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# ANAEROBIC AND AEROBIC FITNESS OF ICE HOCKEY PLAYERS THROUGHOUT ANNUAL TRAINING CYCLE

Moroščák Jozef [1]*,
Ružbarský Pavel [2],
Balint Gheorghe [3],
Vodicka Tomas [4]

*[1,2]University of Prešov, Slovakia*
*[3]"Vasile Alecsandri" University of Bacau, Str. Marasesti No 157, Bacau, Romania*
*[4]Masaryk University Brno, Czech Republic*

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## Abstract

The study deals with partial findings making part of the research project VEGA 1/1020/11 targeted at the variability of aerobic and anaerobic fitness in athletes throughout annual training cycle. The purpose of the present study was to determine the effect of training and competition load on aerobic and anaerobic fitness in ice hockey players throughout 2012/2013 hockey season. Nine ice hockey players aged 15 to 16 years on P.H.K. Prešov ice hockey team were tested for parameters of both aerobic and anaerobic fitness. Anaerobic power was measured using Wingate test performed on cycle ergometer Monark894E. The parameters measured were peak anaerobic power and average anaerobic power. Aerobic fitness was assessed using field-based Beep test and laboratory spiroergometric test $W_{170}$ performed on cycle ergometer. Both tests were used to determine maximal oxygen uptake. The results of the study showed significant increase in aerobic fitness mainly in preparatory and pre-season period (49-56.7 ml/kg.min$^{-1}$). Aerobic fitness remained at a relatively stable level up to the playoffs (55.5-57.5 ml/kg.min$^{-1}$). Anaerobic fitness increased especially in the regular season (from 10.9 to 11.7 W/kg) until the end of season due to specific on-ice training.

## 1. Introduction

The objective of controlled training throughout annual training cycle is to achieve peak athletic performance in the required period of the season (Dovalil et al., 2008). Off-ice conditioning as a part of hockey training (Twist, Rhodes, 1993a) enhances motor preconditions underlying performance capacity of players (Bukač, 2005). Pre-season training is targeted at the development of determining motor abilities and formation of a wide spectrum of motor skills (Perič, 2002). The off-ice training includes exercises to develop especially speed, power, strength, strength endurance, endurance and coordination (Pavliš, Perič, 2003). The hockey season is characterized as period aimed to maintain the conditioning level and game readiness (Twist, 2007, Duvač, Zvonař, Psalman 2010). Some physical components of

* *E-mail*: jozef.moroscak@smail.unipo.sk , tvodicka@fsps.muni.cz, pavel.ruzbarsky@unipo.sk,

athletic performance are maintained or improved by the on-ice activity. Other components such as aerobic power and muscular strength need to be maintained via off-ice conditioning. Hockey games do not provide specific stimulus needed to build these components. Physiological profiles of hockey players have confirmed that players benefit mainly from aerobic endurance, muscular endurance, flexibility and skating speed (Montgomery, 1988, Twist, Rhodes, 1993b). Hockey training of young ice hockey players is demanding both physically and mentally and the emphasis is placed in performance and training of young players is as demanding as training of adult players (Krejčí, 2007). Effectiveness of training may be assessed by functional field-based and laboratory tests that provide feedback for the adjustment in volume and intensity of exercise (Havlíčková et al. 1993).

## 2. Material and methods

The purpose of the study was to monitor changes in anaerobic and aerobic fitness in hockey players throughout regular hockey season. Nine players on the hockey team P. H. K. Prešov participated in the study. Mean age of the players was 15.66 ±0.5 years. The players trained 5 times a week during the preparatory period. Training in the preparatory period lasted for 9 weeks and included general off-ice conditioning exercises. The duration of the training sessions ranged from 75 to 105 minutes. The preseason period lasted for 6 weeks. Training in the preseason was based on specific on-ice conditioning complemented by training sessions performed off the ice. In preseason, players played 11 preliminary hockey games. The season lasted for 30 weeks including playoffs. Training at this stage included 7 on-ice training sessions and 2 hockey games. Prior to on-ice training, players performed exercises and drills twice per week to develop their lower-body explosive power. On-ice training sessions lasted for 60 minutes and off-ice sessions for 30 minutes. Aerobic fitness was tested via laboratory spiroergometric test ($W_{170}$) performed on cycle ergometer to volitional exhaustion using continuous graded increase in load by 1.5 watts every minute and field-based running Beep test. Both tests were administered to measure maximal oxygen uptake ($VO_2max$). Anaerobic fitness was tested using 30-second Wingate test performed on cycle ergometer Monark894E. The parameters measured were peak anaerobic power (PP) and average anaerobic power (AP). Players were tested every 8 to 9 weeks. The exercise intensity in the preparatory and the preseason period was monitored using heart rate monitors Polar. The pulse rates measured were used to specify training zones of players during training. The data were processed using basic descriptive statistics: median and quartile range. The results are presented in relative values per kilogram body mass.

## 3. Results and Discussions

Basic characteristics and statistical differences in peak anaerobic power are presented in Table 1. The measure of peak anaerobic power is more hockey-specific compared to average anaerobic power. Peak power output represents the energy-generating capacity of the high-energy phosphates, while the average anaerobic power value reflects glycolytic capacity (McArdle et al., 1996).

**Table 1.** *Basic descriptive characteristics of peak anaerobic power throughout annual training cycle*

| *Testing* | *Start of preparatory period (W/kg)* | *End of preparatory period (W/kg)* | *End of preseason (W/kg)* | *Regular season (W/kg)* | *Regular season (W/kg)* | *Beforeplay-offs (W/kg)* |
|---|---|---|---|---|---|---|
| *Median* | 11.6 | 10.9 | 11.1 | 11.7 | 11.3 | 11.5 |
| *Quartile range* | 1.7 | 1.13 | 1.5 | 0.94 | 1.625 | 0.17 |

W/kg – watts per kilogram body mass.

As reported by Heller (1995) peak anaerobic power in 15-year-old hockey players in Czech Ice Hockey League averaged 13.3 ±1.4 W/kg. In a study conducted by Šťastný (2006) peak anaerobic power in junior ice hockey players who managed to become senior hockey players ranged from 15.1 to 16 W/kg.Potteiger et al. (2010) reported that peak anaerobic power in 20-year-old hockey players averaged 14.7 ±1.5 W/kg. The difference in testing procedure in the study by Potteiger et al. (2010) was that the players were allowed to stand when pedaling. Gacesa et al. (2009) conducted testing in 20-year-old hockey players in the preparatory period and peak anaerobic power averaged 10.14 ±2.26 W/kg. The higher the value of peak anaerobic power, the better preconditions for explosive, acceleration and maximal strength and speed.

At the beginning of the general preparatory phase, peak anaerobic power averaged 11.6 W/kg. After completing 9-week general off-ice conditioning phase the mean value of peak anaerobic power decreased by 0.7 W/kg. The value of peak anaerobic power after preparatory period is consistent with results reported by Gacesa et al. (2009). According to 7-grade rating scale of anaerobic power for collegiate athletes devised by Zupan et al. (2009), peak anaerobic power of our sample was classified as below average. After preseason peak anaerobic power increased and ranged throughout the regular season from 11.3 to 11.7 W/kg. The increase in peak anaerobic power contributed to the enhancement of explosive, acceleration and maximal strength.

**Table 2.** *Average anaerobic power of hockey players throughout annual training cycle*

| *Testing* | *Start of preparatory period (W/kg)* | *End of preparatory period (W/kg)* | *End of preseason (W/kg)* | *Regular season (W/kg)* | *Regular season (W/kg)* | *Beforeplay-offs (W/kg)* |
|---|---|---|---|---|---|---|
| *Median* | 9.5 | 9.03 | 9.0 | 9.7 | 9.5 | 9.6 |
| *Quartile range* | 0.25 | 0.6 | 0.45 | 0.46 | 0.725 | 0.04 |

W/kg – watts per kilogram body mass.

As seen in Table 2, average anaerobic power at the beginning of general preparatory phase was 9.5 W/kg. After the completion of general and specific training, average anaerobic power decreased by 0.5 W/kg. The higher the average anaerobic power, the higher the level of speed and strength endurance. After on-ice and off-ice volume training, the delayed training effect was observed during the regular season, where the average anaerobic power ranged from 9.5 to 9.7 W/kg.

According to 7-grade rating scale of average anaerobic power for collegiate athletes devised by Zupan et al. (2009), average anaerobic power of our sample was classified as excellent. This finding may be attributed to lack of muscular development and increase in glycolytic capacity during the preparatory period.

**Table 3.** *Aerobic power – maximal oxygen uptake $VO_2max$*

| ***Testing*** | ***Start of preparatory period (ml/kg.min$^{-1}$)*** | | ***End of preparatory period (ml/kg.min$^{-1}$)*** | | ***End of preseason (ml/kg.min$^{-1}$)*** | | ***Regular season (ml/kg.min$^{-1}$)*** | | ***Regular season (ml/kg.min$^{-1}$)*** | | ***Before play-offs (ml/kg.min$^{-1}$)*** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$W_{170}$** | **Beep test** | **$W_{170}$** | **Beep test** | **$W_{170}$** | **Beep test** | **$W_{170}$** | **Beep test** | **$W_{170}$** | **Beep test** | **$W_{170}$** | **Beep test** |
| ***Median*** | 49 | 55.1 | 52.7 | 57.2 | 56.7 | 57.7 | 55.5 | 57.2 | 57.5 | 58.3 | 49.6 | 54.6 |
| ***Quartile range*** | 4.6 | 1.99 | 8.45 | 3.45 | 4.5 | 2.58 | 9.73 | 6.26 | 7.5 | 5.08 | 8.15 | 4.8 |

ml/kg.min$^{-1}$ – milliliter per kilogram body mass per minute, $W_{170}$ – spiroergometric testing.

Aerobic capacity is expressed as maximal oxygen uptake ($VO_2max$). Maximal oxygen uptake of hockey players should be around 60 ml/kg.min$^{-1}$. Elite players usually demonstrate maximal oxygen uptake values up to 65 ml/kg.min$^{-1}$. Due to the specifics of movement and recruitment of muscle groups, hockey players are tested more frequently on cycle ergometers. Treadmill testing activates more muscles compared to cycle ergometry, therefore, values of maximal oxygen uptake are higher by 7 to 8 % when measured by treadmill testing (Pavliš, Perič, 2003). Field-based Beep test was designed as a simulation of graded spiroergometric treadmill test or cycle ergometer test.

At the start of the preparatory period, the mean value of $VO_2max$ measured via spiroergometric testing on cycle ergometer was 49 ml/kg.min$^{-1}$. The lower range limit of maximal oxygen uptake recommended for hockey players is 50 ml/kg.min$^{-1}$. Upon the completion of 9-week training, $VO_2max$ increased by 6.7 ml/kg.min$^{-1}$. After completing extensive volume of training complemented by general conditioning during preseason under specific conditions, $VO_2max$ increased to 56.7 ml/kg.min$^{-1}$, which is close to the optimal level of maximal oxygen uptake equaling 60 ml/kg.min$^{-1}$ recommended for hockey players (Grasgruber, Cacek, 2008). An interesting finding of the study was that aerobic fitness was maintained up to the late season. Prior to testing, players underwent specific conditioning as members of the national team. It may be hypothesized that increase in $VO_2max$ to the value of 57.5 ml/kg.min$^{-1}$ may be attributed to increased training volume. Training before play-offs included mainly game-like and technical-tactical training which led to decrease in $VO_2max$ by 7.9 ml/kg.min$^{-1}$ after 8 weeks of training. Durocher, Leetun, Carter (2008) reported that hockey players may benefit from an increased focus on aerobic training in the preseason and throughout the season. In the late season, aerobic fitness of players declines due to positional play and reduction in intensity and duration of practices fearing that players are at risk for overtraining, fatigue and injuries.

Figure 1 shows the course of fitness levels represented by values of peak anaerobic power (PP) and aerobic power ($VO_2max$) of a selected player throughout regular hockey season.

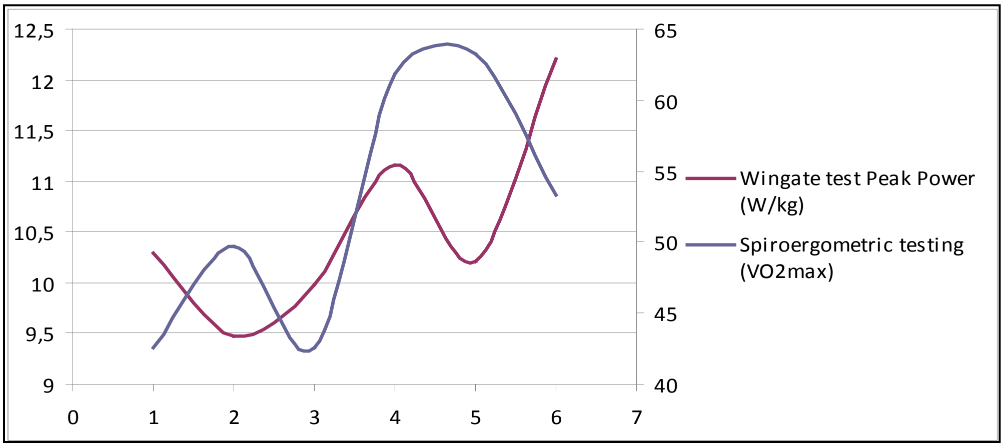


**Figure 1:** *Variability of anaerobic and aerobic fitness throughout annual training cycle of ice hockey player L. S.*

Maximal oxygen uptake of the selected player after preparatory period increased moderately. However, upon the completion of specific training in preseason, maximal oxygen uptake declined. It may be hypothesized that decline in $VO_2max$ was caused by high volume of training and by not following the principles of supercompensation. After reduction in the training volume, there was continuous increase in $VO_2max$ to the value of 63.2 $ml/kg.min^{-1}$. This value corresponded with recommendations for hockey players. After this measurement the structure of training changed. The volume of training was reduced and training was targeted more at the technical and technical game skills before the play-off games. Therefore, it may be concluded that reduction in the training volume and increased focus on technical and tactical skills caused decline in maximal oxygen uptake throughout 8-week period by 9.9 $ml/kg.min^{-1}$.

## 4. Conclusions

The purpose of the study was to determine the effect of conditioning on functional and performance measures of aerobic and anaerobic fitness in ice hockey players throughout the annual training cycle. The results of study showed that aerobic fitness remained relatively constant and increased up to the period before play-offs. During play-offs a significant decline in aerobic fitness was observed due to demanding training and game schedule. Anaerobic fitness throughout the annual training cycle changed variably. Peak anaerobic power after the preparatory period declined significantly due to predominant on-ice aerobic conditioning. Contrary to that, during the season peak and average anaerobic power increased due to predominance of on-ice anaerobic training. The greatest rate of decrease in the measures of anaerobic fitness was recorded during play-offs. In aerobic power, $VO_2max$ value increased up to the period prior to play-offs. Due to changes in training structure and due to increased focus on technical and tactical skills, maximal oxygen uptake decreased. We may hypothesize that more training sessions targeted at enhancement of aerobic fitness should be incorporated into training.

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