4-24-2014

A periodized, 52-week training program for a women’s ice hockey team

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April 2014

Abstract

The job of a strength and conditioning professional is to improve athletic performance. A periodized training program can enhance athletic performance while minimizing the risk of injuries. Designing training programs to maximize performance for ice hockey players can be difficult because ice hockey is one of the most physically demanding sports. All of the components of fitness are important in hockey: muscle endurance, strength, and power, and high oxidative and glycolytic capacities. The purpose of this project was to examine the muscular and cardiovascular demands of a women's ice hockey team and design a 52-week, periodized training program to facilitate advantageous physiological adaptations. A review of the literature was conducted prior to the program design to determine the common muscular and cardiovascular demands. Research on women's hockey is limited so men's hockey was analyzed when necessary. A needs analysis summarized the findings from the literature. The primary muscle groups for skating include: hip abductors and adductors, gluteus maximus and minimus, the quadriceps and the hamstrings. Explosive muscular power is the most important aspect for hockey performance, which requires a solid strength base. Muscular endurance is also necessary to maintain peak performance for an entire game. The primary energy systems used on-ice are the ATP-CP and the glycolytic systems. The oxidative system must also be trained to facilitate rapid recovery between on-ice shifts. A 52-week, periodized training program was created to address the muscular and cardiovascular needs. The program is organized into three primary phases: preparation, competition, and transition. The mesocycles within the preparatory sub-phases gradually decrease in volume and increase in intensity and build off of the adaptations acquired in previous mesocycles. The emphasis during the competition phase is to maintain early strength and power gains. After peaking for the MIAC championships, a transition phase follows where no organized exercise is prescribed to facilitate full recovery. All training aspects of this periodized program were fully researched to ensure specific adaptations within the mesocycles.

STRENGTH AND CONDITIONING PROGRAM: ANNUAL PLAN

Anatomical Adaptations (Weeks 1-7)

The anatomical adaptation (AA) phase will establish a foundation for further strength training practices (Bompa & Haff, 2009). There are several goals within the AA phase: increase lean body mass, strengthen the tendons and ligaments, increase short term work capacity, and develop a neuromuscular foundation (Bompa & Haff, 2009). This phase will also develop balance between agonist and antagonist muscles, as well as between the two sides of the body (Bompa & Chambers, 2003). Developing adequate muscle balance, as well as laying a strong neuromuscular foundation, will decrease an athlete's risk of injury (Bompa & Haff, 2009). Increasing short term work capacity during the AA phase will reduce fatigue in the later stages of training (Bompa & Haff, 2009). This program is designed for a Division III women's ice hockey team, including players with minimal strength training experience. Therefore, the anatomical adaptations block will last approximately 7 weeks to ensure proper form and technique, and to establish a solid foundation upon which to build off of (Bompa & Haff, 2009). Within the anatomical adaptations phase, there are two sub-phases: general physical preparedness (GPP), and hypertrophy. GPP will focus primarily on increasing short term work capacity, while the hypertrophy phase will increase lean body mass, strengthen the tendons, and establish a neuromuscular foundation.

General Physical Preparedness (Weeks 1-3)

The GPP phase is three weeks long and will occur immediately after the postseason or transition phase. There are three strength training sessions and three energy system development (ESD) sessions each week, with the exception of week three, due to Easter break. The strength training sessions will consist of three different circuits, using 1-2 sets of 10-12 repetitions. Strength training intensity will remain between 50-60% of 1RM. The purpose of the circuits are to improve cardiovascular fitness and increase cardiovascular endurance by utilizing short rest periods to maintain an elevated heart rate throughout the entire circuit (Fleck & Kraemer, 2004). Circuit training is also an effective method of building muscular endurance (Zatsiorsky & Kraemer, 2006). ESD sessions will be between zones 5 and 6 of Bompa's training zone intensities (Bompa & Haff, 2009). ESD sessions will consist of biking, running, or rollerblading continuously, beginning at 20 minutes and progressing to 40 minutes by week 3.

Hypertrophy (Weeks 4-7)

There is a positive relationship between muscle cross-sectional area and muscle strength (Hunter & Harris, 2008). The hypertrophy sub-phase is designed to increase the amount of lean body mass, thereby increasing the force generating potential and providing a base for greater strength and power training (Bompa & Haff, 2009; Twist & Rhodes, 1993a). The players will follow an accepted method of stimulating hypertrophy, which utilizes three to six sets of ten to twelve repetitions per exercise (Baechle, Earle, & Wathen, 2008). Additionally, research suggests that the most effective way to increase muscle size is to perform three or more exercises per muscle group (Baechle et al., 2008). This continual stimulation of the muscle will increase recruitment of type II muscle fibers (Hedrick, 1995). This is important for hockey players because they rely more on type II fibers for power and speed during skating. This method of training will create a substantial increase in training volume for the duration of this four week block. In order to minimize the training volume while still providing adequate stimulus, the three weekly strength training sessions are designed as a split training program: lower body exercises will be performed during Lift 1, upper body exercises during Lift 2, and Lift 3 will be a total body lift. Lower body exercises include: back squats, lateral lunges, single-leg deadlifts, glute bridge, and calf raises. Upper body exercises consist of: bench press, lat pulldowns, dumbbell shrugs, close-grip bench press, and bicep curls. The total body lift includes: hex bar deadlift, incline dumbbell press, dumbbell step ups, one arm dumbbell rows, and single-leg squats. The use of multi-joint, large mass exercises (e.g. back squats, bench press, lunges, hex bar deadlift) enable fewer total exercises performed per day (Bompa & Haff, 2009). All lifts will consist of 3 sets of 12 repetitions, with short rest intervals (30 seconds to 90 seconds) between sets (Baechle et al., 2008). Using short rest periods, combined with 10-12 repetitions will result in significant increases in serum levels of human growth hormone (GH) (Kraemer, Vingren, & Spiering, 2008; Hedrick, 1995). GH is known to increase protein synthesis and may directly influence muscle strength (Kraemer et al., 2008). All strength training sessions should be separated by 24 to 48 hours to allow for adequate recovery (Stone, Stone, & Sands, 2007).

ESD sessions occur on the day in-between strength training sessions. The 3 ESD sessions will be submaximal, continuous exercise of biking, running, or rollerblading. Two of the ESD sessions during this phase will consist of "long reps" (Bompa & Chambers, 2003). ESD 1 will be 3 sets of 15 minute intervals will a 5 minute rest interval between sets. ESD 2 will be 2 sets of 25 minutes with a 5 minute rest interval. According to Bompa and Chambers (2003), long reps provide a better transition from training the aerobic to the anaerobic systems. Furthermore, during long rep training, the average velocity is higher and the average heart rate is between 168-174 beats per minute, compared to aerobic training, where heart rates remains between 156-164 beats per minute, (Bompa & Chambers, 2003). Using the age-predicted maximum heart rate (APMHR) formula, a 20 year old female hockey player has a maximum heart rate of 200 bpm. A heart rate of 168-174 bpm is between 84% and 87% of their APMHR (Reuter & Hagerman, 2008). At this intensity, the athlete would be working between 75% and 80% of their VO_{2max} (Reuter & Hagerman, 2008). This is below the maximal lactate steady state (85% of VO_{2max}), which will enable the athletes to maintain this intensity for the designated 15-25 minutes (Reuter & Hagerman, 2008). At a heart rate of 156-164 bpm, the athletes would be working between 65% and 75% of VO_{2max}. Therefore, the intensity of the long reps is a closer simulation to the demands of a hockey game, where on-ice oxygen uptake averages 90% of VO_{2max} (Twist & Rhodes, 1993).

Basic Strength (Weeks 8-11)

The purpose of this phase is to increase alactic strength. Strength is defined as the ability of the neuromuscular system to generate force against an external load or resistance and is a crucial component of power development; stronger athletes produce higher power outputs (Bompa & Haff, 2009). This phase will continue to build off of the anatomical adaptations phase by further developing the neuromuscular components necessary for muscular power (Bompa & Haff, 2009). Heavy resistance training can increase motor unit synchronization, reduce neural inhibition, lower motor unit recruitment thresholds, and increase motor unit rate coding (Bompa & Haff, 2009). Adaptations to these neuromuscular components can increase an athlete's ability to generate force and improve the rate of force generation (Bompa & Haff, 2009).

The exercises in this block are designed to increase total body strength and familiarize the athletes with basic power exercises and techniques. ESD sessions will be focused on alactic speed development, with one aerobic capacity session at the end of the week. This block is four weeks long and consists of four strength training sessions and three ESD sessions per week. The strength training sessions are increased from three to four sessions per week and organized into a lower body/upper body split routine to maximize muscular strength gains and ensure adequate recovery between sessions (Stone, Stone, & Sands, 2007; Bompa & Haff, 2009). Research is inconclusive about the optimal number of sets and repetitions for the greatest strength gains, but based on the available research, the NSCA promotes a range of two to six sets of six or fewer repetitions (Baechle et al., 2008; Fleck & Kraemer, 2003). Therefore, strength training sessions will consist of 4 sets of 6 repetitions for all core exercises during weeks 8 and 9, and 4 sets of 4 repetitions during weeks 10 and 11. Intensity will increase from 80% during week 8 to 87% by week 11. Core exercises include: back squats, single leg deadlifts, glute-ham bar lifts, bench press, chin ups, reverse lunges, and bent over rows. Basic plyometrics—squat jumps, medicine ball throws, and Russian plyos—are introduced within the strength training program to familiarize the hockey players with proper jumping and landing mechanics, as well as laying the foundation for power development. These plyometric exercises are to be performed immediately after the primary core lift, creating a complex training system. Complex training is performance of a strength exercise (i.e. back squat) followed almost immediately by a biomechanically similar power-type exercise (i.e. squat jumps) (Matthews, Comfort, & Crebin, 2010; Fleck & Kraemer, 2004). The goal of this method is to increase short-term power output through neural adaptations (Fleck & Kraemer, 2004). Although the exact mechanisms are not fully understood, the strength exercise appears to increase the inhibition of the Golgi tendon organs, resulting in greater power output during the power-type exercise (Fleck & Kraemer, 2004). It may also cause an increase in the activation of motor units, which may increase the rate of force development (Stone, Stone, & Sands, 2007). This effect is often referred to as a post-activation potentiation effect, or a potentiation complex (Stone, Stone, & Sands, 2007). Typical complex training utilizes loads of greater than or equal to 85% of 1RM for the strength exercise, followed by 30 to 45% of 1RM loads for the power-type exercise (Fleck & Kraemer, 2004). However, it is important that the initial strength movement does not create excessive fatigue (Stone, Stone, & Sands, 2007). Because this program is designed for Division III athletes who may be unfamiliar with heavy weight lifting, the load for the strength exercises will begin at 80% of 1RM during week 8 and progress to 87% of 1RM in week 11. This is designed to familiarize the athletes with complex training, as well as limit excessive fatigue.

Relaxation and prehabilitation exercises are also programmed within the strength training sessions to speed up recovery and prevent injuries (Zatsiorsky & Kraemer, 2006). These exercises target areas at an increased risk of injury for hockey players and include: neck slides, Cook hip lift, shoulder internal and external rotation, and isometric groin holds. In addition to helping to reduce the risk of injuries, these exercises will ensure the athletes are obtaining adequate interset rest. The guidelines for interset rest periods range from 2 to 5 minutes or 3 to 5 minutes (Baechle et al., 2008). Greater strength gains have been observed in athletes who rested 3 minutes between sets compared to resting for 30 seconds (Baechle et al., 2008). This is due to substrate availability and resynthesis. Complete ATP resynthesis does not occur until after 3-5 minutes of rest, and 84% of phosphocreatine (PCr) stores are replenished after 2 minutes of rest (Bompa & Haff, 2009).This program has a 2 minute rest period in between training blocks, but the prehabilitation exercises will add an additional 1-2 minutes between the strength-power complex. This will ensure adequate substrate replenishment, while keeping workout duration manageable.

Power Endurance (Weeks 12-15)

Power is defined as the amount of work performed in a period of time ($P = \frac{W}{t}$) and may be one of the most important factors in determining on-ice performance (Fleck & Kraemer, 2004). Hockey requires repeated, explosive start and stop movements, and few hockey players reach maximal speed (Barnes & Fry, n.d.). Acceleration, therefore, is more important to develop in hockey players than maximal speed (Barnes & Fry, n.d.). This phase of the program focuses on developing the players' power—and by extension, acceleration—through repeated, explosive, high intensity exercises. Explosive strength training can increase power production and acceleration by increasing Type II muscle fiber size and the ratio of Type II fibers to Type I fibers (Bompa & Haff, 2009). Explosive training will also increase acceleration and the rate of force development (RFD). A high RFD is important for hockey because players have a very short time period to generate high force and produce fast, explosive movements (Bompa & Haff, 2009). This program will last for 4 weeks with 4 strength training sessions and 3 ESD sessions per week.

Power can be increased through many different methods, but in essence, power output increases as the time an athlete takes to perform an exercise decreases (Fleck & Kraemer, 2004). To do this, power training uses lighter resistances and higher velocities. This can be brought about through 'traditional' power-type exercises—such as cleans, snatches, and pulls—or through stretch-shortening cycle exercises, like plyometrics (Fleck & Kraemer, 2004). Due to the training-intensive nature of Olympic lifting and because most Division III women are not familiar with them, this phase of the program will not utilize Olympic lifting for power development. Instead, the hockey players will perform body weight plyometrics after a heavy strength exercise. This method will induce the post-activation potentiation effect that was mentioned earlier, and lead to further increases in motor unit recruitment and RFD (Stone, Stone, & Sands, 2007; Dietz & Peterson, 2012). Strength exercises in this phase include front squats, bench press, hockey lunges, and a dumbbell incline bench press. The front squats on Monday and the bench press on Tuesday involve 4 sets of 2 repetitions, done as a cluster set. Athletes will perform 1 repetition at a 95% load, rest for 20 seconds, and then perform another repetition. Cluster sets enable an athlete to lift more weight for more repetitions than she would normally be able to in succession, which will recruit additional motor units without excessive fatigue (Dietz & Peterson, 2012; Stone, Stone, & Sands, 2007). The short rest period between repetitions partially restores the ATP-CP system so that each repetition can be performed with close to maximal force and velocity, or maximal power (Dietz & Peterson, 2012). Immediately after the cluster set, the athletes will perform a plyometric exercise using body weight or medicine balls. Exercises include: Russian Plyos, 45 degree jumps, power set ups, medicine ball chest passes, and medicine ball side throws. This format is a progression of the complex training methods first introduced in the previous phase.

Thursday and Friday will also use the complex training system, but the exercises will be performed for 4 sets of 4 repetitions at 83% of 1RM. This will increase the volume of work completed on Thursday and Friday compared to Monday and Tuesday. Intensity will also decrease from early in the week to later in the week. This forms an undulating periodization model within the microcycle. Athletes will have the weekend to recovery from the higher volume and be ready to increase their intensity early in the week (Dietz & Peterson, 2012).

There are three ESD sessions per week. Tuesday and Friday are high-intensity bike intervals. Tuesday's workout consists of 6 to 8 repetitions of a near-maximal intensity sprint for 30 seconds with a rest interval of 2 minutes. Target heart rate is between 182-186 bpm, which is 91-93% of APMHR (Reuter & Hagerman, 2008). Friday's workout is six repetitions of one minute, high-intensity bike sprints with a rest interval of 2-3 minutes. Target heart rate is 176-182 bpm, or 88-91% of APMHR (Reuter & Hagerman, 2008). The duration of the bike intervals and the rest periods are designed to closely mimic the shifts during a hockey game, which last an average of 45 seconds (Twist, 2007; Twist & Rhodes, 1993). The intensity is also specific to competition intensity. At 92% of APMHR, the hockey players are working at approximately 85% of their VO_{2max} (Reuter & Hagerman, 2008). During a hockey game, the on-ice oxygen uptake averages 90% of VO_{2max} (Twist & Rhodes, 1993). By utilizing training modes that closely mimic a hockey game there will be a greater performance improvement (Baechle et al., 2008). The ESD session on Saturday is an active recovery session. Players will perform a 15 minute dynamic warm up, followed by a 15 minute bike ride. Target heart rate is 150 bpm, which is 75% of APMHR. At this intensity, players will be working around 60% of VO_{2max} (Reuter & Hagerman, 2008). Active recovery that consists of light, aerobic-type activity with stretching facilitates blood flow and the removal of metabolites that may have accumulated during the week (Jeffreys, 2005). These sessions will also restore muscle length and function (Jeffreys, 2005).

Triphasic (Weeks 17-27):

The theory behind triphasic training is that all dynamic muscle actions consist of three phases: eccentric, isometric, and concentric (Dietz & Peterson, 2012). If only the concentric movement is trained, athletic movement and performance will be limited by the weaker eccentric and isometric movements. Therefore, the purpose of the triphasic phase is to individually develop and strengthen all three movements in order to create a strong link between the phases of dynamic movements and optimize performance (Dietz & Peterson, 2012). For Division III women's hockey players, only the lower body will be trained with triphasic means. There are three primary reasons for this. First, the fitness levels and work capacity of the athlete must be very high (Dietz & Peterson, 2012). Most Division III athletes have a limited training background, and would not meet the fitness demands of triphasic training. Second, skating is the most important skill in ice-hockey and skating primarily uses the lower body (Bracko, 2004). Finally, the main goal of triphasic training is to train the nervous system (Dietz & Peterson, 2012). The nervous system encompasses the entire body, so by training the legs triphasically, the athletes are also inducing similar neurological changes in their upper body, without the added stress (Dietz & Peterson, 2012).

Each phase of triphasic training is two weeks long, with a download or light week in between. The 9 weeks of triphasic training will also use undulating periodization within the microcycle. Monday will be a submaximal, medium intensity day, Wednesday will be a low volume, high intensity day and Friday will be a high volume, low intensity day. Varying the training loads on a day-by-day basis prevents premature accommodation to training stimulus (Zatsiorsky & Kraemer, 2006). Furthermore, the athletes have Saturday and Sunday off, which will allow for 72 hours of recovery between stressors (Dietz & Peterson, 2012). The 72 hour rest period also means that the athletes can be slightly overreached by the end of the week without harmful effects (Dietz & Peterson, 2012). After the athletes have been slightly overreached for two weeks, they will have a download week, which will be discussed later on in greater detail. The combination of slight overreaching with a download week enhances the supercompensation effect and increases performance (Dietz & Peterson, 2012).

The ESD sessions for the triphasic phase will be on Tuesdays and Thursdays and follow the same format for all three phases. ESD sessions begin with a circuit of plyometrics and agility ladders, followed by a medicine ball circuit, and ending with cone agility drills and speed work on Tuesday and anaerobic sprints on Thursday. Plyometric exercises consist of a rapid deceleration of the body, followed immediately by acceleration in the opposite direction. This movement pattern utilizes and develops the stretch-shortening cycle, which will increase the amount of force that can be produced at a high velocity (Wathen, D. 1993). The plyometric program consists of box jumps, skater jumps, and hurdle hops, beginning with double-leg and progressing to single-leg. The plyometric exercises will be alternated with agility ladders. A medicine ball circuit will follow the plyometric block. Medicine ball training is beneficial for sports that require rotational power—such as ice hockey—because medicine ball training more closely imitates the range of motion and velocities required for ice hockey (Earp & Kraemer, 2010). Medicine ball training is most effective when performed with other, high-velocity movements such as plyometrics (Earp & Kraemer, 2010). The medicine ball block consists of forward, side, and overhead passes to a partner using double and single-leg stances. The plyometric and medicine ball work will focus on single-leg drills because up to 85% of time during the first 3 to 4 acceleration strides of skating is spent on one leg (Twist & Benicky, 1996). Medicine ball lateral twist and overhead sit-up tosses are also included to strengthen the trunk musculature and improve trunk rotational power (Potach & Chu, 2008). Tuesday’s session ends with agility drills designed to increase lateral movement speed and explosiveness. In ice-hockey, initiating a change of direction typically begins with a lateral movement (Twist & Benicky, 1996). In order to develop lateral explosiveness, the drills will be performed only 3 times, with adequate rest in-between. The distance between the cones will also be kept to 2 or 3 strides so that athletes can focus on being quick and explosive (Twist & Benicky, 1996). Thursday's session will end with 10 sets of 15 second maximal sprints to further develop anaerobic capacity.

After the three primary phases of triphasic training, a two week high force at high velocity—or power—phase is included as an extension of the triphasic training methods (Dietz & Peterson, 2012). The triphasic training phase will start at the end of July and the power phase will conclude one week prior to the start of the season, allowing for a recovery week before try-outs. Every dynamic movement starts with an eccentric muscle action; therefore, the eccentric phase is trained first (Dietz & Peterson, 2012).

Eccentric Phase (Weeks 17-19)

The purpose of the eccentric phase is to improve the hockey players' abilities to absorb greater amounts of force. This is important for improving the movements associated with rapid on-ice deceleration in preparation to change directions. To improve the eccentric movement phase, the exercises are designed to develop the stretch reflex and the stretch-shortening cycle (SSC) (Dietz & Peterson, 2012; Fleck & Kraemer, 2004). The stretch reflex is composed of two proprioceptors: muscle spindles, which act as neuromuscular stimulators, and Golgi tendon organs (GTO), which are the neuromuscular inhibitors (Dietz & Peterson, 2012). One of the goals of the eccentric phase is to maximize the excitatory response of the muscle spindles and minimize the inhibitory GTO response (Dietz & Peterson, 2012). The increased stretch reflex response from the muscle spindles will allow an athlete to absorb more energy eccentrically (Dietz & Peterson, 2012). This is where the SSC comes in. The SSC dictates that the amount of energy an athlete absorbs is stored within their muscles and tendons and is used during a concentric movement (Dietz & Peterson, 2012). This is an application of Newton's second law of motion: the greater the intensity of the eccentric contraction, the greater the concentric force produced (Dietz & Peterson, 2012).

The eccentric phase of this program consists of three, total body lifting sessions and two ESD sessions, which were described earlier. Lifting sessions will use 3 sets of 3-5 repetitions with intensities ranging from 75-80% of 1RM. The eccentric specific work utilizes large, compound exercises with a 6 second eccentric movement. The increased time under tension enables the muscle spindles and GTO to adapt to the high stress (Dietz & Peterson, 2012). Eccentric training taxes the athlete's nervous system and requires the athletes to handle high levels of stress; therefore, the eccentric specific work is only performed at the beginning of a workout (Dietz & Peterson, 2012). The lifts performed eccentrically are the back squats on Monday and front squat on Friday. The eccentric lift on Monday and Friday is immediately followed by a plyometric jump, a drop set such as a weighted squat jump (30% of 1RM), and another plyometric or an accelerated plyometric. This exercise order creates what is known as a French contrast method, and is a progression of the complex training the hockey players are doing in earlier phases. The French contrast method is a combination of complex and contrast training methods designed to maximize explosive strength and speed endurance (Dietz & Peterson, 2012). The French contrast imposes a much greater stress on the athlete compared to just complex or contrast training, which forces the anaerobic work capacity to increase (Dietz & Peterson, 2012). This will increase the physiological adaptations of the energy systems without the added volume of traditional anaerobic training, such as sprints.

Wednesday is the high intensity, low volume day. The core exercises will be performed for 3 sets of 3 repetitions at 85% of 1RM with no eccentric focus. The higher loads will impose a great enough stress on the athletes without the eccentric means (Dietz & Peterson, 2012). These exercises should instead be performed with a reactive focus so that athletes continue to increase power development (Dietz & Peterson, 2012).

Isometric Phase (Weeks 20-21)

The purpose of the isometric phase is to train the muscles to maximize the force transfer between the eccentric and concentric contractions (Dietz & Peterson, 2012). Motor unit recruitment and rate coding are the two primary neurological aspects trained in the isometric phase (Dietz & Peterson, 2012).

Hockey players need to be able to be able to quickly decelerate, stop, and accelerate in the opposite direction at very high speeds. This movement requires absorption of high eccentric forces, followed by a rapid concentric movement. The high forces involved require activation of the large motor units that innervate Type II muscle fibers; if the athletes are unable to quickly recruit their Type II muscle fibers, the transition from decelerating in one direction to accelerating in the opposite direction will be slow (Ratamess, 2008; Dietz & Peterson, 2012).

Motor unit recruitment is dictated by the size principle; as muscle force increases, larger motor units are recruited (Ratamess, 2008; Bompa & Haff, 2009). Isometric training will increase the number of large motor units recruited, as well as the speed at which they can be activated (Dietz & Peterson, 2012). This neurological adaptation will increase the amount of force that can be absorbed into the stretch reflex and SSC from the eccentric contraction (deceleration), and result in a higher RFD (Ratamess, 2008; Dietz & Peterson, 2012).

Rate coding is the second neurological aspect trained during the isometric phase and its primary job is to quickly build enough intramuscular tension (force) to overcome an external load (Dietz & Peterson, 2012). The nervous system increases the frequency of action potentials sent to the alpha motor neuron, which increases the amount of tension within the muscle and can eventually cause maximal force production (Dietz & Peterson, 2012). Specifically training this neurological factor will improve the athletes' response times; they will be able to stop high eccentric forces quickly and increase the amount of energy stored in the SSC and stretch reflex (Dietz & Peterson, 2012).

This program utilizes "resisted load isometrics" as the primary means of isometric training (Dietz & Peterson, 2012). The athletes will perform a dynamic movement, using a medium to high load, with a 6 second isometric hold between the eccentric and concentric phases (Dietz & Peterson, 2012). The joint angle for the isometric hold should be specific to hockey to ensure maximum transferability (Dietz & Peterson, 2012). In the double-leg propulsion, hips are flexed to 30 and the knees to 50 (Manners, 2004). However, faster skaters tend to have greater knee-flexion (Moeller & Bracko, 2004). Using the back squat as an example, hockey players should hold the position at a knee angle between 50 and 90 degrees to ensure maximum transferability.

Players will perform three, total body lifting sessions per week and have two ESD sessions per week. The isometric phase follows the same undulating periodization within the microcycle as described above. Lifts on Monday (80% 1RM) and Wednesday (87% 1RM) consist of 3 sets of 3-5 repetitions. Friday is a high-volume day and uses 3 sets of 8 repetitions at 73% 1RM. The isometric lifts are the back squat, glute-ham bar lifts, and rear-foot elevated split squats.

Concentric Phase (Weeks 23-24)

The primary goal of the concentric phase is to maximize explosive strength and RFD, which ultimately leads to increased performance (Dietz & Peterson, 2012). The concentric phase focuses on improving both intra- and intermuscular coordination (Dietz & Peterson, 2012). The intramuscular factors—motor unit recruitment and rate coding—have been previously described. The only difference is that the intramuscular factors will now be trained to respond to concentric contractions (Dietz & Peterson, 2012). The two intermuscular factors are inhibition/disinhibition and synchronization (Dietz & Peterson, 2012).

Rapid concentric contraction of the agonist muscle triggers a protective mechanism that causes an eccentric contraction of the antagonist muscle (Dietz & Peterson, 2012). This eccentric contraction is designed to decelerate the speed and force of the concentric contraction to protect the joint and to prevent the antagonist muscle from tearing (Dietz & Peterson, 2012). This protective mechanism tends to be overprotective and can be safely detrained without causing injury. Training with explosive concentric movements can inhibit the antagonist muscle, resulting in maximal RFD (Dietz & Peterson, 2012).

Synchronization is perhaps the most important intermuscular factor trained in all of triphasic training. Synchronization is the ability to coordinate all of the previously mentioned neuromuscular mechanisms—Golgi tendon organ, stretch reflex, SSC, rate coding, RFD, and motor unit recruitment—into a smooth, explosive, dynamic movement (Dietz & Peterson, 2012). The concentric phase is where all of the individual neurological aspects trained in the previous phases come together.

The concentric phase is set-up similarly to the eccentric and isometric phases: 3 total body lifting sessions and the 2 previously described ESD sessions. The undulating periodization method will still be used during the concentric phase. Monday and Wednesday will use 3 sets of 3 repetitions with intensity ranging from 80-90% 1RM. Friday will have 3 sets of 8 reps at 75% 1RM. Regardless of the intensity, the goal of the concentric phase is to move the weight as fast as possible to maximize intermuscular coordination, motor unit recruitment, and force production (Dietz & Peterson, 2012).

Power Phase (Weeks 26-27)

This primary goal of the power phase is to integrate the neuromuscular factors developed throughout the three triphasic training phases and use them to increase power output. The standard force-velocity curve of a concentric muscle action indicates an inverse relationship between force and velocity (Plisk, 2008). This suggests that the highest power output of an athlete would occur around loads of 50% of 1RM. However, this curve is true only for a maximally activated muscle and does not factor in components of dynamic movements, such as the series elastic component (American College of Sports Medicine, 2010; Dietz & Peterson, 2012). In 2000, Dr. Komi published a new force-velocity curve that factored in the SSC. This new curve indicates that high forces can be produced at high velocities, which leads to increased power output (Komi, 2000; Dietz & Peterson, 2012). Dr. Fred Hatfield had a similar result when he tested athlete's power production at varying loads (Dietz & Peterson, 2012). According to Dr. Hatfield, the optimal training zone for increasing power production uses loads between 55% of the athlete's 1RM to 80% of 1RM (Dietz & Peterson, 2012). This range maximizes the SSC and facilitates the highest power outputs, as well as high rates of force development; loads below 55% of 1RM are too light to generate high power outputs and loads above 80% of 1RM are too heavy and decrease movement velocity and power output (Dietz & Peterson, 2012). Therefore, this program will utilize intensities ranging from 65% to 77% of 1RM. The primary lifts are the front and back squats and GH bar lifts. These will be performed for 3 to 4 sets of 3 to 6 repetitions. Although the load range means that the athletes will be able to perform more repetitions, the focus is on the quality and the speed of movement (Dietz & Peterson, 2012; Plisk, 2008). Every exercise—core and assistance—should be performed at high velocities to accentuate the SSC (Dietz & Peterson, 2012). Band lunge jumps, power step ups, hurdle hops, and split squat drop jumps are other assistance exercises that are specifically designed to increase the SSC and RFD. The power phase will have 3 lifting sessions and 2 ESD sessions per week and it will follow the same undulating periodization as the previous three triphasic phases. All plyometrics in the ESD sessions will be reactive to further emphasis development of the SSC and increase RFD.

A specialized method of this high force at high velocity training will utilize timed drop off sets. The back squat on Wednesday will be performed for up to six sets of 2 repetitions at 77% of 1RM and will use a timed drop off. The athlete will perform 2 reps of the back squat as fast as possible with correct technique. Another athlete or coach will time every set. The athlete will continue to repeat the sets—with a 1:15min rest period—until a 5% drop off from the athlete's best time is reached, or the athlete performs all 6 sets. This will motivate the athletes to push themselves and try to attain high movement velocities, but it also minimizes neural fatigue. Once a 5% drop off in time has been reached, the athlete is done with that lift for the day.

Download Weeks (Weeks 16, 19, 22, 25, & 28)

There are several recovery and regeneration microcycles integrated into this program after macrocycles of planned overreaching. Performance decrements and mild overtraining symptoms—fatigue—will be the primary effect after these weeks and an unloading week is necessary to dissipate this fatigue (Bompa & Haff, 2009; Stone, Stone, & Sands, 2007). Proper management of fatigue results in physiological compensations that elevate preparedness and preparation (Bompa & Haff, 2009). This regeneration period is called the period of delayed transformation, and results in the phenomenon of supercompensation, a regeneration of muscle tissue and energy substrates to levels above and beyond the athlete's previous levels. (Dietz & Peterson, 2012; Bompa & Haff, 2009; Zatsiorsky & Kraemer, 2006). Recovery weeks are achieved by decreasing intensity, density, and/or frequency of training (Bompa & Haff, 2009). The download weeks for this program will have two training sessions at 63% 1RM, which is a decrease from three sessions at 80% 1RM. Sessions will also incorporate a longer dynamic warm up before the training session and stretching and foam rolling after. If athletes are feeling very fatigued, the program can be modified to include other recovery techniques such as: pool workouts, sitting in a sauna, and warm or cold water immersion (Bompa & Haff, 2009).

In-Season (Weeks 30-45)

The primary goal of in-season training is to maintain the physiological adaptations acquired in previous phases, while focusing on peaking for the MIAC championships at the end of February. Games during the season are played back-to-back against the same team, with one on Friday night typically held at home and the away game on Saturday afternoon. In-season games are important because entrance into the MIAC play-offs is determined by the regular season record, however; it is not possible to peak for every game. Players will train through most games in the regular season. In-season workouts will be held on Mondays and Wednesdays to allow for two unloading days in order to dissipate fatigue prior to the games. Taper will occur during the last two weeks of the regular season, which will increase performance for the last two games.

The exercises during in-season are designed to limit additional fatigue, while still providing an adequate stimulus to maintain strength and power levels accumulated during the pre-season training (Wathen, Baechle, & Earle, 2008). Players will lift two times per week during the in-season, which is the recommended training frequency during the competitive phase (Gamble, 2006). The NSCA recommends increasing training intensity and decreasing training volume during the competitive phase (Wathen et al., 2008). However, other research suggests that this low volume/high intensity method may not provide sufficient stimulus for power sports athletes to maintain lean body mass (Gamble, 2006; Allerheiligen, 2003). One recommended method to combat this problem is to use multiple mini-microcycles lasting 2 weeks long and mimicking the preseason microcycles of strength, power-endurance, and power (Gamble, 2006; Allergeiligen, 2003). Average intensity should remain around 80% of 1RM to maintain strength levels (Gamble, 2006). Primary exercises during the in-season phase consist of progressions/regressions of split squats, single-leg deadlifts, bench press and bent over rows. Sets and repetitions range from 3-5 sets of 3-8 repetitions, depending on the primary goal of the mini-microcycle. Power exercises—box jumps, Russian plyos, hang cleans, and power step-ups—are included at the beginning of each workout and intermittently throughout the lifting session. Exercises will alternate between upper and lower body between sets to minimize fatigue as well as the time spent in the weight room. All ESD will occur during practices.

Taper (Weeks 46-47)

The primary goal of the taper period is to elevate performance in preparation for a major competition—in this program, the MIAC play-offs (Bompa & Haff, 2009). Tapering is the best method of stimulating supercompensation and elevating the athletes' performance prior to a major competition (Bompa & Haff, 2009). The taper period should last from 8 to 14 days and have a reduction in training volume and intensity (Bompa & Haff, 2009). For team sports, the training volume during the first taper microcycle should be reduced to obtain an unloading effect, and intensity should also be reduced to 50-60% of 1RM (Bompa & Haff, 2009). Volume and intensity should continue to be reduced during the second taper microcycle, with a greater reduction in volume than intensity (Bompa & Haff, 2009). Tapers that lead to a 75% reduction in training volume have been shown to optimize the taper effects, while maintaining a higher intensity sustains the preseason and in-season performance adaptations (Bompa & Haff, 2009).

The taper phase of this program consists of 3 sets of 3 repetitions for the 3 primary lifts, which are: skater jumps, push-ups + partner medicine ball drop pass, and a dumbbell crossover lunge step. Between the sets of each exercise are different prehabiliation exercises to facilitate full recovery and provide adequate rest between the primary exercise sets. Volume during the first taper microcycle drops from 120 repetitions to 36 repetitions, which is a 70% reduction in training volume. During the second microcycle, volume drops even further to 24 repetitions, equating to an 80% reduction from in-season training volume. Intensity also drops from 80% of 1RM during the in-season to 65% and 60% of 1RM during the first and second taper microcycles, respectively.

Peaking (Weeks 48-49)

Peaking results in optimal performance if it is performed before only two or three competitions (Bompa & Haff, 2009). If a program attempts to peak the athletes before every competition, further enhancements in training will be neglected and the athletes will not reach their full training potential (Bompa & Haff, 2009). This program will taper for the MIAC Quarter- and Semifinals, and continue through the MIAC championships if the team makes it that far. Based on the record of previous seasons, reaching the NCAA play-offs is unlikely. The taper and peaking phases can be altered if necessary to accommodate the NCAA play-offs. There are no scheduled lifting or ESD sessions during the peaking phase in order to minimize fatigue and maintain the high performance developed through the taper weeks. Instead, players will come in for a recovery-type workout that will consist of an extended, low-intensity warm-up, 10-15 minutes of no-resistance cycling, and some stretching and foam rolling.

Active Rest (Weeks 50-52)

The active rest or transition phase comprises the last three weeks of this year-long training program. This phase is designed to provide a break between the high-volume and high-intensity training that is performed for the rest of the year (Graham, 2002). The primary goal of the transition phase is to recover both physically and mentally from the stress of training and competitions (Graham, 2002). Athletes should focus on rest and nutrition, as well as recovering from any lingering injuries remaining from the season. Activities performed during this phase should consist of unsupervised, low volume and low intensity exercise in the form of recreational games and activities (Graham, 2002). This physical and mental break will not only dissipate any lingering fatigue from the competitive phase, but will also prepare the athletes for next season.

Conclusion

This program is designed to meet the needs of a Division III collegiate women's ice hockey team. All phases of this program have been carefully researched and organized to create a safe and effective program that will improve performance. As a strength and conditioning coach, it is important to continually evaluate the effectiveness of the program through testing, injury reports, and results from games and player feedback throughout the training program. The primary goal of this program is to prepare the hockey players for their season through increasing strength, power, and anaerobic capacity, while reducing the risk of injury.

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