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Changes in Aerobic and Anaerobic Capacity of Junior Ice Hockey Players in Response to Specific Training

by

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To main objective of the research project was to identify the effect of a specific training program on changes in aerobic and anaerobic capacities in groups of junior ice-hockey players and compare these variables to values obtained by senior athletes. All subjects performed in a randomized order an incremental cycling exercise with graded intensity for estimation of aerobic capacity ($V0_2max$) and a all-out 30-s Wingate test for evaluation of anaerobic capacity (P_{max} and W_{tot}). The results of this study showed that the induced changes in the training program made it more anaerobic in nature and led to a dissociation between aerobic and anaerobic capacity in ice-hockey players. Such a training intervention caused an increase of P_{max} and W_{tot} with a parallel decrease in VO_2max.

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Introduction

Ice hockey is a high intensity sport activity with a multidirectional nature. The ability to change direction rapidly while maintaining balance without loss of speed is an important component for successful performance in ice hockey. Thus, ice hockey competition puts heavy aerobic and anaerobic energy demands on players. To improve both of these metabolic pathways responsible for efficient ATP resynthesis in working muscles coaches apply high intensity activities such as weightlifting and sprinting into the training process. As a method of choice for activation of aerobic and anaerobic pathways in skeletal muscle short-interval training has been used (Gendron 2003). This type of training has been shown to increase both VO_2 max and to increase activity of some glycolytic enzymes (Taylor et al. 1981).

It is evident from previous studies that the ability of energy utilization from a given metabolic pathway is strongly related to intristic properties of muscle fibers (Henriksson and Reitman 1977). It may be modified by increase of sustained contractive activity (Henriksson et al. 1986). Although the aforementioned changes are mainly attributed to endurance training, recently obtained evidence using recreationally active men showed that sprint training may enhance muscle oxidative but not glycolytic capacity (Barnett et al. 2004).

The vast majority of experimental evidence acquired with the effect of training on muscle fiber properties indicates the transformation sequence from fast to slower transition in myofibril contractile characteristics in response to endurance training (Gondret et al. 2005). Previously, O'Neil et al. (1999) found that the mRNA abundance for MHC IIx was reduced in vastus lateralis muscle in young men after performing endurance bicycle training. This is in agreement with findings that endurance training results in a decrease in percentage of type IIb fibres (Howald et al. 1985). A recent study revealed that average muscle fiber conduction velocity and output power corresponding to LT and VO_2max were positively correlated with percentage of myosin heavy chain I isoform (Farina et al. 2006).

Little information is available on the metabolic characteristics and fiber composition of ice–hockey players. There is also little data related to metabolic adaptation taking place after a longer period of intense training in a group of ice-hockey players. This study explores long term ice hockey training in regards to specific changes in aerobic and anaerobic capacities among young ice hockey players. In order to evaluate this, VO_2max, and anaerobic capacity were measured by using the Wingate test in different stages of the training process and compared with the same variables detected in senior ice hockey players.

Material and Methods

Subjects

A group of polish national ice hockey players took part in the study. They were divided into four age groups: under 16 (U-16), under 18 (U-18), under 20 (U-20) and seniors (S). Their basic characteristics are presented in table 1. For inclusion in the study, the subjects had to participate in a whole training process. All of the subjects were informed of the purpose and nature of the investigation and gave their written consent to participate. The studies were approved by the Bioethical Committee of the Silesian Medical University, Katowice, Poland. None of the participating athletes showed evidence of anabolic steroid use. The subjects were evaluated at the beginning of the pre-competition period of training. All performed in a randomized order an incremental cycling exercise with graded intensity for estimation of aerobic capacity and an all-out 30-s Wingate test for evaluation of anaerobic capacity. The rest period between both trials was 3 days. On the day of the test protocol the subjects reported to the Laboratory after an overnight fast.

Study design

All subjects performed an incremental cycling exercise with graded intensity (Ex). The intensity of work was displayed on a digital indicator to motivate the subjects to generate the required force. The tests started at a power output of 1 W/kg b.w. with 0.5 W/kg b. w. increments every three minutes until voluntary exhaustion which was determined when the subject could not maintain the required pedaling frequency. HR, VO_2, $ExCO_2$ and VE were measured from the 6th min prior to exercise, and during each exercise load until the tests were completed. Gas exchange variables were measured continuously breath-by-breath using the Oxycon Apparatus (Jaeger, Germany) and maximal work load was recorded.

The Wingate test was preceded by a 5 min warm-up with the intensity ranging from 5-75 W. The Wingate test was performed with resistance 0.09 kg/kg b. w. During the Wingate test the frequency of wheel revolutions was recorded using magnets placed on the flywheel and an electronic counter. Power output was calculated online every 3 s during the test by computer. The P_{max}, usually during the second interval and the W_{tot} during the whole 30 s were analyzed.

Training intervention

The training process was assessed by recording training volume (expressed as the total number of hours per year). The battery of anaerobic exercises is given in % of total training volume. All players wore a Polar System heart rate belt and monitor (Polar Electro) throughout the interval (anaerobic) exercises. The working intensity of anaerobic exercises was at 90-95 % of HR max. The training structure is given in table 2 and it was prepared according Gendron's (2003) and Mathews and Fox (1980) recommendations.

Statistics

The computer program STATISTICA 5.0 (StatSoft, INC, Tulsa, OK) was used for statistical analysis. Data are presented as mean ± SE. A one way or a two way repeated analysis of variance (ANOVA) was used to test differences between groups comprising one or two conditions, respectively. The Duncan's test was used as a *post hoc* test. The level of significance was set at $P<0.05$.

Results

The VO_2max and Vemax results are presented in Fig. 1. The average value of VO_2max reached by the S group during the graded test performed on a cycloergometer was 49.10 ± 5.52ml/kg/min. This variable was significantly higher ($P<0.05$) in U-16 as compared to S, U-18 and U-20 ice hockey players (Fig. 1A). The VE max was significantly higher ($P<0.005$) in U-18 and U-20 in comparison to U-16 (Fig. 1B).

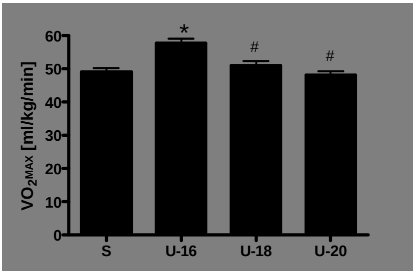

Fig. 1A

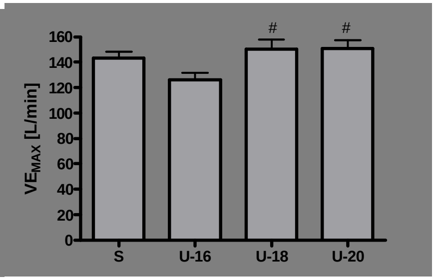

Fig. 1B

The P_{max} attained during the Wingate test was 13.84 ± 0.90 W/kg in S ice hockey players and was significantly higher than that attained in U-16 and U-18. There was no difference ($P>0.05$) in P_{max} between S and U-20 but the P_{max} of U-20 was significantly higher ($P<0.05$) in comparison to both U-16 and U-18 (Fig. 2A).

The W_{tot} was significantly lower in U-16 ($P<0.05$) as compared to S, U-18 and U-20. There was no difference in W_{tot} ($P>0.05$) between S, U-18 and U-20 (Fig. 2B).

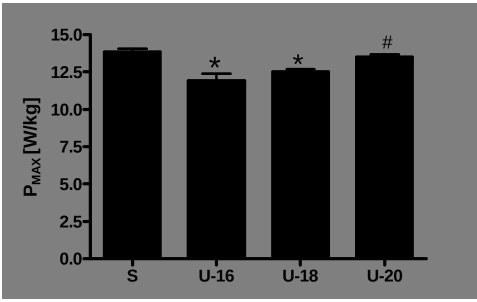

Fig. 2A

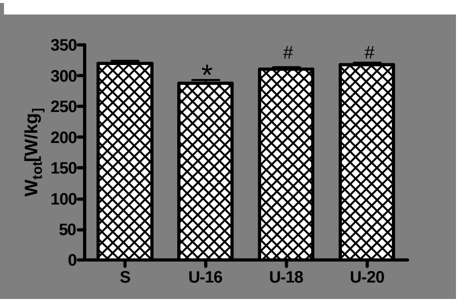

Fig. 2B

The resting blood LA concentration did not differ between investigated groups of ice hockey players. However, the post exercise LA concentration measured in the 4th min of recovery was significantly lower in U-16 as compared to S (P<0.05), U-18 (P<0.05) and U-20 (p<0.05). No statistical difference was seen between S, U-18 and U-20 (p>0.05). (Fig. 3.)

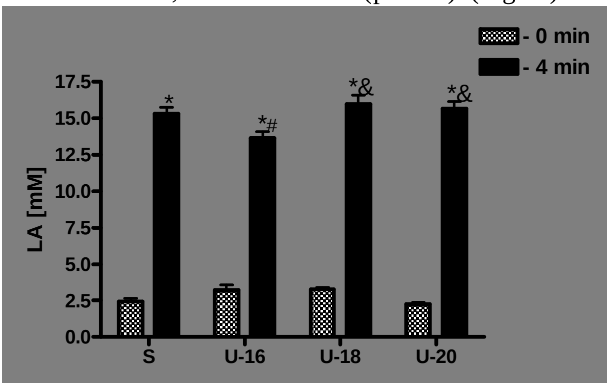

Fig 3.

Discussion

All of the ice hockey-players taking part in the present study had performances placing them among the best in Poland but not at the international level. The senior VO_2 max values measured in this experiment were about 20 % lower in comparison to those generally reported for elite, highly trained ice-hockey players (Persival 1999). The present study showed that this value decreased with age and training experience, being at the highest level in the youngest group of hockey players (U-16). The significant decrease in VO_2 was somewhat unexpected given the nature of the training process which consisted of submaximal training loads in all investigated training periods. Moreover, there is substantial data showing that short-term interval training causes a significant increase in VO_2max (MacDougal et al. 1998, Barnett et al. 2004). The issue as to whether a combined program of anaerobic and aerobic training can result in an increase in the maximal activity of either glycolytic or oxidative enzymes is still controversial. There are reports that sprint training has either no effect (Costill et al.1979, Kowalchuk et al. 1988) or a lesser effect (Saltin et al. 1976) on mitochondrial enzyme activity than endurance training. It is generally thought that both the intensity of the exercise and volume of training are important components of aerobic capacity.

The opposite effect was seen in anaerobic capacity which was lowest in U-16 juniors. Both P_{max} and W_{tot} values reached during the Wingate test in U-18 and U-20 ice hockey players were similar to those obtained by seniors. Since the applied training program differs between investigated groups being more anaerobic in U-18 and U-20 groups in comparison to U-16, it indicates a superiority of short-interval training to influence adaptive changes in anaerobic metabolism. The increase in W_{tot} may be related to the post-training increase in maximal glycolytic enzyme activities. Such changes were evidenced in untrained students which participated in sprint interval training (MacDougal et al. 1998). Moreover, these changes were accompanied by increased activities of regulatory glycolytic enzymes (MacDougal et al. 1998). Previously, Thorstensson et al (1975) found increased creatine phosphokinase, ATPase, and myokinase activities as well as increased performance on the vertical jump test after sprint training in adolescent boys. However, there are also reports in literature that sprint training has no effect on glycolytic enzyme activity (Henriksson and Reitman 1976, Hickson et al.1976). The fact that blood lactate concentration after the Wingate test was unaltered in U-18, U-20 an S and significantly higher than in U-16 gives further support for the assumption that shifting into a more anaerobic training process induced adaptive changes in glycolitic enzyme activities. However, the detected value of LA concentration in our study was very low (about 15 mM) as compared to values (about 25-32mM) obtained by others (MacDougall et al. 1998). It is possible that this disparity may be attributed to more efficient LA removal after the Wingate test in ice hockey players. This assumption was based on knowledge indicating improvement of post-exercise LA metabolism in endurance trained subjects (Billat at al. 2003). The training loads applied by subjects participating in this study include submaximal exercises with a predominance of aerobic metabolism in all investigated stages of the training process. It is thus possible that the described above phenomenon of efficient lactate removal is attributed to these processes.

In summary, this study indicates that shifting the training loads to a more anaerobic character led to a dissociation between aerobic and anaerobic capacity in ice-hockey players. This dissociation was manifested by a decrease in VO_2max with a parallel increase in P_{max} and W_{tot}.

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