Repeated-sprint performance in junior ice-hockey players following a 3-week “train low” nutritional intervention

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Abstract

Ice-hockey requires players to perform intermittent high-intensity exercise, which can last from 30-90 seconds followed by around three minutes of recovery. The utilization of carbohydrates (CHO) is important during high-intensity exercise sports like ice hockey. **Purpose:** To explore the effect of training combined with a nutrition intervention with low carbohydrate intake on repeated Wingate sprint performance in high-school ice-hockey players.

**Method:** Twelve healthy male junior ice-hockey players (age 16.8 ± 0.8 years, height 178.9 ± 5.0 cm, body mass 78.1 ± 9.7 kg) performed three repeated Wingate sprints before and after a three-week nutritional intervention with different carbohydrate intake in a mixed-factor design study. Participants were randomly allocated into a train low group (TL) and a control group (CON). Participants got a nutrition snack plan which contained 60% CHO (CON) and 40% CHO (TL). Performance was assessed using peak power, mean power and fatigue index.

**Results:** There was no effect of training with low CHO intake on peak power (p=0.432), mean power (p=0.089) or fatigue index (p=0.361) at the before vs after tests.

**Conclusion:** There was no significant difference between the control group and the train low group regarding training following low CHO intake. The result thus shows no improvement in performance with a special intake of carbohydrates after exercise.

**Key words:** Carbohydrates, wingate, anaerobic power, exercise

Vid ishockey krävs det att spelare ska utföra återkommande träning med hög intensitet som kan variera från 30 till 90 sekunder ända upp till 1,5 minut följt av tre minuters återhämtning. Nyttjandet av kolhydrater är viktigt under högintensiva sporter likt ishockey. **Syfte:** Att undersöka effekten av träningen kombinerat med en nutritionsplan innehållande lite kolhydrater på upprepad Wingate sprint hos unga hockeyspelare som går på gymnasiet. **Metod:** Tolv friska manliga hockeyspelare på gymnasiet (ålder 16,8 ± 0,8 år, längd 178,9 ± 5,0 cm, vikt 78,1 ± 9,7 kg) utförde tre upprepad Wingate sprinter med en tre veckors kostintervention med olika intag av kolhydrater i mellan före och efter tester i en mixad-faktors design studie. Försökspersonerna delades in randomiserat in i en train low grupp (TL) och en kontroll grupp (CON).

Försökspersonerna fick en matdagbok innehållande 60% kolhydrater (CON) och 40% kolhydrater (TL). Prestation mättes i topp effekt, medel effekt och trötthets index (%). **Resultat:** Det var ingen effekt på train low på topp effekt under före och efter tester (p=0,432), ingen effekt på medel effekt under före och efter (p=0,089), och ingen effekt på trötthets index under före och efter testerna (p=0,361). **Slutsats:** Det fanns ingen signifikant skillnad mellan kontrollgruppen och train low gruppen kopplat till deras träning följande ett lågt kolhydratsinnehåll. Resultaten visar således ingen förbättring av prestation med ett särskilt intag av kolhydrater efter träning.

**Nyckelord:** Kolhydrater, wingate, anaerobisk effekt, träning
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Introduction

Ice hockey requires players to perform intermittent high-intensity exercise which can last from thirty seconds up to one and a half minutes followed by one to three minutes of recovery. Therefore, the physiological demands of the sport are characterized by the need for both muscular power and muscular endurance fueled by both the anaerobic and aerobic energy systems (Åkermark, Jacobs, Rasmusson and Karlsson, 1996). During a game players typically achieve both maximal heart rates and maximal oxygen consumptions as well as increases in blood lactate due to the high-intensity work (Green, Daub, Painter & Thomson, 1978). Anaerobic capacity is defined as the maximal amount of adenosine triphosphate resynthesized via anaerobic metabolism during a specific mode of short-duration maximal exercise (Green & Dawson, 1993). Since ice-hockey players are required to be able to maintain power output during repeated sprints throughout a game, it is important to perform anaerobic power tests to determine this ability (Peterson, Fitzgerald, Dietz, Ziegler, Baker & Snyder, 2016).

The utilization of carbohydrates (CHO) is important during high-intensity exercise sports like ice hockey (Saltin, 1973). CHO availability to the muscle and the central nervous system can be compromised during high-intensity intermittent exercise lasting more than 90 minutes (Hargreaves, 1999; Hawley et al. 1997). Muscle glycogen levels have been reported to decline between 38 and 88 percent during an ice hockey game (Montgomery, 1988). Previous studies have shown the importance of CHO utilization during high-intensity work and a decrease in work capacity associated with depletion of muscle glycogen (Green et al. 1978; Montgomery, 1988). Several studies shows that insufficient CHO intake can impair physical performance (Costill, Flynn, Kirwan, Houmard, Mitchell, Thomas and Park, 1988; Hargreaves, Hawley and Jeukendrup, 2004).
Ice hockey is a sport that includes high-intensity movements and sport-specific skills for a longer duration of time and the player’s performance is dependent on the combination of anaerobic and aerobic energy systems (Lindsay, Ian, Kimberly & Asker, 2015). These systems are dependent on muscle glycogen to produce energy (Lindsay et al. 2015). Training with high CHO availability may allow athletes to train harder and achieve better performances for a longer period of time (Burke, 2007). Recently, training with low muscle glycogen availability or in a fasting state has become a popular method to enhance training adaption compared to training with normal glycogen stores and high CHO availability (Bartlett, Louhelainen, Iqbal, Cochran, Gibala, Gregson, Morton, 2013). According to Baar & McGee (2008) there is convincing evidence that training in a low CHO environment promotes a greater training response, before switching to high CHO availability when optimal performance is required.

The purpose of this study was to explore the effect of training with low CHO intake on repeated Wingate sprint performances in young high-school ice-hockey players. The hypothesis was that training following low carbohydrate intake and an overnight fast for 2 days per week over 3 weeks would lead to impaired performance in the form of peak power, mean power and fatigue index during three repeated Wingate sprints compared to training with a normal intake of CHO.
Method

Participants

Twelve healthy male junior ice-hockey players between 16-19 years of age were recruited through a meeting and e-mails from a local high-school, to take part in the study. The characteristics of the subjects were as follows: age 16.8 ± 0.8 years, height 178.9 ± 5.0 cm and body mass 78.1 ± 9.7 kg. At the time of inclusion participants were free from lower body injuries, and were not smokers or diabetics.

Study design

The study used a mixed-factor design who explored two groups over time consisting of pre-post design for control and intervention groups. Participants were randomly allocated into two groups, one train low (TL) and one control group (CON). This design is used to determine the presence of a statistical interaction between the different groups from the pre-to post-time-points (Creswell, 2009). In this study the participants performed three repeated Wingate sprints before and after a randomized nutritional intervention.

Procedures

A Monark 894E bicycle ergometer (Monark Exercise AB, Vansbro, Sweden) with Monark anaerobic test software was used to perform the Wingate anaerobic test (WanT). During the warm up the participants used a Monark 828E bicycle ergometer (Monark Exercise AB, Vansbro, Sweden). A Forerunner 110 (Garmin, Schaffhausen, Schweiz) with an additional heart rate chest strap monitor was used during the testing. A lactate scout system (EFK Diagnostics, Cardiff, UK) was used to assess blood lactate from fingertip capillary samples. Malto (maltodextrin)
(Mm sports) was used as a carbohydrate supplement on both testing days, one hour before the participant’s Wingate sprints so the participants would get the same preconditions during the before and after tests.

Repeated-sprint performance was assessed using a Wingate cycle ergometer test. The participants were instructed to refrain from caffeine for 24 hours before testing. One hour before testing the participants ingested a carbohydrate drink which contained 1g CHO/kg bodyweight (Burke, Hawley, Wong & Jeukendrup, 2011). After one hour participants began a standardized warm-up on a bicycle ergometer (Monark 828 E) for five minutes at 1.5 kp, 60 rpm including a 5 second sprint after 3 minutes. Participants then rested for 3 minutes before the first Wingate sprint. The participants were instructed to remain seated on the saddle at all times during the test (Haff & Dumke, 2012). Participants then performed three 30-s Wingate cycle tests (separated by 2-min rest intervals) at a load corresponding to 0.075 kp/kg body mass. The software was adjusted so that the weight-basket would drop at 70 rpm. Immediately after each sprint the test-leader performed a blood lactate test. Average power (W) (the mean from all Wingate sprints), peak power (W) (the best Wingate sprint), and fatigue index (the percentage decrement in peak power from the best to the worst sprint) were recorded as measures of the repeated sprint performances. The blood lactate is presented as the highest from all three sprints.

**Nutrition intervention**

The subjects were randomly allocated into two different groups with 6 subjects in each group, one control group and one train low group. The participants filled out a three day food diary at the beginning of the study, prior to the training and nutritional intervention, but the information provided was insufficient to use for the allocation of the participants to groups, so participants were instead randomized to groups. The food diary was designed to record the participant’s daily eating habits and snack intake. The amount of carbohydrates in energy percent was decided before the study in accordance with the study of Achten, Halson, Moseley, Rayson, Casey & Jeukendrup (2004). The participants used food scales (OBH NORDICA) so they could measure the right amount of food
when the intake of the snack was going to happen. After the pre-testing they got a personal nutrition program of what they were going to eat during these two days for three weeks. The two-day-a-week nutritional intervention started with the groups trained together on Tuesday and Thursday night. Then the participants ate their designed snack after practice and went to bed. The day after (Wednesday and Friday) the participants trained without breakfast together in both groups.

(Figure 1). Snack plans for both groups are displayed in Table 1.

Randomly allocated into two groups

<table>
<thead>
<tr>
<th>TL Snack (40 % CHO)</th>
<th>CON Snack (60 % CHO)</th>
</tr>
</thead>
</table>

- Bedtime
- No breakfast
- Morning training

*Figure 1. Two day nutrition intervention procedure*
Table 1. Snack plan for both groups, macronutrient breakdown in grams (g) and energy percent in percentage (%). (Numbers in grams are from the application My Fitness Pal)

<table>
<thead>
<tr>
<th>Control group diet snack plan</th>
<th>Train low diet snack plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lindahls Quark 0.2 %</td>
<td>Boiled egg</td>
</tr>
<tr>
<td>(PRO: 12 grams (80%) CHO: 3 grams (20%) FAT: 0 grams (0%) =60 Kcal/100g</td>
<td>(PRO: 7 grams (34%) CHO: 0 grams (0%) FAT: 6 grams (66%) =82 Kcal/100 g</td>
</tr>
<tr>
<td>Banana</td>
<td>Cashew-nuts</td>
</tr>
<tr>
<td>(PRO: 2 grams (5,5%) CHO: 35 grams (89%) FAT: 1 grams (5,5%) =157 Kcal/100 g</td>
<td>(PRO: 15 grams (10%) CHO: 26 grams (18%) FAT: 46 grams (72%) =578 Kcal/100 g</td>
</tr>
<tr>
<td>Oats ICA</td>
<td></td>
</tr>
<tr>
<td>(PRO: 13 grams (15%) CHO: 58 grams (67%) FAT: 7 grams (18%) =347 Kcal/100 g</td>
<td></td>
</tr>
<tr>
<td>Actual energy percent in macronutrients n=4</td>
<td>Actual energy percent in macronutrients n=4</td>
</tr>
<tr>
<td>PRO= 24.5 % ± 1.9 %</td>
<td>PRO= 21.5 % ± 1.7 %</td>
</tr>
<tr>
<td>CHO= 61.7 % ± 0.9 %</td>
<td>CHO= 36.5 % ± 0.8 %</td>
</tr>
<tr>
<td>FAT= 13.8 % ± 0.4 %</td>
<td>FAT= 42 % ± 1 %</td>
</tr>
<tr>
<td>Kcal/kg bodyweight 3.0</td>
<td>Kcal/kg bodyweight 2.9</td>
</tr>
</tbody>
</table>

Ethical aspects of research

Each subject provided written, informed consent to participate after explanations of the experimental procedures and possible risks and benefits according to the Declaration of Helsinki. The participants were informed that participation was voluntary and they were free to drop out anytime without a reason (Olsson & Sörensen, 2011).

The purpose of this study was to explore the effect of training combined with a nutrition intervention with low carbohydrate intake on repeated Wingate sprint performances in young hockey high school players. The target carbohydrate intake in the snack plan for the control group was 65 E% and the train low group
was 40 E%. The total difference in energy percent in CHO of the snack between the two groups was around 15 E%.

Data analysis

All data was reported as mean ± standard deviation (SD). The Statistical Package for the Social Sciences (SPSS 22, IBM, Armonk, NY, USA) was used for the analysis of the collected data. The data was normally distributed according to a Shapiro-Wilk test of normality. A mixed model repeated measures ANOVA for each variable was used to explore interaction effects between group and time. Microsoft Excel (Redmond, USA) was used to design the figures and tables. The level of significance was determined at $p \leq 0.05$. 
Results

Of the twelve participants who were recruited to take part in the study, eight completed the 3-week nutritional and training intervention and returned for post-testing (TL: n = 4 and CON: n = 4). The percentage change in body weight was 1 ± 1% for CON and -0.3 ± 0.7% for TL.

There was no effect of train low on peak power at the post vs pre-tests (F (1. 6) = 0. 71, p=0.432; Figure 1), no effect of train low on mean power at the post vs pre-tests (F (1. 6) = 7.78, p=0.089; Figure 2) no effect of train low on fatigue index at the post vs pre-tests (F (1. 6) = 0.98, p=0.361; Figure 3) and no effect of train low on peak blood lactate at the post vs pre-tests (F (1. 6) = 1.91, p=0.217; figure 4).

![Figure 1. Mean ± standard deviation peak power (W) for control group (CON) and train low group (TL).](image-url)
Figure 2. Mean ± standard deviation mean power (W) for control group (CON) and train low group (TL).

Figure 3. Mean ± standard deviation fatigue index (%) for control group (CON) and train low group (TL).
Figure 4. Mean ± standard deviation for peak blood lactate concentration (mmol/l) for control group (CON) and train low group (TL).
Discussion

The purpose of this study was to explore the effect of training combined with a nutrition intervention with low CHO intake on repeated Wingate sprint performances in young high-school ice-hockey players. The hypothesis was that the group who trained with low carbohydrate intake for 2 days per week over 3 weeks would lead to impaired performance in the form of peak power, mean power and fatigue index in three repeated Wingate sprints compared to training with a normal intake of CHO, which did not match the outcome of the study.

The Wingate Anaerobic Test (WAnT) is a test to determine anaerobic capacity over 30 seconds using a mechanically braked cycle ergometer (Zupan, Arata, Dawson, Wile, Payn & Hannon, 2009; Haff & Dumke, 2012; Smith & Hill, 1991). The 30-s WanT test has been validated to assess the development of anaerobic power in ice hockey (Peterson et al. 2016). The WanT was an appropriate test to use during the testing for the ice-hockey players given how similar it is to ice-hockey with high-intensity sprinting and short substitutions.

The goal of the train low intervention was to demonstrate what previous research (Saltin, 1973) on the subject claims, that the utilization of CHO is important during high-intensity exercise sports like ice hockey and that train low will be detrimental to performance. Ice hockey players are required to be able to maintain power output during repeated sprints throughout a game (Peterson et al, 2016). Previous studies have shown the importance of carbohydrate utilization during high intensity work and the decrease in work capacity associated with depletion of muscle glycogen (Green et al. 1978). Therefore the hypothesis was that the train low group would have a decrease in performance during the repeated Wingate sprints.
To achieve the purpose and to test the proposed hypothesis, a nutrition plan was developed where the experimental group had less carbohydrates than the control group during the snack meals. Burke et al, (2011) claims that it is useful to adjust an athletes CHO intake by strategically consuming snacks/meals that contain CHO and other important nutrients around important exercise sessions. In this study the train low group got less CHO in their snack plan, to see if it had any impact on their performance. According to Burke et al, (2011) strategically consuming snack meals that contain CHO allows energy and nutrient intake to track the needs of an athletes’ exercise commitments for high CHO availability to enhance performance and recovery at important times. One goal of the study was to show that it is important to eat carbohydrates before and after the workout to improve and speed up the recovery. As there was no significant difference between the experimental group and the control group, the result of the study does not reinforce this.

In summary, previous research shows that carbohydrate intake has an impact on athlete’s performance in high-intensity sports (Åkermark et al, 1996; Lindsay et al, 2015; Burke et al, 2011; Green et al, 1978). This study’s results do not fit with the literature and the study’s hypothesis was rejected.

Limitations

There were too few subjects to obtain a sufficient statistical power to fully evaluate the effect of this intervention. At the beginning of the study, the plan was that the sample would consist of 16 subjects. After losses due to injuries and lack of time, only eight subjects completed the study.

The participants were instructed to refrain from caffeine for 24 hours before testing. This can be seen as a source of error because it was not possible to check if the participants had taken caffeine before the tests were carried out. If they had, it could have affected the results of the study. What could be controlled in this study is what participants in the different groups ate for
snacks. And no control how they ate before, after or between the wingate tests. This may have affected the outcome of the participants' Wingate tests.

Before the study the nutritional intervention was the main focus and the training adaption could be varied for the participants during the train low morning training session the day after the intake of the designed snack meal. Lindsay et al (2015) claims that the player’s performance is dependence on the combination of anaerobic and aerobic energy systems. These systems are dependent on muscle glycogen to produce energy.

**Future Directions**

For future research it would be interesting to conduct this study on a larger group with more participants and at different ages to see if there is any significant difference between carbohydrate intake and performance. It would also be interesting to design a training program combined with a nutrition plan, so all the participants get the same training conditions throughout.

**Conclusion**

There was no significant difference between the control group and the train low group regarding their performance (peak power, mean power and fatigue index) during repeated Wingate sprints. The result thus shows no improvement in performance with a reduced amount of carbohydrate intake after exercise.
Acknowledgements

I would like to start by thanking my participants for choosing to be a part of my study. Without your participation and contribution there would be no study, so thank you! I would also like to take the opportunity to thank my study colleagues, Markus Molin, Luciën Sloof and Tzs-Hin Tang, for all of your help and support during the tests. And Kalle Björklund, the ice-hockey coach, for all the help. Last but not least I would like to thank my mentor, Helen Hanstock, for all the help and the support during this time.

Markus Axner

15/5-2017


Appendix 1- Information letter

Hello!

My name is Markus Axner and I’m studying the last year in Sport science at Mid- university in Östersund. Right now I’m doing my final exam. The purpose with this study is to explore the effect of training with low carbohydrate intake on repeated Wingate sprint performances in young male high school hockey players. On an intermittent basis in ice hockey high exercise intensity is involved, which can last from thirty seconds all the way up to one and a half minute followed by one to three minutes of recovery. Physiological demands are very high on an ice hockey player, both endurance muscle and muscle power strength is involved. The study design to compare high school hockey players in a 3 week randomized controlled training intervention study to see if there’s any differences in physical performance when you are low on carbohydrates. There will be a performance test before and after the intervention. The test is an anaerobic fitness test (Wingate anaerobic test). There will be two different groups, one control group, and one “train low” group. The participants will be randomly allocated to groups of 8. The outcome variables that will be measured are blood lactate (between and after the performance test) and the outcomes of the Wingate test is peak power (PP), mean power (MP). Heart rate (HR) (between and after the performance tests). Weight (kg) and height (cm) will be measured before every test. The “train low” group and the control group will follow a 2 day nutrition program each week.

Exercising on tuesday and thursday evening before bed, and on Wednesday and Friday morning they will train with an overnight carbohydrate fast in their body. And the control group will be training and eating as usual. Before the testing begins your height (cm) and your weight (kg) will be measured. After that you will do a warm-up 5 min on a Monark ergometer. And before the first wingate test you will be assigned with a heart rate monitor transmitter to your chest. A 10 second countdown will be made from the test leader and after that a 30 second
all out performance. After the first wingate sprint the subject will rest for two minutes. The test-leader will perform a blood lactate test right after the first, the second and the third wingate sprint. And HR will be monitored after the first, second and third wingate test. Peak power and mean power will be monitored during each sprint.

1. Before the study I need to know how much food you eat during three days, this will be recorded in a food diary which I will give to you so I can adapt the nutrition plan during the study. I also have to know if you have any allergies or any metabolic disease for example, diabetes. Also if you have any lower body injuries, if you use nicotine (smoking, snusning).

2. With this information letter there will be an “informed consent” letter that you will sign if you want to take part of this study and understood all the criteria’s for the study.

3. 24 hours before the tests you can´t have any caffeine or alcohol in your body. 1 hour before the testing you will get a high-carbohydrate drink, this drink will be handed out from the test-leader.

4. The pre and the post-testing will start with taking the subject’s weight (kg) and height (cm). A 5 min warm up on a Monark 894 e ergometer. After the warm up the weight basket will be prepared for the subject with 7,5 % of his bodyweight. 30 second wingate, 2 min rest (lactate 1, HR and peak power, mean power will be recorded). Same procedure during sprint 2 and 3.

5. A designed nutrition plan will be handed to you so you know how much you will eat during these three weeks.

6. 24 hours before the post testing you can´t have any caffeine or alcohol in your body. 1 hour before the testing you will get a high-carbohydrate drink, this drink will be handed out from the test-leader
Appendix 2- Confidentiality

Data and information which could identify you as a participant in the study will be handled with utmost familiarity partly through that the result will be used for the purpose of the study. Treatment of the participants information (name, height, weight and sex) and results will be handled so unauthorized will not have access to it (according to the personal data act) which all the participants will be coded with numbers.

Risks with the study
During the time of the study you can feel that you´re tired, have a smaller amount of energy which can decrease your performance and you will be exposed to high intensity tests which can affect your heart, lungs, muscles and joints. During the blood lactate tests during the tests you will feel a small sting in your finger, it could hurt if you´re not used to it.

Benefits with the study
To understand the importance of a good nutrition plan, to know when and how much of every macronutrient (protein, carbohydrates and fat) you should have in your body both during and after games and training. And the benefits with the wingate anaerobic test you can plan your training according to the results you will get.

Participation
If you agree the terms and if you sign this document you will have your right and participation in any circumstances cancel all testing and intervention during the time of the study without any sanctions or consequences (according to the declaration of Helsinki.)
Appendix 3- Informed consent

Repeated sprint performance in junior ice hockey players following a 3 week “train low” intervention

I understand the purpose and the setup of the study and agrees to participate as a subject. I’m aware of my rights and confidentiality to cancel the study for any reason at all.

Participant’s signature: ________________________________

Participant’s signature (printed name): __________________________

Date:______________ Location: ________________

Test leader signature: ________________________________

Test leader signature (printed name): Markus Axner

Date:______________ Location: ________________

If you have any questions or details, email or call me, Markus Axner,
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