Opinion

Training for hockey players during a pandemic: How should hockey players train during COVID-19 quarantines?

Abstract

Objectives: The purpose of the paper is to highlight and demonstrate how to train, specifically for hockey players, while in a COVID -19 quarantine. Moreover, without access to training facilities and very limited equipment, what should players focus on during this time of societal shutdown. This paper will discuss physiological adaptations beyond simply localized muscular strength and "hockey specific" modalities. Rather, focused literature highlighting effects building a physiological base for return to play will be further discussed. Furthermore, expanded literature and application on oxygen consumption, lactate threshold, work capacity, heart rate deceleration/recovery and injury prevention will be highlighted.

Search Methods: A search was conducted on the wide-body of research that exists in and around the skeletal muscle and sports performance and aligns the research in a clear manner, specifically describing the physiological response of various training to the hockey players, particularly in this time of quarantine. Literature gathered involved trails of comparative analysis with control groups in various exercise settings.

Main Results: In an attempt to demonstrate the goal of training during a time with no access to training facilities and very minimal equipment, the purpose of this paper is to demonstrate and describe how aerobic training during this societail shut down might be the best way to prepare their body when players can return to traditional training and on ice play. The present paper identifies each adaptation specific to the training modality to clarify the scientific evidence for the sport practitioner.

Keywords: Aerobic training, Muscle adaptations, Lactate threshold, Hockey, Repeat bouts

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Abbreviations: ATP, ddenosine triphosphate; PCr, phosphocreatine; LT, lactate threshold

Introduction

Hockey players all over the country are in a unique situation that has never been dealt with before; how to train for the game of hockey in a mandated shutdown during a pandemic. Without typical resources and training equipment, players are left on their own to train and condition. Many of which have a limited knowledge base to develop their own training programs. However, there may be one very simple answer to the question; Aerobic/Steady State training. That's right, tie up your shoes and run players! In today's game of hockey, many current coaches have shunned at the thought of their player's training aerobically. "For most young hockey players, college age or younger, distance running is a waste of time and energy," says an exercise physiologist and writer for *Let's Play Hockey* magazine. The term aerobic, distance, or endurance training have been the near equivalent to four letter expletives in hockey circles. But why?

Ice hockey is a game characterized by high intensity competitive shifts, followed by short intermittent recovery periods. Normal competitive shift lengths range from 30 to 60 seconds. Shifts are followed by recovery periods generally lasting 80 seconds or more depending on each player's specific role to their team. Therefore the game itself comprises anaerobic bouts, leading most to assume there is no place for aerobic training. "Young athletes should focus on other attributes like speed, power, agility, coordination, strength, and hockey skills," claims the writer for *Let's Play Hockey*. However, why do cross-country runners incorporate resistance training and sprint training in their training regimes? One could argue that these sorts of training methods are a waste of time and energy for distance runners. But do these athletes recognize something that most team sports don't by training all muscle fibers and energy systems?

This mindset, combined with our nation's pandemic, many players are striving for ways to train, while feeling isolated. In our countries 'stay at home orders,' players are very limited in terms of training. With closures of training facilities, social distancing parameters mandated, our current societal shutdown is limiting the majority forms of "hockey specific" training. Players are not being allowed to train in ways they have traditionally been exposed to and those modalities that many have deemed as the "gold standard." However, this shutdown may have a very significant silver lining; *the opportunity to focus on aerobic (steady state) training… something once shunned upon by many players, coaches and trainers.*

The ensuing pages will answer the need for aerobic conditioning in hockey training programs, and help decipher what this type of training will provide players when the pandemic lifts.

Review of literature

Physiology of aerobic training

Aerobic training, otherwise known as oxidative phosphorylation happens when an activity such as running, biking, or skiing is carried out. According to the American College of Sports Medicine (ACSM) aerobic conditioning "uses large muscle groups, and can be maintained continuously and is rhythmic in nature."

Physiologically, in aerobic activity, ATP production occurs in the mitochondria, which contains the appropriate enzymes for oxidative phosphorylation. The ATP production is caused because of the multifaceted interaction between the Krebs cycle and the electron transport chain. The Krebs cycle's role is to complete the oxidation of the substrates obtained from food and form NADH along with FADH to be entered into the electron transport chain. The electron transport chain then converts NADH and FADH into ATP and water. The water is a result of oxygen-accepting electrons; for this reason we breathe oxygen to be used as the acceptor of electrons in aerobic metabolism.[1-3]

Physiological demands of hockey

The game of hockey, as mentioned previously, consists of short all out bouts/shifts lasting from 25-60 seconds. However, as the game is now evolving, on ice bouts/shifts have been recorded as long as 90-120 seconds. Recovery time generally lasts 60-120 seconds, but again, resting intervals have been noted to fall well short of the general 60 seconds in duration. Given the parameters of the game, it can comfortably be labeled according to Siff,[4] as an anaerobic lactate sport. The label of anaerobic lactate defines hockey as a sport in which high intensity intervals are repeated that accumulate lactate, with phosphocreatine (PCr), adenosine triphosphate (ATP), and glycogen as the primary means of energy.[4]

Provided the nature of the game, the intermittent high intensity bouts not only provide the sport with the anaerobic label, but also the intensity of the working bouts disrupts the homeostasis state of the body. Following high intensity shifts found in hockey, most significantly disruptive to the athlete are the depleted stores of ATP/PCr used to fuel powerful short bursts of energy. Additionally, when shifts last longer than a few seconds, anaerobic glycolysis also fuels the body with energy.[5] The end result of anaerobic glycolysis metabolically is the increase of H^+ concentration and the reduction of pH, which will adversely affect sport performance.[3,6,7] Upon completion of a hockey shift, ATP/PCr levels generally are incompletely replaced, before the athletes are required to return to the ice. Therefore, ATP/PCr stores compoundly decrease as the game progresses, and an intensified dependence on anaerobic glycolysis will be utilized as the game progresses.[8]

Physiclocal recovery of hockey

The intermittent style of hockey allows players to rest and recover in between shifts. Recovery bouts allow for very important periods of restoration before completing the next shift. It is in the recovery interval, where contracting muscles return to their pre-exercise state and at least some of the ATP/PCr is restored. During recovery is where many important functions take place. First oxygen consumption is elevated to aid the restoration of the body to homeostasis. This time period of heightened oxygen consumption beyond what is required at rest is what is known as excess post-exercise oxygen consumption or EPOC. It is during EPOC where ATP/PCr is replaced. The rate of the replenishment is dependent on the rate of oxidative metabolism inside the contracting skeletal muscle. Therefore, with little or limited circulation, PCr stores are only minimally restored.[8]

Beyond the ATP/PCr stores becoming depleted during ice hockey shifts, lactate is also obviously produced. However, it is in the recovery bout where the capacity to tolerate and/or get rid of H^+ ions that may be saturating the contracting skeletal muscle is important. The ability for the body to clean itself of lactate during recovery is dependent on particular buffers. PCr, inorganic phosphate, protein-bound histidine residues, and carnosine, are significant inter-muscular buffers of lactate. Once lactate has reached the blood, it is buffered out via sodium bicarbonate. Roughly 65% of the lactate is converted into pyruvate, via the enzyme lactate dehydrogenase (LDH), where is aerobically metabolized via the Krebs cycle and the electron transport chain. The remaining 35% of the lactate is converted to glucose, excreted, or converted to protein. Lactate metabolization primarily occurs within skeletal muscle, predominantly in slow twitch muscle fibers. It is very important for the body to restore itself, especially restoration of skeletal muscle. Restoration levels heavily affect power outputs, and therefore, one's ability to perform athletically at a greater level.[8]

As summed up by Tomlin & Wenger,[8] "The ability to perform maximally on repeated exercise bouts is influenced by the nature of both exercise and recovery periods. Generally, the more that exercise disrupts homeostasis the greater the effect on recovery metabolism. The more complete these restorative processes, the greater the ability to generate force or maintain power on subsequent work intervals."

With the information given in the previous paragraphs, and misinterpreted by many current hockey coaches, it is clear that aerobic pathways have the ability to play a very important role within hockey, an anaerobic lactate sport. And provided the societal shutdown and stay at home orders, now is a great time to partake in aerobic based training. Research by Tomlin & Wenger,[8] explain the function that aerobic pathways have in the recovery in sports such as hockey, "*Theoretically, an increase in aerobic fitness could enhance recovery from anaerobic performance both by supplementing anaerobic energy during the exercise and by providing aerobically derived energy at a faster rate during the recovery period. Additionally, any improvements that aid in transport to or from the muscle, such as increased blood flow, could enhance the removal of lactate H^+ and heat.*"

Research by Thoden,[9] poses the notion that athletes with higher aerobic fitness capacities could enhance their body's ability to recover from the intermittent anaerobic type performances. He mentions *"an increase in aerobic fitness could enhance recovery from anaerobic performance both by supplementing anaerobic energy during the exercise and by providing aerobically derived energy at a faster rate during the recovery period.*" Given that information, enhancements of muscle blood flow will also have the ability to buffer lactate and remove heat during recovery.

To summarize much of the research claims, aerobic conditioning has a relatively substantial role even in anaerobic type settings. First, aerobically trained athletes have been shown to consume higher levels of oxygen during intermittent intervals. Therefore, by consuming more oxygen, this may reduce the dependence on anaerobic glycolysis, and limiting lactic acid production equating less H^+ and higher athletic performance.[10] Secondly, due to an elevated VO_{2max}, aerobically trained athletes consume more oxygen during bouts than untrained. Consequently, VO_2 is heightened at the beginning of the recovery bout resulting in the likelihood of a faster EPOC. A faster EPOC results in one's ability to replenish ATP/PCr sooner, and therefore return to play at a higher more powerful level.[10] Lactate removal is also a benefactor of athletes being aerobically trained. Research by Oyono-Enguelle et al.,[11] found aerobically trained subjects reach their peak lactate level more quickly than untrained during EPOC, therefore causing a swifter flushing of lactate from the contracting skeletal muscle in trained subjects. Finally, research by McCully, et al.,[12] documented higher rates of PCr resynthesis in aerobically trained individuals following repeated exercise bouts than of untrained. These findings have been associated with improved power recovery, a very advantageous characteristic during hockey.

Aerobic training and injury

Injury rates have also been reduced with the association of aerobic fitness. Research conducted on military cadets by Kaufman, et al.,[13] correlated aerobic capacity to the reduction of basic training injuries, as well as future "overuse" injuries. According to Kaufman et al.,[13] military cadets holding low levels of physical fitness were more likely to sustain injury during training. "To reduce injuries and maintain fitness of Marine recruits, the San Diego MCRD conducted a training intervention trial. The intervention included reducing the amount of running miles, gradual build-up of exercise and military hiking, and emphasis on aerobic activities in early training phases…Evaluation of this intervention demonstrated a significant reduction in all over use type injuries."[13]

Aerobic training and concurrent strength

Hockey players also often feel strength gains will be compromised due to the influence of aerobic conditioning. Documented research in a review by Elliott, et al.,[14] stated, "on trained individuals… power development is impaired when training incorporates a moderate to high degree of sustained aerobic exercise." Research by McMillian, Helgerud, & Hoff,[15] to dispute the review, found no negative correlations of strength, jumping ability, or sprint performance when soccer players were subject to 10 weeks of Aerobic training. Results of McMillian et al.,[15] provided concrete data to support that aerobic training will lead gains such as heightened $VO_{2\ max}$ and not decrease any strength or sprinting capacities, an issue that will be discussed later in the ensuing pages.[16]

Aerobic training and heart rate recovery

Increased heart rate during exercise is the result of decreased parasympathetic activity and increased sympathetic activation.[17,18] The decline of heart rate after exercise is due to the reactivation of the parasympathetic nervous system.[18,19] Specifically, HRD is a result of vagal reactivation, previous research links physical fitness, operationally defined by VO_{2max}, with HRD. Goldsmith, Bigger, Bloomfield, and Steiman[20] and Goldsmith, Bloomfield, and Rosenwinkel[21] show a relationship between vagal activation and modulation with maximal oxygen uptake in healthy males when age was controlled. The relationship between aerobic capacity and HRD is a vital key to hockey players and their ability to perform at maximal levels.

Discussion

The aforementioned literature supporting the need for aerobically trained hockey players could be argued outside of our current pandemic. Currently, with the limited amount of resources, our current pandemic appears to be a great training ground for aerobic and steady state training for hockey players. It is apparent in documented research there is significant evidence calling for aerobic training. The extent of the need for aerobic conditioning may continue to be refuted and a controversy will continue to exist; however, one will be hard pressed to eliminate aerobic training especially in today's state of training. The above research is not intended to revolutionize the training practices of current coaches, rather address the issue that exists in today's game, and help educate current coaches on this hot topic especially under the constraint of COVID-19.

The above literature clearly explains the probability that aerobic fitness will enhance performance, especially concerning hockey players. Regardless of one's personal stance on training and conditioning, one can't argue with the fact that aerobic training provides a base for all other training to follow. As inferred in the Kaufmann et al. research, aerobic training not only prepares individuals for higher workloads of training, but also serves as a means to build work capacity and fight overtraining, an issue that many athletes face. Aerobic training has the ability to set the groundwork for future training protocols, and is essential for all other types of training. It often seems as if coaches are putting the cart in front of the horse, and not preparing athletes to progress into different phases and macro-cycles of training. A common result is an injury or a setback that may have been prevented by previous proper aerobic conditioning and fitness. In order for athletes to progress and adapt to training, a base needs to be firmly set, and according to the literature, aerobic training is running away with the ability to do so. And what better time to set that base then during our current societal shutdown.

Of all the literature presented in this research review, the single most abstained issue on behalf of coaches are the possible metabolic affects aerobic training has on the recovery process of athletes. Much of the literature points to the probability that the more aerobically trained an athlete is, the more recovery from anaerobic activities will be improved. Heightened aerobic capacity has the physiological ability to increase EPOC, VO_{2max}, buffer lactate, and improve PCr storage replacement. All three physiological factors play a huge role in performance, especially pertaining to the high intensity, intermittent demands hockey has.

In rebuttal to all of the physiological factors presented above, there is still very much validity in training athletes with programs that resemble game like situations and prepare athletes in a sport specific manner. "In order to perform optimally in an activity, the experiences of prior training and competition are often necessary for an athlete to evaluate afferent inputs properly and to utilize them in determining the maximal rate as which physiological power can be meted out during competition,"[18] Athletes do need to be trained with game-like intervals so each player knows what it is like to play when fatigued. Players need to be exposed to training protocols that are composed of intervals at high intensities intermittently; that is exactly the game of hockey. However, that still does not discount the fact that repeated intervals at high intensities are metabolized by aerobic sources, and that prior to training with such intervals, a given level of fitness and work capacity must be built and maintained with aerobic training. We have the opportunity right now during this pandemic to build these physiological adaptations. Coaches surely can't expect their athletes to jump right into training programs that start out with interval and speed training. Players can set a base level of fitness and total work volume now, to prepare their body to recover quickly from any future bouts, but also to prevent any future injuries and overtraining type situations when our pandemic ends.

An issue on behalf of power athletes who participate in anaerobic sports is that with the influence of aerobic training, power development is impaired. In a review composed by Elliot et al.,[14] their findings suggested that trained individuals exposed to moderate or higher levels of aerobic exercise, experienced negative power development. However, relating to the training protocols one should undergo in preparation for hockey should not exceed moderate levels of aerobic training. It is not the purpose of this research review to totally transform the methodology behind training hockey players, but rather bring to the surface the necessity of aerobic training and display that we have a great window of time during our pandemic to train this system. Hockey players need not to be exposed to high volumes of aerobic training, but rather aerobic training should be used as a vehicle to bring players up to certain standards of fitness, build a platform to improve upon more anaerobically, and to maintain baseline levels of aerobic capacity. Aerobic training should also not be raised to the level of eliciting any catabolic effects via decreased anabolic hormone release. In the work by Elliot et al.,[14] consequences of endurance training volumes became hormonal. As coaches and conditioning experts, the training protocols, especially ones involving aerobic training, should not be raised to the level and intensity to which such negative effects may occur.

Conclusion

To make bold statements that discount the necessity of aerobic training is a disservice to the game of hockey. No one can argue that the training and conditioning for hockey should be highly reliant on intervals that represent game like conditions, along with speed and power training; however, there is also a need for aerobic training based on the information provided. And what better time than now, during a societal shut down, where many players have no ice, no access to weights and limited interaction with trainers.

Outside our pandemic, players and coaches should formulate training for hockey around all energy systems, and target all muscle fibers. The game of hockey clearly identifies the primary energy systems and muscle fibers that should be stressed, but documented research also clearly explains the role aerobic training has in setting a firm base for all different types of training, and well as all the recovery and restoration benefits it provides to players. Steady state aerobic training results in athletes being aerobically fit. This characteristic has been documented to benefit not only the endurance type athletes but also the speed and power athletes like hockey players. This is because hockey players require repeated bursts of speed and power with rapid recovery and restoration during their game. Recovery is essentially an aerobic activity; therefore players that have been aerobically trained will benefit. Aerobic training also serves as a base to build all other forms of training and conditioning on, as well as serve as a means of injury prevention for those who are trained by it.

The purpose behind this review was not to totally transform training for hockey, but rather identify the need and role aerobic training has in the game. When uneducated coaches read articles like "*Leave Jogging to Adults*," published in a highly read hockey publication, they don't know any better but to eliminate all and any forms of aerobic training. Leave no stone unturned in terms of training for hockey, and stop playing the game shorthanded. Use this pandemic as a springboard for future training. Take the time now, when the table is set to train aerobically.

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