad, B. Nymark, B. & Raastad, T. 2011. Effects of In-Season Strength Maintenance Training Frequency in Professional Soccer Players. Journal of strength and conditioning research / National Strength & Conditioning Association, 25, p. 2653-2660

Rønnestad, BR. Øfsteng, SJ. & Ellefsen, S. 2019. Block periodization of strength and endurance training is superior to traditional periodization in ice hockey players. Scandinavian Journal of Medicine and Science in Sports, 29, 2, p. 180-188

Sadres, E. Eliakim, A. Constantini, N. Lidor, R. & Falk, B. 2001. The Effect of Long-Term Resistance Training on Anthropometric Measures, Muscle Strength, and Self Concept in Pre-Pubertal Boys. Pediatric Exercise Science, 13, p. 357-372

Sandercock, GR. Bromley, PD. & Brodie, DA. 2005. The reliability of short-term measurements of heart rate variability. International Journal of Cardiology, 103, 3, p. 238-247

Schoenfeld, BJ. Pope, ZK. Benik, FM. Hester, GM. Sellers, J. Nooner, JL. Schnaiter, JA. Bond-Williams, KE. Carter, AS. Ross, CL. Just, BL. Henselmans, M. & Krieger, JW. 2016. Longer Interset Rest Periods Enhance Muscle Strength and Hypertrophy in Resistance-Trained Men. Journal of Strength and Conditioning Research, 30, 7, p. 1805-1812

Science for sport. Chronological, biological and technical age. At: https://www.scienceforsport.com/chronological-biological-technical/ Read: 28.9.2020

Science for Sport. Post-exercise stretching. At: https://www.scienceforsport.com/post-exercise-stretching/#toggle-id-1. Read: 24.9.2020

Seiler, S. & Tønnessen, E. 2009. Intervals, Thresholds, and Long Slow Distance: The Role of Intensity and Duration in Endurance Training, Sportscience, 13, p. 32-53

Seitz, LB. Reyes, A. Tran, T. de Villarreal, ES. & Haff, GG. 2014. Increases in Lower-Body Strength Transfer Positively to Sprint Performance: A Systematic Review with Meta-Analysis. Sports medicine, 44, p. 1693-1702

Senna, GW. Willardson, JM. Scudese, E. Simão, R. Queiroz, C. Avelar, R. & Martin Dantas, EH. 2016. Effect of Different Interset Rest Intervals on Performance of Single and Multijoint Exercises With Near-Maximal Loads. Journal of Strength and Conditioning Research, 30, 3, p. 710-716

Serpell, BG. Young, WB. & Ford, M. 2011. Are the perceptual and decision-making components of agility trainable? A preliminary investigation. Journal of Strength and Conditioning Research, 25, 5, p. 1240-1248

Sheppard, JM. 2003. Strength and conditioning exercise selection in speed development. Strength and Conditioning Journal, 25, 4, p. 26-30

Shrier, I. 1999. Stretching before exercise does not reduce the risk of local muscle injury: a critical review of the clinical and basic science literature. Clinical Journal of Sport Medicine: official journal of the Canadian Academy of Sport Medicine, 9, 4, p. 221-227

Siahkouhian, M. & Hedayatneja, M. 2010. Correlations of anthropometric and body composition variables with the performance of young elite weightlifters. Journal of Human Kinetics, 25, p. 125-131

Simão, R. de Salles, B. Figueiredo, T. Dias, I. & Willardson, J. 2012. Exercise Order in Resistance Training. Sports medicine, 42, p. 251-65

Simão, R. Farinatti, Pde T. Polito, MD. Viveiros, L. & Fleck, SJ. 2007. Influence of exercise order on the number of repetitions performed and perceived exertion during resistance exercise in women. Journal of Strength and Conditioning Research, 21, 1, p. 23-28

Simão, R. Spineti, J. de Salles, B. Oliveira, L. Matta, T. Miranda, F. Miranda, H. & Costa, P. 2010. Influence of Exercise Order on Maximum Strength and Muscle Thickness in Untrained Men. Journal of sports science & medicine, 9, p. 1-7

Soriano, MA. Jime ´nez-Reyes, P. Rhea, MR. & Marı ´n, PJ. 2015. The Optimal Load for Maximal Power Production During Lower-Body Resistance Exercises: A Meta-Analysis. Sports Medicine, 45, 8, p. 1191-1205

Steele, J. Endres, A. Fisher, J. Gentil, P. & Giessing, J. 2017. Ability to predict repetitions to momentary failure is not perfectly accurate, though improves with resistance training experience. PeerJ, 5:e4105.

Stone, M. Pierce, K. Sands, W. & Stone, M. 2006. Weightlifting: A Brief Overview. Strength and Conditioning Journal, 28, 1, p. 50-66

Stone, M. & Stone, M. 2012. Periodization and programming for strength and power sports. National Strength and Conditioning Association, Coaches Conference, youtube video at https://www.youtube.com/watch?v=z53YuD3VrlU&t=3389s

Stone, NM. & Kilding, AE. 2009. Aerobic Conditioning for Team Sport Athletes, Sports Medicine, 39, 8, p. 615-642

Suchomel, TJ. Nimphius, S. & Stone, MH. 2016. The Importance of Muscular Strength in Athletic Performance. Sports Medicine, 46, 10, p. 1419-1449

Suchomel, TJ. Wagle, JP. Douglas, J. Taber, CB. Harden, M. Haff, GG. & Stone, MH. 2019. Implementing Eccentric Resistance Training—Part 2: Practical Recommendations. Journal of Functional Morphology and Kinesiology, 4, 3, p. 55

Taber, C. Bellon, C. Abbott, H. & Bingham, G. 2016. Roles of Maximal Strength and Rate of Force Development in Maximizing Muscular Power. Strength and Conditioning Journal, 38, 1, p. 71-78

Tavares, LD. de Souza, EO. Ugrinowitsch, C. Laurentino, GC. Roschel, H. Aihara, AY. Cardoso, FN. & Tricoli, V. 2017. Effects of different strength training frequencies during reduced training period on strength and muscle cross-sectional area, European Journal of Sport Science, 17, 6, p. 665-672

Timmons, J. 2010. Variability in training-induced skeletal muscle adaptation. Journal of applied physiology (Bethesda, Md. : 1985), 110, p. 846-853

Turner, A. 2011. The Science and Practice of Periodization: A Brief Review. Strength and Conditioning Journal, 33, 1, p. 34-46

Turner, A. Comfort, P. McMahon, J. Bishop, C. Chavda, S. Read, P. Mundy, P. & Lake, J. 2020. Developing Powerful Athletes, Part 1: Mechanical Underpinnings. Strength and Conditioning Journal, 42, 1, p.1-11

Turner, A. Comfort, P. McMahon, J. Bishop, C. Chavda, S. Read, P. Mundy, P. & Lake, J. 2020. Developing Powerful Athletes Part 2: Practical Applications. Strength and Conditioning Journal. Publish Ahead of Print, 1

Weakley, J. Till, K. Read, D. Leduc, C. Roe, G. Phibbs, P. Darrall-Jones, J. & Jones, B. 2018. Jump Training in Rugby Union Players: Barbell or Hexagonal Bar? Journal of Strength and Conditioning Research, Volume Publish Ahead of Print

Wallace, BJ. Kernozek, TW. White, JM. Kline, DE. Wright, GA. Peng, HT. & Huang, CF. 2010. Quantification of vertical ground reaction forces of popular bilateral plyometric exercises. Journal of Strength and Conditioning Research, 24, 1, p. 207-212

Lorenz, DS. Reiman, MP. Lehecka, BJ. & Naylor, A. 2013. What performance characteristics determine elite versus nonelite athletes in the same sport? Sports Health, 5, 6, p. 542-547

Wilson, JM. Marin, PJ. Rhea, MR. Wilson, SM. Loenneke, JP. & Anderson, JC. 2012. Concurrent training: a meta-analysis examining interference of aerobic and resistance exercises. Journal of Strength and Conditioning Research, 26, 8, p. 2293-2307

Young, W. James, R. & Montgomery, I. 2002. Is Muscle Power Related to Running Speed With Changes of Direction? The Journal of sports medicine and physical fitness, 42, p. 282-288

Zankovets, VE. & Popov, VP. 2015. Interconnection of speed, power and speed-power abilities of professional hockey players on ice and out of ice. Pedagogics, psychology, medical-biological problems of physical training and sports, 19, p. 12-19

Zweifel, M. 2017. Importance of Horizontally Loaded Movements to Sports Performance. Strength and Conditioning Journal, 39, p. 21-26.

Zwolski, C. Quatman-Yates, C. & Paterno, MV. 2017. Resistance Training in Youth: Laying the Foundation for Injury Prevention and Physical Literacy. Sports Health, 9, 5, p. 436-443

Photo credits

Barisik, Y. 2020. Beginner strength standards, Strength training for ice hockey, p. 165

Barisik, Y. 2020. Intermediate strength standards, Strength training for ice hockey, p. 165-166

Barisik, Y. 2020. Advanced strength standards, Strength training for ice hockey, p. 166

Bompa, T. & Buzzichelli, C. 2015. Agonist-to-antagonist ratios for slow concentric isokinetic movements, Periodization training for sports, 3rd Edition, Human kinetics, p. 179

Bompa, T. & Buzzichelli, C. 2015. Training parameters for the ballistic method, Periodization training for sports, 3rd Edition, Human kinetics, p. 279

Bompa, T. & Buzzichelli, C. 2015. Categorizing energy systems training within a micro-cycle, Periodization training for sports, 3rd Edition, Human Kinetics, p. 169

Bompa, T. & Buzzichelli, C. 2015. Periodization of speed training, Periodization training for sports, 3rd Edition, Human Kinetics, p. 57

Bompa, T. & Buzzichelli, C. 2015. Periodization of agility, Periodization training for sports, 3rd Edition, Human Kinetics, p. 270

Cunanan, AJ. DeWeese, BH. Wagle, JP. Carroll, KM. Sausaman, R. Hornsby, WG 3rd. Haff, GG. Triplett, NT. Pierce, KC. & Stone, MH. 2018. General adaptation syndrome, The General Adaptation Syndrome: A Foundation for the Concept of Periodization. Sports Medicine, 48, 4, p. 790

Helms, E. Morgan, A. & Valdez, A. 2019. Warm-up sets for strength training, Muscle and strength pyramid 2.0. Training, p. 224

Science for sport, Force-velocity curve, At: https://www.scienceforsport.com/force-velocity-curve/, read 3.9.2020.

Seiler & Tønnessen 2009. Intensity scale for endurance training. In Intervals, Thresholds, and Long Slow Distance: The Role of Intensity and Duration in Endurance Training, Sportscience, 13, p. 32-53

Sheppard & Young, 2006. Model of universal agility components, The Periodisation and Monitoring of Change of Direction Speed - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Model-of-universal-agility-components-Sheppard-and-Young-2006_fig2_319174450 [accessed 13 Nov, 2020]

Suchomel Et. al. 2019. Theoretical relationship between strength and the optimization of plyometric exercise performance. In: Implementing Eccentric Resistance Training—Part 2: Practical Recommendations. Journal of Functional Morphology and Kinesiology, 4, 3, p. 55

**Appendix**

# U-18 Ice hockey off-ice training program

## Table of contents

# 1 Introduction

This is a strength and conditioning program for u-18 ice hockey athletes (16 to 18-years-old). Program includes the annual plan, strength training program, speed and plyometric sessions and guidelines for conditioning sessions. Guidelines and examples for warm-ups for each training mode are included. Movement bank, monitoring methods and testing battery are in the end of the program.

## 1.1 Overview of the program

This program includes suggested structure for the off-ice training on a weekly (microcycle) and on a daily level. I suggest keeping the frequency of the training modes as stands in the program. If any modifications to the structure are needed, I recommend altering timing of the small-sided games or swapping them to ice-practices all together. I must note that a major goal of this program is to increase strength and speed. However, if different goals are considered, rather than adding more training sessions, something needs to be removed.

Strength training section includes sets, repetitions, tempo of movements, and rest periods. Almost all exercises are paired into upper-lower pairings. The beginner program includes three total body sessions, and the intermediate program has a four-day total body split. The days in intermediate program are divided into upper body push and squat pattern, and upper body pull and deadlift/hinge pattern. Core training is done at the end of most of the sessions. The exercise pairings are marked A1-A2, and B1, B2, B3 ect. If a single exercise is performed, it will simply stand as A1, and so on. Percentages are not included in the program with an exception in the power blocks. Rather than working off percentages, let repetitions dictate the intensity. The chart below can be helpful with correlation of percentages and repetitions that can be performed. Avoid failure in all sets. RPE of 7 to 9 (1-3 reps in reserve) for beginners and RPE 8 to 9 for intermediates (1-2 reps in reserve). Instruct the athletes to increase working weight each workout, and even during the workout. Proper technique should always be maintained.

| Percentage of 1RM | Repetitions allowed |
|---|---|
| *100%* | *1* |
| *95%* | *2* |
| *90%* | *3-4* |

| | |
|---|---|
| *85%* | *5-6* |
| *80%* | *7-8* |
| *75%* | *9-10* |
| *70%* | *11-12* |
| *65%* | *13-15* |
| *60%* | *16-20* |

Note: Individual differences influence repetitions allowed on a given percentage. These numbers are based on an average.

Strength training is programmed as follows: Introductory / light training week -> moderately heavy week -> moderately heavy week -> heavy week. Check the guidelines for introductory weeks from the periodization chapter of the theoretical part. Speed and plyometric training follow the same loading pattern throughout the annual plan. In endurance training loading is different. Volume increases for the first three week, and the final week is unloading week. In some cases, there are only three-week blocks. In those cases, the third week is light week.

Movement bank of the strength training movements is included in the end of this program. Suggested main exercises (big multi-joint movements, such as squats and deadlifts) and assistance exercises (isolation and other) are in different sections. The exercises are categorized by movement patterns (hinge, push, pull ect.) in order to help finding the right movements. The strength training program does not include exercises, rather movement patterns. This provides opportunity to make individual tweaks to program in case on injuries or mobility restrictions.

Monitoring tools such as training diary for strength training and session RPE questionnaire after the training sessions are recommended. Guidelines for creating a training diary for strength training and for RPE questionnaire are presented in the end.

### 1.2 Off-season microcycle structure

Speed, agility, and jump/plyometric training should be always done at fresh state. After a rest or a recovery day. Strength training is divided into two groups, beginner and intermediate athletes. Beginners have anything between 0-2 years of strength training experience, intermediates have 2 to 4 years of training experience. Correct lifting techniques should be monitored. For this reason, dividing athletes into smaller groups of 5 to 10 is

suggested. This will make monitoring the training sessions easier. Perform the interval training sessions prior to a rest or a recovery day because they are the most taxing.

*If programmed. First block does not include speed session.
**Can be substituted to full rest day if needed.

| Off-season Microcycle Schedule Beginner | | | | | | | |
|---|---|---|---|---|---|---|---|
| AM / PM | Mon | Tue | Wed | Thu | Fri | Sat | Sun |
| *AM* | Speed* | Strength | SSG** | Speed* | | REST | REST |
| | Strength | Intervals | Active | Strength | Intervals | | |
| *PM* | SSG | | recovery | SSG | | | |

| Off-season Microcycle Schedule Intermediate | | | | | | | |
|---|---|---|---|---|---|---|---|
| AM / PM | Mon | Tue | Wed | Thu | Fri | Sat | Sun |
| *AM* | Speed* | Strength | SSG** | Speed* | Strength | REST | REST |
| | Strength | Intervals | Active | Strength | Intervals | | |
| *PM* | SSG | | recovery | SSG | | | |

### 1.3 Pre-season microcycle structure

During the pre-season the amount of ice-practices increase, and practice games begin. Strength training in both groups decreases in frequency to three times per week with three total body sessions. Speed, agility, and plyometric training is still in similar volume as in during the off-season. Ice-practices replace small-sided games completely and interval training is the final session of the week in case there are no games on the weekend. If practice games are played during the weekend, interval training is suggested to be done on a Tuesday, at the end of the practice or after the game.

| Pre-season Microcycle Schedule | | | | | | | |
|---|---|---|---|---|---|---|---|
| AM / PM | Mon | Tue | Wed | Thu | Fri | Sat | Sun |
| *AM* | Speed* | | REST | Speed* | | REST | REST |
| | Strength | Strength | | Strength | Intervals | | |
| *PM* | Ice | Ice | | Ice | Ice | | |

### 1.4 In-season training

During the competitive season, attempt to maintain adequate recovery for the games. Especially during the spring season when the play-offs and other important games take place. Speed and agility training (zone 1) should be done at fresh state, as always. Frequency drops down to once per week. Second shorter session can be done the day before the game, including only few short sprints. Strength training frequency drops down to

two sessions per week in both groups, with two total body sessions. Conditioning is now done during ice-practices (marked as zones 2 and 3 in the chart below). However, if absolutely necessary, interval training can be done off-ice with athletes outside the roster. Prefer zone 4, 3 and 2 in the interval training.

| In-season Energy-system training | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ***RPE*** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** | **Sun** |
| ***1 game / Week*** | Zone 1 | | | | | | GAME | |
| | Zone 2 (On-ice) | | | | | | | |
| | Zone 3 | | | | | | | |
| | Zone 5 | | | | | | | |
| ***2 games / Weekend*** | ***RPE*** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** | **Sun** |
| | Zone 1 | | | | | | GAME | GAME |
| | Zone 2 (On-ice) | | | | | | | |
| | Zone 3 | | | | | | | |
| | Zone 5 | | | | | | | |
| ***2 games / Week + Weekend*** | ***RPE*** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** | **Sun** |
| | Zone 1 (On-/Off-ice) | | | GAME | | | | GAME |
| | Zone 2 (On-ice) | | | | | | | |
| | Zone 3 | | | | | | | |
| | Zone 5 | | | | | | | |
| ***3 games / Week + Weekend*** | ***RPE*** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** | **Sun** |
| | Zone 1 | | | GAME | | | GAME | GAME |
| | Zone 2 (On-ice) | | | | | | | |
| | Zone 3 | | | | | | | |
| | Zone 5 | | | | | | | |

| In-season Strength training | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ***RPE*** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** | **Sun** |
| ***1 game / Week*** | Hard | | | | | | GAME | |
| | Moderate | | | | | | | |
| | Light | | | | | | | |
| ***2 games / Weekend*** | ***RPE*** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** | **Sun** |
| | Hard | | | | | | GAME | GAME |
| | Moderate | | | | | | | |
| | Light | | | | | | | |
| ***2 games / Week + Weekend*** | ***RPE*** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** | **Sun** |
| | Hard | | | GAME | | | | GAME |
| | Moderate | | | | | | | |
| | Light | | | | | | | |
| ***3 games / Week + Weekend*** | ***RPE*** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** | **Sun** |
| | Hard | | | GAME | | | GAME | GAME |
| | Moderate | | | | | | | |
| | Light | | | | | | | |

# 2 Warming-up

Following presents examples for general warm-up, speed warm-up and warm-up sets for strength training. General warm-up can be used for any training session, speed warm-up is suggested to be used prior to sprint and jump session. Warm-up sets are important in strength training, they work as a neural warm-up and will help in injury prevention since rise of the intensity is more gradual.

## 2.1 General warm-up

-5 minutes of low intensity activity: jogging, soccer, jump rope ect. (This part is optional!)
-Activation & Dynamic mobility

| ***Movement*** | ***Distance / Repetitions*** |
|---|---|
| Linear miniband walk | 15m |
| Walking lunge | 5 each leg |
| Lateral lunge | 5 each leg |
| Cross-over lunge | 5 each leg |
| 1-legged RDL | 5 each leg |
| Squat with internal & external hip rotation | 8 repetitions |
| Push-up with reach | 4 reaches each arm |
| Thorasic-spine rotations | 5 each |

## 2.2 Speed warm-up

-5 minutes of low intensity activity: jogging, soccer, jump rope ect. (This part is optional!)
-Activation & Dynamic mobility

| ***Movement*** | ***Distance / Repetitions*** |
|---|---|
| Walking lunge | 5 each leg |
| Lateral lunge | 5 each leg |
| Cross-over lunge | 5 each leg |
| 1-legged RDL | 5 each leg |
| Hip rotations | 8 repetitions each |
| Push-up with reach | 8 (4 reaches each arm) |
| Thorasic-spine rotations | 5 each |
| A-skip | 15m |
| A-skip with arm rotations | 15m each way |

| | |
|---|---|
| A-run | 15m |
| Backwards run | 15m |
| Side suffle | 15m each |
| Carioca | 15m each |
| Skip for height | 3 x each leg |
| 10m sprint with falling start | 10m x 2 sets, increase velocity |

### 2.3 Warm-up sets for strength training

*Working set repetition target 1-5 repetitions*

| | ***Repetitions*** | ***Load*** |
|---|---|---|
| *Set 1* | 5-10 | Barbell (if applicable) |
| *Set 2* | 5 | 50% of working set |
| *Set 3* | 4 | 60% of working set |
| *Set 4* | 3 | 70% of working set |
| *Set 5* | 2 | 80% of working set |
| *Set 6* | 1 | 90% of working set |

*Working set repetition target 6+ repetitions*

| | ***Repetitions*** | ***Load*** |
|---|---|---|
| *Set 1* | 6-8 | 50% of working set |
| *Set 2* | 4 | 70% of working set |
| *Set 3* | 2 | 90% of working set |

# 3 Testing and monitoring

## 3.1 Testing

Recommended testing battery:
-Anthropology (height, weight, BMI)
-1RM test
-Maximal Vertical jump (countermovement jump)
-30-meter Sprint
-3 hop jump
-2,5km Run test or Windgate-test

One repetition maximum (1RM) testing is recommended to be done during the final week of the maximum strength II blocks. Exception with 1RM test during the fourth week of beginner maximum strength I (week 33). Perform the test for main movements, such as squat, deadlift, bench press, chin-up/pull-up.

For the jump and sprint tests allow multiple attempts. Two or three repetitions in a row for jumps for three total sets. For the sprint tests allow three to four attempts. Full recovery between sets in both jump and sprint tests.

The first testing battery can be executed on week 18. After the first block. Testing should set the baseline for further testing. All testing dates are included in the annual plan.

## 3.2 Monitoring

Monitoring methods:
-Session-RPE rating
-Strength training diary
-Mood, nutrition, sleep ect. questionnaires-
-Summary of total training volume based on RPE ratings.
-Heart-rate variability test (HRV)
-Countermovement jump test (CMJ)

During the competitive season perform CMJ tests in the beginning of the week. Prior to speed and power session. Allow two to three repetitions in a row for thee sets. Full recovery between sets. Record the best result for each test.

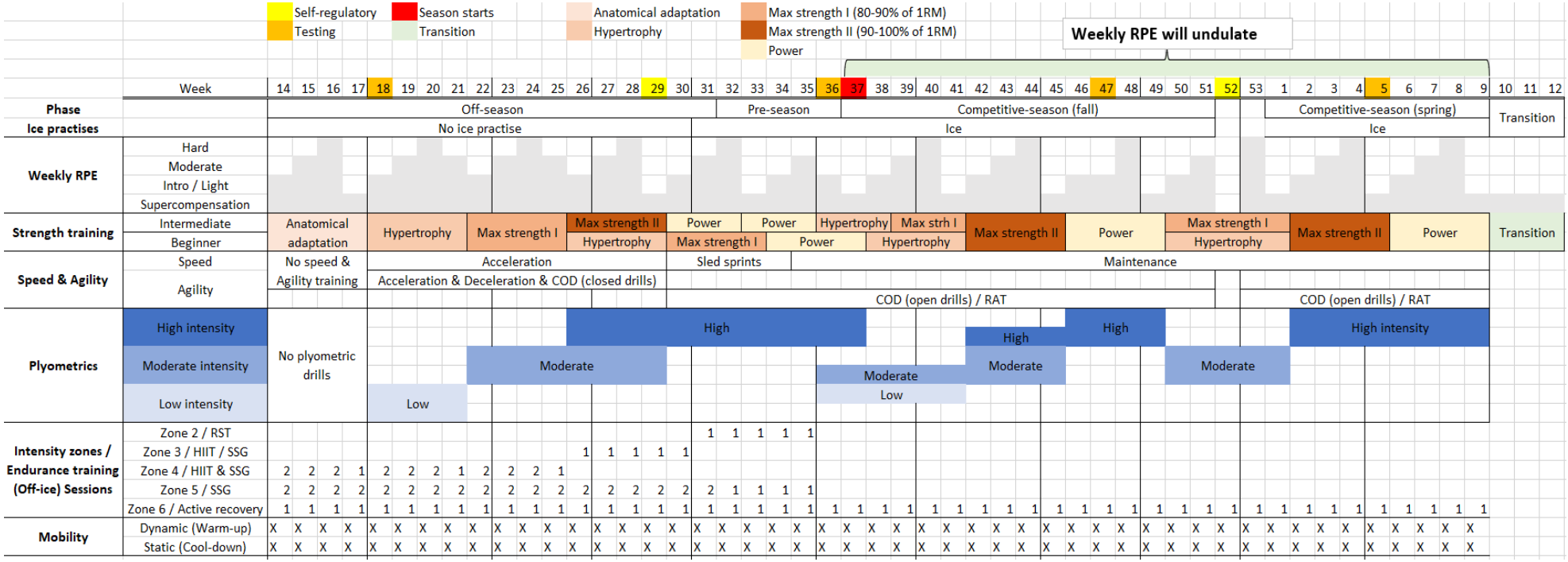
Heart-rate variability (HRV) testing can be performed anytime. Baseline values are recommended to be set after a supercompensation week. Athletes need to perform this test on their own. Athletes check their resting heart rate first thing in the morning and report the results into survey base (Google Forms, or training apps).

During the off-season deliver RPE-questionnaires after interval and SSG sessions. During the competitive season RPE-questionnaires can be filled out after training sessions or after hard ice-practices. RPE-scale should be simple, for example 1 to 10 scale, one noting rest, 10 noting extremely hard session. Example of the RPE questionnaire in the end of the product.

Training diary for strength training should be filled out during the training session every workout.

Count the total volume for the training week based on RPE questionnaires. Total volume is counted by multiplying the duration of the session by athletes estimated RPE. For example, 75-minute session x RPE of 8/10 -> 75 x 8 = 600. This gives the total volume based on athletes internal feeling. This result can be compared to the planned volume. If the session was planned at 7/10 intensity with same duration, this makes up for 75 x 7 = 525. If the planned volume of the sessions do not match with athletes internal view on a regular basis, training program might need some alterations or an individual athlete may need to focus more on recovery.

Questionnaires of mood, nutrition, sleep ect. can be delivered at any times. I do not recommend using too many monitoring methods at the same time. This can put too much pressure on the athletes since they need to focus on so many different tasks. Keep things simple and vary questionnaires used. Some athletes may need more focus on certain aspects in case there are issues with something. Overweight athletes might need more monitoring on nutrition and if someone has bad sleep habits, sleep should be monitored.


Self-regulatory
Testing
Season starts
Transition
Anatomical adaptation
Hypertrophy
Max strength I (80-90% of 1RM)
Max strength II (90-100% of 1RM)
Power
Weekly RPE will undulate
Week
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 1 2 3 4 5 6 7 8 9 10 11 12
Phase
Off-season
Pre-season
Competitive-season (fall)
Competitive-season (spring)
Transition
Ice practises
No ice practise
Ice
Ice
Weekly RPE
Hard
Moderate
Intro / Light
Supercompensation
Strength training
Intermediate
Beginner
Anatomical adaptation
Hypertrophy
Max strength I
Max strength II
Hypertrophy
Power
Power
Max strength I
Hypertrophy
Hypertrophy
Max strh I
Max strength II
Power
Max strength I
Hypertrophy
Max strength II
Power
Transition
Speed & Agility
Speed
Agility
No speed & Agility training
Acceleration
Acceleration & Deceleration & COD (closed drills)
Sled sprints
Maintenance
COD (open drills) / RAT
COD (open drills) / RAT
Plyometrics
High intensity
Moderate intensity
Low intensity
No plyometric drills
High
Moderate
Low
High
Moderate
Moderate
Low
High
Moderate
High intensity
Intensity zones / Endurance training (Off-ice) Sessions
Zone 2 / RST
Zone 3 / HIIT / SSG
Zone 4 / HIIT & SSG
Zone 5 / SSG
Zone 6 / Active recovery
Mobility
Dynamic (Warm-up)
Static (Cool-down)

# 4 Program

## 4.1 Block 1: Weeks 14-17 Preparatory-season

***General info:***

Preparatory season begins with focus on anatomical adaption in strength training, and aerobic capacity. Prefer small-sided games (SSG) for aerobic conditioning. Strength training is divided into two separate programs. With beginner program more focus on the technique work in the main exercises.

***Strength training***

Program layout includes exercise order with movement patterns. Actual movements can be chosen from the movement bank. Prefer movements that require use of bigger muscle groups in the beginning of the workout. The program is done in movement pairs or groups. A1 and A2 are main exercises, these should be always done first. B1, B2 and B3 are assistance exercises. Tempo description is different in push and pull movements. With an exception, deadlifts are better performed with 4010-tempo. Rest periods differ with main and assistance movement pairs. ”Core”-movements are dynamic. Use at least one rotational movement in the program. ”Core (carry)” means farmer’s walk or its variant. ”Core (static)” means isometric movements with anti-rotational emphasis, such as pallof press’s.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 14-17 Anatomical adaptation (Off-season)** | **Beginner** | ***Main exercises A1-A2*** | ***Assistance exercises B1-B2 ect.*** |
| | | *Sets: 3-4* | *Sets: 3, Repetition range: 12-20* |
| | | *Repetition range: 8-10* | *Repetition range: As many as possible (AMAP) in bodyweight (BW) movements* |
| | | *Push / squat tempo: 4010* | |
| | | *Hinge / pull tempo: 2013* | *Controlled tempo* |
| | | *Rest periods 90-120 sec* | *Rest periods: 60 sec* |
| | | | **Core carry: 4 Sets, 30m distance, 30 sec rest* |
| | **Intermediate** | ***Main exercises A1-A2*** | ***Assistance exercises B1-B2 ect.*** |
| | | *Sets: 3-4* | *Sets: 3, Repetition range: 12-20* |
| | | *Repetition range: 8-10* | *Repetition range: As many as possible (AMAP) in bodyweight movements* |
| | | *Push / squat tempo: 4010* | |
| | | *Hinge / pull tempo: 2013* | *Controlled tempo* |
| | | *Rest periods 90-120 sec* | *Rest periods: 60 sec* |
| | | ***Core (static) 4x5 (5 sec)* | **Core carry: 30m distance, 30 sec rest* |

***Beginner***

| Day 1 | | Day 2 | | Day 3 | |
|---|---|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Unilateral squat | A1 | Hinge / Deadlift | A1 | Unilateral squat |
| A2 | Horizontal push (BW) | A2 | Vertical pull (BW) | A2 | Horizontal push |
| B1 | Unilateral hinge / deadlift | B1 | Unilateral squat | B1 | Unilateral horizontal pull |
| B2 | Horizontal pull | B2 | Horizontal push | B2 | Hamstring |
| B3 | Core | B3 | Core | C1 | *Core (carry) |
| | | | | | |

***Intermediate***

| Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* | *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Unilateral squat | A1 | Hinge | A1 | Unilateral squat | A1 | Unilateral deadlift |
| A2 | Horizontal push | A2 | Vertical pull (BW) | A2 | Horizontal push | A2 | Horizontal pull |
| B1 | Horizontal push (BW) | B1 | Unilateral horizontal pull | B1 | Unilateral squat | B1 | Horizontal pull |
| B2 | Unilateral squat | B2 | Hamstring | B2 | Unilateral vertical push | B2 | Hamstring |
| C3 | Core | B3 | *Core (carry) | B3 | Core | C1 | **Core (static) |
| | | | | | | | |

***Small-sided games***: 40-60 min SSG aerobic. 10-15 minute periods, 1-2 minute rest between. 3-4 sets. Increase volume throughout the block by increasing total duration. Average heart rate <80%.

***Interval training:*** Bike or run, 5-7 x 3 min @ 82-85% HR (zone 4), rest 1 min between.

Increase the amount of sets each week. Except in week the fourth week, deload, only one session. 5 x 2 min @ 75% HR (zone 4), rest 1 min between.

## 4.2 Block 2: Weeks 18-21 Preparatory-season

***General info:***

Focus in strength training is in hypertrophy. Olympic lifting technique training is in the beginning of the workout. Speed and jump training begin with emphasis on acceleration, deceleration and starting power. Conditioning is similar to block 1.

***Strength training***

Olympic lifting technique training use light weights 40-50% of estimated 1RM. Begin with barbell and use small weight increments. Make sure bar speed is high but the weight is challenging. Increase intensity each workout if proper technique is maintained. Increase volume after two weeks by one working set in main exercises.

***Speed and plyometric training***

Plyometric training should be done with maximal intent. Pauses in landing are included with emphasis on eccentric strength and to ensure proper movement mechanics. Full recovery between sets. 60+ seconds should be adequate. Increase volume by one set every week for three weeks, with third and fourth weeks 5 sets per movement in jumps and 6 sets in sprints.

***Strength***

| | | ***Main exercises A1, B1, C1*** | ***Assistance exercises D1-D2 ect.*** |
|---|---|---|---|
| **Weeks 18-21 Hypertrophy (Off-season)** | **Beginner** | *A1 Olympic lifting technique: Sets: 4-5,* | *Sets: 3* |
| | | *Rep range 3-5, rest 60-90 sec* | *Repetition range 8-12* |
| | | *Sets: 4-5* | *Rest periods: 60-75 sec* |
| | | *B1, C1 Rep range 8* | *Core (carry) 4 x 25m, rest 90 sec* |
| | | *Rest periods 2-3 min* | *Fast concentric, controlled eccentric* |
| | | *Fast concentric, controlled eccentric* | |
| | **Intermediate** | *A1 Olympic lifting technique: Sets: 4-5,* | *Sets: 3* |
| | | *Rep range 3-5, rest 60-90 sec* | *Repetition range 8-12* |
| | | *Sets: 3-4* | *Rest periods: 60-75 sec* |
| | | *B1, C1 Rep range 6-8* | **Core (carry) 4 x 25m, rest 90 sec* |
| | | *Rest periods 3-4 min* | ***Core (static) 4 x 30 sec, rest 90 sec* |
| | | *Fast concentric, controlled eccentric* | *Fast concentric, controlled eccentric* |
| | | | |
| | | | |

***Beginner***

| Day 1 | | Day 2 | | Day 3 | |
|---|---|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift | B1 | Squat |
| C1 | Horizontal push | C1 | Vertical pull (BW) | C1 | Horizontal push |
| D1 | Hinge | D1 | Unilateral squat | D1 | Hinge |
| D2 | Horizontal pull | D2 | Vertical push | D2 | Horizontal pull |
| D3 | Core | D3 | Core | E1 | Core (carry) |

***Intermediate***

| Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* | *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Unilateral deadlift |
| B1 | Squat | B1 | Deadlift | B1 | Squat | A2 | Horizontal pull |
| C1 | Horizontal push | B1 | Vertical pull (BW) | C1 | Horizontal push | B1 | Horizontal pull |
| D1 | Unilateral squat | D1 | Hamstring | D1 | Unilateral squat | B2 | Hamstring |
| D2 | Horizontal push (BW) | D2 | Horizontal pull | D2 | Vertical push | C1 | **Core (static) |
| D3 | Core | E1 | Core (carry) | D3 | Core | | |

***Sprints and jumps:***

Session #1: -Low hurdle jump with pause; 3 x 5, rest 60 sec
-Lateral bound with pause; 3 x 5 each, rest 90 sec
-10m sprint x 4 sets, rest 60 sec

Session #2: -1-leg hurdle hop with pause; 3 x 5 each, rest 60 sec
-Lateral low hurdle jump with pause; 3 x 5, rest 60 sec
-5m acceleration-deceleration x 2, 4 sets, rest 90 sec

***Small-sided games:*** 40-60 min SSG aerobic. 10-15-minute periods, 1-2-minute rest between. 3-4 sets. Increase volume throughout the block by increasing total duration. Average heart rate <80%.

***Interval training:*** Zone 4 Bike or run; 5-7 x 3 minutes @ 85-88% HR, rest 90 seconds between.

Increase the amount of sets each week. Except in week the fourth week, only one session. 4 x 3 min @ 80% HR (zone 4), rest 90 sec between.

### 4.3 Block 3: Weeks 22-25 Preparatory-season

***General info:***

Focus in strength training is in maximum strength 1. Focus in Olympic lifts in now still in submaximal technique. However, loads should be higher at this point with RPE 7-9 on a scale of 10. Conditioning includes two interval training sessions and two or three SSG sessions. Increase the field dimensions and use fewer players.

***Strength training***

In main movements, intensity is 80-90% of estimated 1RM. Increase intensity in Olympic lifts each workout. Focus on fast bar velocities and proper technique. Repetition range in C1 movements is 5 to 7, with exception on day 2, five repetitions.

***Speed training***

Remove use of pauses in plyometric drills. Focus on fast ground contact times and maximal height or distance. Increase volume by one set every week for three weeks, with third and fourth weeks 5 sets per movement in jumps and 6 sets in sprints.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 22-25 Max strength I (Off-season)** | **Beginner** | ***Main exercises A1, B1, C1*** | ***Assistance exercises D1-D2 ect.*** |
| | | *A1 Olympic lifting: Sets: 4-5, Rep range 3-5, rest 2 min* | *Sets: 3* |
| | | | *Repetition range 6-10* |
| | | *Sets: 3-4* | *Rest periods: 60-75 sec* |
| | | *Repetition range: 5* | **Med-ball: sets 3, Rep range 10, Rest 75-90 sec* |
| | | *Rest periods: 2-3 min* | *Fast concentric, controlled eccentric* |
| | | *Fast concentric, controlled eccentric* | |
| | **Intermediate** | ***Main exercises A1, B1, C1*** | ***Assistance exercises D1-D2 ect.*** |
| | | *A1 Olympic lifting: Sets: 4-5, Rep range 3-5, rest 3 min* | *Sets: 3* |
| | | | *Repetition range 6-10* |
| | | *Sets: 3-4* | *Rest periods 60-90 sec* |
| | | *Repetition range: B1 5, C1 5-7* | **Med-ball: sets 3, Rep range 10, Rest 75-90 sec* |
| | | *Rest periods: 3-4 min* | *Fast concentric, controlled eccentric* |
| | | *Fast concentric, controlled eccentric* | |

***Beginner***

| Day 1 | | Day 2 | | Day 3 | |
|---|---|---|---|---|---|
| *No* | *Movement* | *No* | *Movement* | *No* | *Movement* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift | B1 | Unilateral squat |
| C1 | Vertical pull (BW) | C1 | Vertical pull (BW) | C1 | Horizontal push |
| D1 | Hinge | D1 | Unilateral squat | D1 | Horizontal pull |
| D2 | Horizontal push | D2 | Vertical push | D2 | Hamstring |
| | | E1 | Med-ball core | D3 | Core |

***Intermediate***

| Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|
| *No* | *Movement* | *No* | *Movement* | *No* | *Movement* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Squat | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift | B1 | Horizontal push | B1 | Vertical pull (BW) |
| C1 | Horizontal push | C1 | Vertical pull (BW) | C1 | Unilateral squat | B2 | Hinge |
| D1 | Unilateral squat | D1 | Horizontal pull | C2 | Vertical push | C1 | Horizontal pull |
| D2 | Horizontal push | D2 | Hamstring | D1 | Med-ball core | C2 | Hamstring |
| | | | | | | D1 | **Core (static) |

***Sprint & Jump:***

*Session #1:* -Hurdle jump; 3 x 5, rest 60 sec
-Lateral bound; 3 x 5 each, rest 60 sec
-15m Sprint from push-up position; 4 sets, rest 2 min

*Session #2:* -1-leg hurdle hop; 3 x 5 each, rest 60 sec
-Lateral hurdle jump; 3 x 5, rest 60 sec
-5m backward – 10m forward sprint; 4 sets, rest 2 min

***Small-sided games:*** -1 x SSG Aerobic; 45-60 min. 10-15 minute periods, 1-2 minute rest between. Average heart rate <80%.

***Interval training:*** -Zone 4 Bike or run @ 85-88% of max HR, 5-7 x 800m Sprint, rest 90-120 sec between. Allow HR to drop below 140 bpm during recovery.

Increase volume each week from 5 sets to 7. The fourth week, 4 x 800m, 80% rest 90-120 sec.

### 4.4 Block 4: Weeks 26-29 Preparatory-season

***General info:***

Intermediate strength training group keeps on increasing intensity in training, with focus on maximum strength II training. The beginner strength program decreases intensity for a block of hypertrophy focused training. The following 5 weeks in conditioning will be focused for zone 3. One interval training session and one zone 3 SSG session.

***Strength training***

In the intermediate program, first week is dedicated to triples in main movements, second week is doubles and final two weeks singles. Intensity between 90-100% of 1RM. In the final week test 1RM in main lifts. The beginner program can add submaximal 1RM tests in the main lifts for final two weeks prior to first working sets. Increase volume in main exercises by one working set for the first three weeks of the block. The final fourth week should have same volume as in week three.

***Speed training***

Increase volume by one set every week for three weeks, with third and fourth weeks 5 sets per movement in jumps and 6 sets in sprints.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 26-29 Hypertrophy (Off-season)** | **Beginner** | ***Main exercises A1, B1, C1*** | ***Assistance exercises D1-D2 ect.*** |
| | | *A1 Olympic lifting: Sets: 3-4, Rep range 3-5, rest 2-3 min* | *Sets 3* |
| | | | *Repetition range 8-12* |
| | | *Sets 3-4* | *Tempo 3310* |
| | | *Repetition range 5-7* | *Rest periods 75-90 sec* |
| | | *Tempo 5010* | |
| | | *Rest periods 3 min* | |
| **Weeks 26-29 Max strength II (Off-season)** | **Intermediate** | ***Main exercises A1, B1, C1*** | ***Assistance exercises D1-D2 ect.*** |
| | | *A1 Olympic lifting: Sets: 4-5, Rep range 2, rest 3 min* | *Sets 3* |
| | | | *Repetition range 5-8* |
| | | *Sets 3-4* | *Rest periods 90-120 sec* |
| | | *Repetition range 3 down to 1* | *Fast concentric, controlled eccentric* |
| | | *Days 1-3 C1 Tempo 5010 / 1410* | |
| | | *Rest periods 3-5 min* | |

***Beginner***

| Day 1 | | Day 2 | | Day 3 | |
|---|---|---|---|---|---|
| *No* | *Movement* | *No* | *Movement* | *No* | *Movement* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift | B1 | Squat |
| C1 | Vertical pull (BW) | C1 | Vertical pull (BW) | C1 | Horizontal push |
| D1 | Unilateral Hinge | D1 | Unilateral squat | D1 | Horizontal pull |
| D2 | Horizontal push | D2 | Horizontal push | D2 | Hamstring |
| D3 | Med-ball Core | E1 | Core | E1 | Core (carry) |

***Intermediate***

| Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|
| *No* | *Movement* | *No* | *Movement* | *No* | *Movement* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Squat | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift | B1 | Horizontal push | B1 | Vertical pull (BW) |
| C1 | Horizontal push | C1 | Vertical pull (BW) | C1 | Unilateral squat | C1 | Horizontal pull |
| D1 | Horizontal push | D1 | Hamstring | C2 | Vertical push | C2 | Hamstring |
| D2 | Unilateral squat | D2 | Horizontal pull | | | C3 | **Core (static) |
| | | | | | | | |

***Sprint & Jump:***

*Session #1:* -3-way hurdle jump; 3 x 5, rest 60 sec
-Diagonal bound; 3 x 5 each, rest 60 sec
-1/2 Kneeling start with turn to 20m sprint; 4 sets, rest 2 min

*Session #2:* -Forward bound; 3 x 3 each, rest 60 sec
-Lateral-backward- forward- lateral hurdle jump; 3 x 4, rest 60 sec
-5m forward–5m side suffle-10m forward sprint; 4 sets, rest 2 min

***Small-sided games:*** -1 x SSG Aerobic; 45-60 min. Average heart rate <80%.

-1 x SSG HIT; 15-30 min 3-4 x 6-7 min, rest 3 min between. Goal HR @ 90-93%. Increase volume each week. The final week is a deload. No HIT SSG.

***Interval training:*** **-Weeks 26-27:** Zone 3 Bike or run @ 95-98% of max HR, 5 x 800m Sprint, rest 2-3 min between. Allow HR to drop below 140bpm during recovery.
**-Weeks 28-30:** Zone 3 Bike or run @ 97-100% of max HR, 6-7 x 800m Sprint, rest 2-3 min between. Allow HR to drop below 140bpm during recovery. Light week: 4 x 800m @ 85%, rest 2min

***Weeks 30-41: The intermediate program has 3-week blocks in length. The beginner program has the same 4-week length. This is because power is peaked to the beginning of the season.***
***The following block will include Two separate power blocks for intermediate program. The first block includes 4 weekly sessions, the second one 3 sessions.***
***See the annual plan to avoid confusion.***

### 4.5 Block 5: Weeks 30-33 Pre-competitive season

*Note: Amount of ice practices increase*

***General info:***

With increase in ice practices strength training volume is decreased to three sessions per week. If the practice games take place on a weekend, do the interval training during the week. Focus in conditioning is now in zone 3 for one week, then switches to zone 2 for five weeks.

Zone 3 conditioning is explained in the previous block.

***Strength training***

Goal in the beginner program is maximum strength I and in the intermediate program goal is power. Goal in the power training is to transfer maximal strength gained during the summer to power. Movement velocities should be maximal in concentric and weights submaximal. Avoid fatigue in working sets. Increase volume for first three weeks in main movements by one working set per week. Fourth week of the block should be at same volume as the previous one.

***Speed training***

At this point sled sprints are introduced to speed training. Make sure the velocities in sprints are not decreased too much. Increase volume by one set each week, with final fourth week at same volume as the third.

***Strength***

| | | ***Main exercises A1, B1, C1*** | ***Assistance exercises D1-D2 ect.*** |
|---|---|---|---|
| **Weeks 30-33 Max-strength I (Pre-season)** | **Beginner** | *A1 Olympic lifting: Sets: 4-5, Rep range 3-5, rest 2 min* | *Sets: 3* |
| | | *Sets: 3-4* | *Repetition range 6-10* |
| | | *Repetition range: 5* | *Rest periods: 60-75 sec* |
| | | *Rest periods: 2-3 min* | **Med-ball: sets 3, Rep range 10, Rest 75-90 sec* |
| | | *Fast concentric, controlled eccentric* | *Fast concentric, controlled eccentric* |

| | | Main exercises A1, B1, C1 | Assistance exercises D1-D2 ect. (C1-C2 on day 3) |
|---|---|---|---|
| **Weeks 30-35 Power (Pre-season)** | **Intermediate** | *A1 Olympic lifting: Sets: 4-5, Rep range* | *Sets 3* |
| | | *1-2, rest 2-3 min* | *Repetition range 5-10* |
| | | *B1 80-90% of 1RM* | *Rest periods 90-180 sec* |
| | | *Day 1: C1 30% of 1RM* | *Fast concentric, controlled eccentric* |
| | | *Sets 3-4, Rep range 3-5* | |
| | | *Rest periods 2-3 min* | |

**B1 Repetitions: 1-3*

### *Beginner*

| Day 1 | | Day 2 | | Day 3 | |
|---|---|---|---|---|---|
| *No* | *Movement* | *No* | *Movement* | *No* | *Movement* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift | B1 | Unilateral squat |
| C1 | Vertical pull (BW) | C1 | Vertical pull (BW) | C1 | Horizontal push |
| D1 | Hinge | D1 | Unilateral squat | D1 | Horizontal pull |
| D2 | Horizontal push | D2 | Vertical push | D2 | Hamstring |
| | | E1 | Med-ball core | D3 | Core |

### *Intermediate (30-32)*

| Day 1 | | Day 2 | | Day 3 | | Day 4 | |
|---|---|---|---|---|---|---|---|
| *No* | *Movement* | *No* | *Movement* | *No* | *Movement* | *No* | *Movement* |
| A1 | Olympic lifting variant | A1 | Squat jump | A1 | Olympic lifting variant | A1 | Med-ball throw |
| B1 | Squat | B1 | Deadlift | B1 | Half Squat | B1 | Squat jump |
| C1 | Bench throw | C1 | Vertical pull (BW) | C1 | Hamstring | C1 | Horizontal push |
| D1 | Horizontal pull | | | C2 | Horizontal pull | | |
| D2 | Core | | | C3 | Core | | |

### *Intermediate (33-35)*

| Day 1 | | Day 2 | | Day 3 | |
|---|---|---|---|---|---|
| *No* | *Movement* | *No* | *Movement* | *No* | *Movement* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift | B1 | Squat jump |
| C1 | Bench throw | C1 | Vertical pull (BW) | C1 | Hamstring |
| D1 | Horizontal pull | C2 | Horizontal push | C2 | Horizontal pull |
| D2 | Core | | | C3 | Core |

### *Sprint & Jump:*

*Session #1:* -Lateral-medial hurdle hop; 3 x 6 each, rest 90 sec
-30cm Depth jump; 3 x 5, rest 2 min
-20m Sled Sprint @15% of BW; 4 sets, rest 2 min

*Session #2:* -Broad jump; 3 x 4, rest 2 min
-3-way hurdle hop; 3 x 4 each, rest 90 sec
-5-10-5 Agility drill with reactive start; 4 sets, rest 2 min

***Interval training:*** ***RST***

Weeks 31-33:

-3 sets

-5-6 x 30m sprint, rest 30 sec between repetitions

-Rest 3-4 min between sets.

-Increase volume throughout the block. 5 sets in weeks 31 and 32. 6 sets in week 33.

## 4.6 Block 6: Weeks 34-37 Pre-competitive season

***General info:***

The final block before the beginning of the season. The beginner program focuses on power training. The intermediate program has 2 more weeks of power block. Then on week 36 switches to hypertrophy. Those first two weeks of hypertrophy can be lower in volume.

The first two weeks of this block are still Zone 2 intervals before tapering off towards the beginning of the season.

***Strength training***

Focus for the beginner program is in power training and in the intermediate program two weeks power before switching to hypertrophy. In beginner program increase volume in all exercises by one set for the first three weeks of the block. The final fourth week should have the same volume as in week three.

***Speed training***

Increase volume by one set in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Strength***

| | | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
|---|---|---|---|
| **Weeks 34-37 Power (Pre-season)** | **Beginner** | *A1 Olympic lifting: Sets: 4-5, Rep range* | *Sets 3* |
| | | *1-2, rest 2-3 min* | *Repetition range 5-10* |
| | | *B1 80-90% of 1RM* | *Rest periods 90-180 sec* |
| | | *Day 1: C1 30% of 1RM* | *Fast concentric, controlled eccentric* |
| | | *Sets 3-4, Rep range 3-5* | |
| | | *Rest periods 2-3 min* | |

*B1 Repetitions: 1-3

| | | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
|---|---|---|---|
| **Weeks 36-38 Hypertrophy (Pre-season)** | **Intermediate** | *A1 Sets 3-4, Rep range 3-5, Rets 2-3* | *Sets 3* |
| | | *min* | *Repetition range 10-15* |
| | | *Sets 3-4* | *Rest periods 75-90 sec* |
| | | *Repetition range 8-10* | |
| | | *Rest periods 90-120 sec* | |
| | | *Fast concentric, controlled eccentric* | |

***Beginner (Above)***

***Intermediate (Below)***

| Day 1 | | Day 2 | | Day 3 | |
|---|---|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* | *No* | *Movement* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift | B1 | Squat jump |
| C1 | Bench throw | C1 | Vertical pull (BW) | C1 | Hamstring |
| D1 | Horizontal pull | C2 | Horizontal push | C2 | Horizontal pull |
| D2 | Core | | | C3 | Core |
| | | | | | |

| Day 1 | | Day 2 | | Day 3 | |
|---|---|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* | *No* | *Movement* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift | B1 | Squat |
| B2 | Horizontal push | B1 | Vertical pull | B2 | Horizontal push |
| C1 | Horizontal pull | C1 | Unilateral squat | C1 | Horizontal pull |
| C2 | Hamstring | C2 | Horizontal push | C2 | Hinge |
| C3 | Core | | | | |

***Sprint & Jump***

-50 cm Depth jump into 3 hurdle jumps; 3 x 4, rest 2 min

-Long hop; 3 x 4 each, rest 2 min

-Partner Chase-tag; 4 x 20m, rest 2 min

***Interval training:*** ***RST***

Weeks 34-35:

-6-7 sets

-20-seconds maximal 10m shuttle run.

-2 minutes active recovery between sprints.

-6 sets in week 34. 7 sets on week 35.

### 4.7 Block 7: Weeks 38-41 Competitive season

*Note: Competitive season starts*

*Note: All conditioning training during ice-practices*

***General info:***

With the beginning of the competitive season, decrease frequency in training to two strength sessions per week and one speed session per week. Week 38 for the intermediate program is the final week of hypertrophy, then the focus is in maximum strength 1 weeks 39-41. Intensities between 80-90% of 1RM. The beginner program focuses on hypertrophy. Two strength sessions per week and one speed session per week. The day before the game can include few short sprints after the warm-up. Zone 6 low intensity conditioning is done for active recovery. 30 minutes of light activity followed by stretching and other mobility exercises.

***Strength training***

Increase volume in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Speed training***

Increase volume by one set in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 38-41 Hypertrophy (In-season)** | **Beginner** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Sets 3-4, Rep range 2-3, Rets 2-3 min* | *Sets 3* |
| | | *Sets 3-4* | *Repetition range 8-10* |
| | | *Repetition range 5* | *Rest periods 60-75 sec* |
| | | *Rest periods 90-120 sec* | |
| | | *Fast concentric, controlled eccentric* | |
| **Weeks 39-41 Maximal strength I (In-season)** | **Intermediate** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Sets 3-4, Rep range 2-3, Rets 2-3 min* | *Sets 3* |
| | | *Sets 3-4* | *Repetition range 8-10* |
| | | *Repetition range 5* | *Rest periods 60-75 sec* |
| | | *Rest periods 90-120 sec* | |
| | | *Fast concentric, controlled eccentric* | |

***Beginner (Above)***

***Intermediate (Below)***

| Day 1 | | Day 2 | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift |
| B2 | Horizontal push | B2 | Vertical pull |
| C1 | Horizontal pull | C1 | Unilateral squat |
| C2 | Hamstring | C2 | Horizontal push |
| C3 | Core | | |

| Day 1 | | Day 2 | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| B2 | Horizontal push | B1 | Vertical pull |
| C1 | Horizontal pull | C1 | Unilateral squat |
| C2 | Hamstring | C2 | Horizontal push |
| C3 | Core | | |

***Sprint & Jump***

-Hurdle jump; 3 x 5, rest 90 sec

-Diagonal bound; 3 x 3 each, rest 90 sec

-Reactive agility mirror drill; 4 sets of <10 sec, rest 2 min between

### 4.8 Block 8: Weeks 42-45 Competitive season

***General info:***

Focus in strength training is in maximum strength 2. Intensities between 90-100% of 1RM. Two strength sessions per week and one speed session per week. Day before the game can include few short sprints after the warm-up.

***Strength training***

First week of the block is triples, second week doubles and two final weeks singles in main exercises. In the final week test 1RM in main lifts.

***Speed training***

Increase volume by one set in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 42-45 Maximal strength II (In-season)** | **Beginner** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Sets 3-4, Rep range 1-2, Rets 2-3 min* | *Sets 3* |
| | | | *Repetition range 6-10* |
| | | *Sets 3-4* | *Rest periods 60-75 sec* |
| | | *Repetition range 3 down to 1* | |
| | | *Rest periods 2 min* | |
| | | *Fast concentric, controlled eccentric* | |
| | **Intermediate** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Sets 3-4, Rep range 1-2, Rets 3 min* | *Sets 3* |
| | | | *Repetition range 6-10* |
| | | *Sets 3-4* | *Rest periods 60-75 sec* |
| | | *Repetition range 3 down to 1* | |
| | | *Rest periods 2 min* | |
| | | *Fast concentric, controlled eccentric* | |

***Beginner (Above)***

***Intermediate (Below)***

| ***Day 1*** | | ***Day 2*** | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| B2 | Horizontal push | B1 | Vertical pull |
| C1 | Horizontal pull | C1 | Unilateral squat |
| C2 | Hamstring/Hinge | C2 | Horizontal push |
| | | | |

| ***Day 1*** | | | ***Day 2*** |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *No* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| B2 | Horizontal push | B1 | Vertical pull |
| C1 | Horizontal pull | C1 | Unilateral squat |
| C2 | Hamstring/Hinge | C2 | Horizontal push |
| | | | |

***Sprint & Jump***

-Forward bound; 3 x 5, rest 90 sec

-3 hurdle jumps into a 10m sprint; 3 x 4, rest 2 min

-4-point reactive agility drill; 4 sets of <10 sec, rest 2 min

### 4.9 Block 9: Weeks 46-49 Competitive season

***General info:***

Focus in strength training is to transfer maximum strength gains to power. High movement velocities and avoid fatigue in working sets.

***Strength training***

Increase volume in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Speed training***

Increase volume by one set in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 46-49 Power (In-season)** | **Beginner** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Olympic lifting: Sets: 4-5, Rep range 1-2, rest 2-3 min* | *Sets 3* |
| | | *B1 80-90% of 1RM* | *Repetition range 5-10* |
| | | *Day 1: C1 30% of 1RM* | *Rest periods 90-180 sec* |
| | | *Sets 3-4, Rep range 3-5* | *Fast concentric, controlled eccentric* |
| | | *Rest periods 2-3 min* | |
| | **Intermediate** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Olympic lifting: Sets: 4-5, Rep range 1-2, rest 2-3 min* | *Sets 3* |
| | | *B1 80-90% of 1RM* | *Repetition range 5-10* |
| | | *Day 1: C1 30% of 1RM* | *Rest periods 90-180 sec* |
| | | *Sets 3-4, Rep range 3-5* | *Fast concentric, controlled eccentric* |
| | | *Rest periods 2-3 min* | |

**B1 Repetitions: 1-3*

***Beginner (Above)***

***Intermediate (Below)***

| ***Day 1*** | | ***Day 2*** | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| C1 | Bench throw | C1 | Vertical pull |
| C2 | Horizontal pull | C2 | Horizontal push |
| | | | |
| | | | |

| ***Day 1*** | | ***Day 2*** | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| C1 | Bench throw | C1 | Vertical pull |
| C2 | Horizontal pull | C2 | Horizontal push |
| | | | |
| | | | |

***Sprint & Jump***

-3 x Lateral hurdle jump into a 10m sprint; 3 x 4, rest 2 min

-3-way hurdle hop; 3 x 4 each, rest 90 sec

-4-point mirror drill; 4 sets x <10 sec, rest 2 min

### 4.10 Block 10: Weeks 50-1 Competitive season

***General info:***

Focus in strength training is in hypertrophy for the beginner program and maximum strength I for the intermediate program. The day before the game can include few short sprints after the warm-up.

***Strength training***

Increase volume in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Speed training***

Increase volume by one set in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 50-1 Hypertrophy (In-season)** | **Beginner** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Sets 3-4, Rep range 2-3, Rets 2-3 min* | *Sets 3* |
| | | | *Repetition range 8-10* |
| | | *Sets 3-4* | *Rest periods 60-75 sec* |
| | | *Repetition range 5* | |
| | | *Rest periods 90-120 sec* | |
| | | *Fast concentric, controlled eccentric* | |
| **Weeks 50-1 Max-strength I (In-season)** | **Intermediate** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Sets 3-4, Rep range 2-3, Rets 2-3 min* | *Sets 3* |
| | | | *Repetition range 8-10* |
| | | *Sets 3-4* | *Rest periods 60-75 sec* |
| | | *Repetition range 5* | |
| | | *Rest periods 90-120 sec* | |
| | | *Fast concentric, controlled eccentric* | |

***Beginner (Above)***

***Intermediate (Below)***

| Day 1 | | Day 2 | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B1 | Deadlift |
| B2 | Horizontal push | B2 | Vertical pull |
| C1 | Horizontal pull | C1 | Unilateral squat |
| C2 | Hamstring | C2 | Horizontal push |
| C3 | Core | | |

| Day 1 | | Day 2 | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| B2 | Horizontal push | B1 | Vertical pull |
| C1 | Horizontal pull | C1 | Unilateral squat |
| C2 | Hamstring | C2 | Horizontal push |
| C3 | Core | | |

***Sprint & Jump***

-3-way hurdle jump; 3 x 5, Rest 90 sec

-Lateral bound; 3 x 4 each, rest 90sec

-Reactive COD Y-run; 4 x 15m, rest 90 sec

### 4.11 Block 11: Weeks 2-5 Competitive season

***General info:***

Focus in strength training is in maximum strength 2. Intensities between 90-100% of 1RM. Two strength sessions per week and one speed session per week. Day before the game can include few short sprints after the warm-up.

***Strength training***

First week is triples, second week doubles and final two weeks singles in main exercises. In the final week test 1RM in main lifts.

***Speed training***

Increase volume by one set in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 2-5 Maximal strength II (In-season)** | **Beginner** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Sets 3-4, Rep range 1-2, Rets 2-3 min* | *Sets 3* |
| | | | *Repetition range 6-10* |
| | | *Sets 3-4* | *Rest periods 60-75 sec* |
| | | *Repetition range 3 down to 1* | |
| | | *Rest periods 2 min* | |
| | | *Fast concentric, controlled eccentric* | |
| | **Intermediate** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Sets 3-4, Rep range 1-2, Rets 3 min* | *Sets 3* |
| | | | *Repetition range 6-10* |
| | | *Sets 3-4* | *Rest periods 60-75 sec* |
| | | *Repetition range 3 down to 1* | |
| | | *Rest periods 2 min* | |
| | | *Fast concentric, controlled eccentric* | |

***Beginner (Above)***

***Intermediate (Below)***

| Day 1 | | Day 2 | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| B2 | Horizontal push | B1 | Vertical pull |
| C1 | Horizontal pull | C1 | Unilateral squat |
| C2 | Hamstring/Hinge | C2 | Horizontal push |
| | | | |

| Day 1 | | | Day 2 |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *No* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| B2 | Horizontal push | B1 | Vertical pull |
| C1 | Horizontal pull | C1 | Unilateral squat |
| C2 | Hamstring/Hinge | C2 | Horizontal push |
| | | | |

***Sprint & Jump***

-Depth jump into forward-lateral-forward-lateral hurdle jump; 3 x 5, rest 2 min

-3 lateral hurdle hop into 2 broad jump; 3 x 5, rest 2 min

-5-point reactive agility drill; 4 set x <10 sec, rest 2 min

### 4.12 Block 12: Weeks 6-9 Competitive season

*Note: Ensure adequate recovery for the important games (play-offs ect.).*

***General info:***

Focus in strength training is to transfer maximal strength gains to power. High movement velocities and avoid fatigue in working sets.

***Strength training***

Increase volume in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Speed training***

Increase volume by one set in all exercises by one set for first three weeks of the block. Final fourth week should have same volume as in week three.

***Strength***

| | | | |
|---|---|---|---|
| **Weeks 6-9 Power (In-season)** | **Beginner** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Olympic lifting: Sets: 4-5, Rep range 1-2, rest 2-3 min* | *Sets 3* |
| | | | *Repetition range 5-10* |
| | | *B1 80-90% of 1RM* | *Rest periods 90-180 sec* |
| | | *Day 1: C1 30% of 1RM* | *Fast concentric, controlled eccentric* |
| | | *Sets 3-4, Rep range 3-5* | |
| | | *Rest periods 2-3 min* | |
| | **Intermediate** | ***Main exercises A1, B1-B2*** | ***Assistance exercises C1-C2 ect.*** |
| | | *A1 Olympic lifting: Sets: 4-5, Rep range 1-2, rest 2-3 min* | *Sets 3* |
| | | | *Repetition range 5-10* |
| | | *B1 80-90% of 1RM* | *Rest periods 90-180 sec* |
| | | *Day 1: C1 30% of 1RM* | *Fast concentric, controlled eccentric* |
| | | *Sets 3-4, Rep range 3-5* | |
| | | *Rest periods 2-3 min* | |

**B1 Repetitions: 1-3*

***Beginner (Above)***

***Intermediate (Below)***

| Day 1 | | Day 2 | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| C1 | Bench throw | C1 | Vertical pull |
| C2 | Horizontal pull | C2 | Horizontal push |
| | | | |
| | | | |

| Day 1 | | Day 2 | |
|---|---|---|---|
| *No* | *Movement pattern* | *No* | *Movement pattern* |
| A1 | Olympic lifting variant | A1 | Olympic lifting variant |
| B1 | Squat | B2 | Deadlift |
| C1 | Bench throw | C1 | Vertical pull |
| C2 | Horizontal pull | C2 | Horizontal push |
| | | | |
| | | | |

***Sprint & Jump***

-3 x Lateral hurdle jump into 10m sprint; 3 x 4, rest 2 min

-Diagonal bound; 3 x 3 each, rest 90 sec

-4-point reactive mirror drill; 4 set x <10 sec, rest 2 min

### 4.13 Block 13: Weeks 10- Transition

This is a self-regulatory training period. No specific training programming. Focus on aerobic compensation, mobility, and recovery. Emphasize good quality nutrition and athletic lifestyle. Stay in shape but without hard training. Very light strength sessions can be done, however the resistance and RPE needs to be low (4 to 5 / 10).

No speed, agility and plyometric training.

# 5 Strength training diary and RPE-questionnaire

***Diary platform***

| ***Movement*** | ***Weight x Repetitions*** | | | | |
|---|---|---|---|---|---|
| *No* | *Set 1* | *Set 2* | *Set 3* | *Set 4* | *Set 5* |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Mark the number of the movement on the left side column. Mark the weight used and the number of repetitions performed for each set. Using app-based strength training diaries is suggested. Less paperwork and the information is always easy to access.

***Example training diary***

| ***Movement*** | ***Weight x Repetitions*** | | | | |
|---|---|---|---|---|---|
| *No* | *Set 1* | *Set 2* | *Set 3* | *Set 4* | *Set 5* |
| A1 | 70kg x 5 | 72,5kg x 5 | 75kg x 5 | 70kg x 5 | 70kg x 5 |
| B1 | 100kg x 8 | 102,5kg x 8 | 105kg x 7 | - | - |
| C1 | 65kg x 8 | 67,5kg x 6 | 62,5kg x 8 | - | - |
| C2 | 80kg x 8 | 80kg x 8 | 80kg x 8 | - | - |
| D1 | 30kg x 30m | 32kg x 30m | 35kg x 30m | - | - |
| | | | | | |

***RPE-questionnaire***

| ***Session RPE*** | ***Athletes evaluation*** |
|---|---|
| *1 = Rest* | |
| *2 = Very light* | |
| *3 = Light* | |
| *4* | |
| *5 = Moderate* | |
| *6* | |
| *7 = Moderately hard* | |
| *8* | |
| *9 = Hard* | |
| *10 = Extremely hard* | |

# 6 Strength training movement bank

H = Horizontal movement pattern

V = Vertical movement pattern

DB = Dumbbell

BB = Barbell

DB/BB = Dumbbell or barbell

### *Main movements*

| Main exercises | | | |
|---|---|---|---|
| ***Lower body*** | | ***Upper body*** | |
| *Squat (Bilateral)* | *Deadlift/Hinge* | *Push* | *Pull* |
| Back squat | Sumo deadlift | H: Bench press | V: Pull-up |
| Front squat | Trap bar deadlift | H: Close-grip Bench press | V: Chin-up |
| Safety bar squat | Romanian deadlift (DB/BB) | H: Incline Bench press | V: Neutral-grip pull-up |
| Half squat | Hip thrust | H: Decline bench press | V: Close-grip pull-up |
| Hack squat | 45 degree Back extension | V: DB seated press | V: Close-grip chin-up |
| | | V: Landmine press | V: Feet assisted pull-up |

*Note: Use hack squats only during anatomical adaptation or hypertrophy blocks.*

### *Assistance movements*

| Assistance exercises | | | |
|---|---|---|---|
| ***Lower body*** | | ***Upper body*** | |
| *Squat (Unilateral)* | *Deadlift/Hinge/Hamstring* | *Push* | *Pull* |
| Split squat (DB/BB) | Lying leg curl | H: DB Bench press | H: Inverted row |
| Safety bar Split squat | Nordic curl | H: DB Incline bench press | H: DB bent over row |
| DB Bulgarian Split squat | 1-leg 45 degree Back extension | H: Push-up | H: Flat chest supported ez-bar row |
| Reverse lunge (DB/BB) | Valslide leg curl | H: Dip | H: Flat chest supported DB row |
| DB Walking lunge | 1-leg Valslide leg curl | V: 1-arm Landmine press | H: Incline chest supported ez-bar row |
| DB Lateral lunge | 1-leg glute bridge | H: Hands and feet evelated push-up | H: Incline chest supported DB row |
| DB Step-up | 1-leg DB romanian deadlift | | H: 1-arm DB row |
| DB Lateral step-up | | | H: Landmine row |
| DB Curtsy step-up | | | H: 1-arm standing low cable row |
| | | | H: Seated V-handle row |
| | | | H: Seated rope Face pull |

### *Core training*

| Linear movements | | Anti-rotational movements | | Med-ball core training |
|---|---|---|---|---|
| ***Dynamic*** | ***Isometric*** | ***Dynamic*** | ***Isometric*** | |
| Ab-wheel | Dragon flag | 1/2 kneeling Cable lift | Pallof press | 2-leg Forward rotational throw |
| Lying leg lowers | L-sit hold | Standing Cable lift | Pallof hold | 1-leg Forward rotational throw |
| Hanging leg raise | Stir-the-pot | Standing cable rotation pull | | 2-leg side pass |
| DB Farmer's walk | | | | 1-leg side pass |
| DB 1-arm Farmer's walk | | | | Overhead throw to wall |
| DB Offset Farmer's walk | | | | 1-leg Overhead throw to wall |
| | | | | Rotational med-ball smash |