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## Article

# Cardiorespiratory Aerobic Fitness and Repeated Sprint Ability in Elite Ice Hockey Players

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## Abstract

Ice hockey represents a sport with predominantly anaerobic efforts best reflected by repeated sprint ability (RSA) testing (5x5 seconds with 10 seconds recovery). A controversy persists about the usefulness of  $\text{VO}_{2\text{max}}$  laboratory testing for the assessment of ice hockey players. The purpose of the study was to evaluate the relationship between laboratory measured  $\text{VO}_{2\text{max}}$  and RSA simulated on a supine ergometer and tested on ice. Elite male hockey players ( $n = 64$ ) were tested in the laboratory ( $\text{VO}_{2\text{max}}$  and RSA). RSA was performed by modified Wingate test (5 x 5-seconds sprints with 10 seconds recovery). In 28 athletes RSA were assessed during an on-ice testing (5 maximal skating sprints between the goal and the blue line). The decrease in performance was assessed by fatigue indices. In the laboratory settings the  $\text{VO}_{2\text{max}}$  correlated significantly with maximum workloads of the 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> bout with increasing correlation strength ( $r = 0.26$ ,  $p = 0.02$ ;  $r = 0.48$ ,  $p < 0.001$ ;  $r = 0.57$ ,  $p < 0.001$ ; and  $r = 0.60$ ,  $p < 0.001$ ) and with fatigue indices - % workload decrement index ( $r = 0.44$ ,  $p < 0.001$ ) and % maximum average workload decrement (%) ( $r = 0.38$ ,  $p = 0.002$ ). In addition,  $\text{VO}_{2\text{max}}$  correlated with lactate levels after 10 minutes of recovery ( $r = 0.31$ ,  $p = 0.01$ ). There was no correlation between  $\text{VO}_{2\text{max}}$  and on-ice testing results. Moreover, the results of RSA measured in laboratory and on ice did not show any correlation. The lack of relationship between laboratory and on-ice testing is further challenging the usefulness of bicycle ergometry laboratory testing in ice hockey.

**Keywords:** ice hockey; cardiovascular physiology; cardiopulmonary exercise stress testing

## 1. Introduction

Ice hockey represents one of the most physically demanding sports. The high intensity skating during individual shifts represents typically an anaerobic effort requiring muscle strength, power, and anaerobic endurance. However, the endurance fitness plays a major role as the typical player performs from 15 to 20 minutes in repeated shifts of 30 to 80 seconds with a brief 3 to 5 minutes recovery time between them. The length of the game and the need to quickly recover between shifts may heavily depend on the quality of the aerobic system [1]. Although several on-ice tests have been proposed to evaluate the fitness of ice hockey players, many professional hockey teams require laboratory testing and measurement of maximal oxygen uptake ( $\text{VO}_{2\text{max}}$ ) for the fitness assessment of players (e.g. recommended by the Czech Ice Hockey Association for the U17 and U20 categories).

The theoretical time window has been reported in some contexts that aerobic metabolism significantly contributes to recovery which is primarily within the first 30–120 seconds after exertion [5]. This approximately corresponds to the time spent on the bench between shifts.

The  $\text{VO}_{2\text{ max}}$  threshold value, determined by laboratory tests, is in some cases included in professional players' contracts. There is an ongoing debate on how useful the  $\text{VO}_{2\text{ max}}$  assessment may be for the anaerobic activity such as ice hockey. It has been proposed that the oxidative capacity of the muscle is the primary component of the aerobic energy system affecting recovery after repeated-sprint activities [24]. Some smaller studies reported only weak relationship between  $\text{VO}_{2\text{ max}}$  measurements and repeated sprint ability (RSA) tests in male field hockey and soccer players ( $n=40$ , national level) and female ice hockey players ( $n=11$ , college level) [2,3]. In contrast, other authors have shown that aerobic capacity may significantly influence RSA in rugby and soccer players [4–6]. A positive relationship between  $\text{VO}_{2\text{ max}}$  and RSA was recently found in ice hockey players ( $n=45$ , college level) as well when comparing of the on-ice repeated shifts results to  $\text{VO}_{2\text{ max}}$  measured on a skating treadmill [7]. Surprisingly,  $\text{VO}_{2\text{ max}}$  was shown to predict non professional ice-hockey players' ( $n=29$ , college level) scoring chances [8]. There could be various factors explaining the discrepancy of the results (e.g. sample size, RSA testing methods, participant motivation) [7]. In ice hockey, performance relies heavily on skating technique, which introduces variability in test outcomes. Laboratory testing may reduce these differences, but off-ice tests have often been questioned as poor predictors of on-ice performance [9]. Another factor is the game's frequent changes in direction, which increase energy demands [10]. Finally,  $\text{VO}_{2\text{ max}}$  testing on a treadmill or supine cycle ergometer may not be appropriate for ice hockey players [11].  $\text{VO}_{2\text{ max}}$  alone does not fully capture the intermittent, high-intensity ice hockey performance, assessment methods focusing on anaerobic power and repeated sprint ability have been increasingly emphasized. One of relatively widely used methods is Wingate Anaerobic Test (WT) [12]. The WT test consists of pedalling with maximal (all-out) effort for 30 seconds against a constant braking force. Many researchers have prolonged the duration to 60 seconds or even 120 seconds [13]. However, even the 30-seconds test is exhausting and does not allow to test the subject immediately with another load. Moreover, this effort does not correspond to the activity delivered by hockey players during their shifts that usually consists of a series of intermittent sprints within a short time that they spend on ice. Several authors proposed a series of short 5-7 seconds sprints for testing athletes such as hockey players [14,15]. Modified RSA tests are suitable for testing assessment of repeated anaerobic fitness [15], because the short sprint length and rest period reflect the demands of exertion and recovery during an ice hockey match [1].

This study aimed at addressing three questions, which have an affinity for the physiological demands of ice hockey:

- 1) Whether the laboratory measurements of  $\text{VO}_{2\text{ max}}$  are related to RSA tests as assessed by laboratory and on-ice testing.
- 2) Whether the laboratory and on ice methods of repeated sprint ability testing are related and comparable.
- 3) Whether the  $\text{VO}_{2\text{ max}}$  relates to recovery after the sprints as assessed by lactate level measurements subsequent to testing.

## 2. Materials and Methods

### 2.1. Design of the Research

Two groups of professional adult men ( $n = 45$ ) and one group of elite juniors ( $n = 19$ ) were invited to participate in the study. Since the study focused on the general performance characteristics of elite ice hockey players, the results from all three teams were combined and analyzed together in all analyses; no subgroup analyses were conducted. All three teams participate in the highest Czech ice hockey league. The testing was gradually carried out as part of probands final summer training for the autumn part of the league season. The average training time during the camp was cca 30 hours

per seven-day microcycle. All participants had one day of rest before being tested and were told to refrain from heavy exercise for 24 hours prior to their testing session.

To exclude a significant cardiovascular pathology, all subjects underwent a clinical examination, ECG assessment and a standard echocardiographic examination performed according to 2005 recommendation of the American Society of Echocardiography and European Association of Echocardiography using Vivid 7 equipment (General Electric Ultrasound, Horten, Norway). Body mass and composition were evaluated by InBody720 (InBody Co. Ltd., Seoul, Korea).

Cardiopulmonary exercise stress testing was performed on a supine ergometer Lode Excalibur (Lode Groningen, The Netherlands) using the Innocor P10 system (Innovision, Glamsbjerg, Denmark). The system was calibrated before each examination. The test was performed in a dedicated laboratory with temperature conditioned to 23°C. The lactate levels were measured using Lactate Pro device (Arkray Europe, Amstelveen, The Netherlands).

The laboratory RSA testing was performed using a modification of WT and bicycle sprint tests [16]. All participants were instructed to complete their typical individual off ice pre-training warm-up lasting approximately 10 minutes. Before test the position of the saddle was adjusted in line the subject's wishes, the subject's feet were strapped to the pedals [23]. The testing was initiated with a 5 minute warm-up using low intensity load of 1 W/kg. Then five series of simulated sprints were performed using the modified WT set to torque factor calculated as  $0.9 \times \text{subject's body weight}$ . Five repeated sprints of 5 seconds were interspersed by 10 seconds of recovery with unloaded pedaling. The test was followed by a 10-minute recovery period with a low-intensity workload of 0.5 W/kg, during which lactate sampling was performed at the 3rd, 5th, and 10th minute. After a one-minute technical transition (Fatigue index was calculated as time while maintaining acceptable physiological stabilization) a standardized cardiopulmonary exercise test was initiated, starting at 1 W/kg for 4 minutes, then 1.5 W/kg for 4 minutes, and subsequently increasing by 0.25 W/kg every 30 seconds until maximal exhaustion. The maximum lactate level was assessed 3 minutes after test completion.

The on-ice testing was offered to all players. Out of thirty-two who gave their consent, four goalies were excluded from the evaluation due to the limitations imposed by their gear. The test was performed within a week after the laboratory testing (the minimum interval of 2 days, maximum of 9 days). All participants were instructed to have their ice-skates sharpened and to complete their typical pre-game warm-up lasting approximately 10 minutes. The test on ice consisted of 5 maximal skating sprints between the goal line and the opposite blue line (approx. 34 meters), performed in full gear (including the hockey stick). The sprints lasted approximately 5 seconds with 10 seconds of passive recovery between the bouts. The time was measured using laser timer equipment. After completion, the lactate levels were measured at 3<sup>rd</sup> and 5<sup>th</sup> minute of a passive recovery. The sampling at 10<sup>th</sup> minute was not performed due to limited availability of instruments.

Fatigue index was calculated as a % decrement score  $[100 \cdot (\text{sprint value} / \text{best sprint value}) - 100]$ , where sprint values represented either the average workload from laboratory testing ( $\text{W} \cdot \text{kg}^{-1} \cdot 5\text{s}^{-1}$ ) or the sprint time (s) measured on ice. The maximum percentage decrement was calculated for laboratory testing as:

$$\frac{(\text{lowest workload} - \text{highest workload})}{\text{highest workload}} \times 100$$

and for on-ice testing as:

$$\frac{(\text{slowest sprint} - \text{fastest sprint})}{\text{fastest sprint}} \times 100.$$

Although this results in an asymmetric formulation, the choice of denominators reflects the different physiological and mechanical characteristics of the two protocols. Laboratory assessment is based on power output, where the highest workload represents the true maximal capacity and therefore serves as the most meaningful reference point. In contrast, on-ice performance is evaluated via sprint times, where the fastest (i.e., lowest) time best reflects maximal skating speed and thus provides the appropriate benchmark. This adaptation of the standard RSA methodology described by Glaister et



al. [17] was made to ensure that the fatigue metrics accurately capture performance decline within the specific constraints and measurement properties of each testing environment.

The study was conducted in accordance with the Declaration of Helsinki and approved by Ethics Committee of Faculty of Physical Education and Sport, Charles University on 25. 9. 2009 (no.: 332/2029). As part of the briefing on the research process, all participants signed an informed consent form agreeing to participate in the research.

2.2. Statistical Methods

The statistical analysis was carried out by using JMP 10.0.1 statistical package (SAS Institute, Cary, NC, USA). The results are given as mean value  $\pm$  standard deviations (SD). Data were analysed using Pearson’s or Spearman’s correlation tests, selected based on the distribution of the variables to ensure appropriate validity and reliability of the results. Correlation coefficients (r) were used to detect the association between the independent and dependent variable: values close to 0 indicate a weak association, approximately  $\pm 0.3$  a moderate association, and values above  $\pm 0.7$  a strong association. Paired t-test was used to compare pre and to post-exercise changes in monitored indicators on ice on-ice sprint and from the laboratory protocol, with each pair representing measurements taken from the same participant under both testing conditions.

In accordance with the standards used for this type of research for all statistical tests, an alpha level of  $p \leq 0.05$  was operationally defined as statistical significance.

3. Results

Laboratory testing was performed in 64 elite hockey players. Table 1 shows the main anthropometric, laboratory, echocardiographic and static spirometry values of the participants. We did not detect any significant pathological findings. All participants completed the entire study protocol. The results of cardiopulmonary exercise testing and repeated sprint testing are shown in Table 2.

**Table 1.** Anthropometric, laboratory, echocardiographic and static spirometry results in the entire study cohort (n = 64).

| Variable                                       | Mean $\pm$ SD   | Range      |
|------------------------------------------------|-----------------|------------|
| Age (years)                                    | 21.8 $\pm$ 4.9  | 17–35      |
| Anthropometric data                            |                 |            |
| Weight (kg)                                    | 84.9 $\pm$ 8.0  | 67.9–100.5 |
| Height (cm)                                    | 183.5 $\pm$ 5.4 | 173–195    |
| Body surface area (m <sup>2</sup> )            | 2.07 $\pm$ 0.12 | 1.86–2.31  |
| Body fat<br>(% of total body weight)           | 11.8 $\pm$ 3.9  | 4.3–23.9   |
| Active muscle mass<br>(% of total body weight) | 50.9 $\pm$ 2.4  | 42.9–55.1  |
| Blood count                                    |                 |            |
| Hemoglobin (g/L)                               | 155.7 $\pm$ 8.0 | 136–177    |
| Hematocrit (%)                                 | 45.0 $\pm$ 2.1  | 39–51      |
| Echocardiography                               |                 |            |
| LV mass index (g/m <sup>2</sup> )              | 86.8 $\pm$ 17.0 | 46.5–138.3 |
| Relative wall thickness                        | 0.33 $\pm$ 0.04 | 0.23–0.45  |
| LV EF (%)                                      | 65.6 $\pm$ 3.9  | 55–70      |
| TAPSE (mm)                                     | 26.9 $\pm$ 3.5  | 19–34      |
| Static spirometry                              |                 |            |
| FVC (L/min)                                    | 6.1 $\pm$ 0.7   | 5.1–8.3    |
| FVC (% of predicted)                           | 108.5 $\pm$ 9.7 | 90–133     |

LV – left ventricle; LV EF – left ventricle ejection fraction; TAPSE – tricuspid annular plane systolic excursion; FVC – forced vital capacity.

**Table 2.** Laboratory cardiopulmonary exercise stress testing and repeated sprint ability testing results (n = 64).

| Variable                                 | Mean ± SD   | Range     |
|------------------------------------------|-------------|-----------|
| Cardiopulmonary exercise stress test     |             |           |
| VO <sub>2</sub> max (ml/kg/min)          | 50.6 ± 4.4  | 40.0–61.0 |
| Maximal workload (W/kg)                  | 4.9 ± 0.4   | 4.0–5.8   |
| W170 (W/kg)                              | 3.5 ± 0.7   | 1.5–4.9   |
| Heart rate max (bpm)                     | 184.8 ± 7.9 | 169–214   |
| Anaerobic threshold (bpm)                | 164.0 ± 9.4 | 149–190   |
| Repeated sprint ability                  |             |           |
| Maximum lactate (mmol/L)                 | 9.3 ± 1.7   | 4.9–13.0  |
| Average workload 1st bout (W/kg/5 s)     | 15.3 ± 1.3  | 12.0–18.3 |
| Average workload 5th bout (W/kg/5 s)     | 12.5 ± 1.2  | 8.0–15.5  |
| % Workload decrement index (%)           | -9.8 ± 4.0  | -1.4—20.8 |
| % Maximum average workload decrement (%) | -18.6 ± 7.2 | -4.0—40.5 |
| Sum of workloads (W/kg/5×5 s)            | 69.4 ± 4.8  | 53.2–80.4 |
| Lactate levels during recovery (mmol/L)  |             |           |
| Lactate level 3rd minute (mmol/L)        | 6.7 ± 1.9   | 3.2–13.3  |
| Lactate level 5th minute (mmol/L)        | 8.1 ± 1.5   | 5.0–11.7  |
| Lactate level 10th minute (mmol/L)       | 7.2 ± 1.6   | 3.7–11.7  |

W170 – workload at HR 170 bpm.

3.1. Laboratory Testing Results

The VO<sub>2</sub> max values did not correlate with values obtained during the 1<sup>st</sup> bout, but correlated with average workloads during the 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> bout (r= 0.26, p=0.02; r=0.48, p<0.001; r=0.57, p<0.001; and r=0.60, p<0.001). There was a trend of an increasing correlation coefficient with the increasing number of repetitions. VO<sub>2</sub> max explained only 5% of the variability of the first bout but 35% variability of the last bout average workload.

There was a correlation between VO<sub>2</sub> max and the sum of workloads (r=0.49; p<0.001), and both fatigue indices - % Workload decrement index (r = 0.44, p<0.001) and % Maximum average workload decrement (%) (r=0.38, p=0.002). Only lactate levels which were measured after 10 minutes of recovery correlated with VO<sub>2</sub> max (r=0.31, p=0.01).

3.2. On-Ice Testing Results

Thirty-two athletes consented with the on-ice testing. To the comparison with laboratory testing, the four goalies were excluded as their gear is not allowing the same performance on ice as to field players. The respective data are shown in Table 3. Weak association was observed (r<0,3) between the VO<sub>2</sub> max and other laboratory testing results and the on-ice performance.

**Table 3.** On-ice testing results in field players (n = 28).

| Variable                 | Mean ± SD   | Range     |
|--------------------------|-------------|-----------|
| Repeated sprint ability  |             |           |
| Sprint time 1st bout (s) | 5.00 ± 0.28 | 4.43–5.51 |

|                                         |              |             |
|-----------------------------------------|--------------|-------------|
| Sprint time 5th bout (s)                | 5.22 ± 0.20  | 4.82–5.64   |
| % Sprint time increment index (%)       | 4.1 ± 1.56   | 1.3–7.8     |
| % Maximum sprint time increment (%)     | 8.3 ± 2.9    | 3.9–14.9    |
| Sum of sprint times (s)                 | 25.52 ± 0.81 | 24.03–26.95 |
| Lactate levels during recovery (mmol/L) |              |             |
| Lactate level 3rd minute (mmol/L)       | 10.0 ± 1.5   | 6.4–12.7    |
| Lactate level 5th minute (mmol/L)       | 10.1 ± 1.4   | 6.7–12.8    |

3.3. Comparisons Between Laboratory and On-Ice Testing Results

We did not find any significant correlation ( $r<0,3$ ) and effect size between the on-ice testing and the laboratory RSA test results. The lactate levels measured during the recovery in the laboratory and on ice did not correlate ( $r<0,3$ ). In within-subject (paired) comparisons, mean blood lactate concentrations were statistically significant higher in the on-ice condition by  $3.45 \pm 2.40 \text{ mmol}\cdot\text{L}^{-1}$  at the 3rd minute ( $p<0.001$ ) and by  $2.50 \pm 1.80 \text{ mmol}\cdot\text{L}$  at the 5th minute of recovery ( $p<0.001$ ).

Relative to on-ice testing, the same athletes exhibited greater reductions in fatigue indices during laboratory testing: the % decrement index decreased by  $4.3 \pm 4.8\%$  ( $p<0.001$ ) and the % maximum decrement by  $7.6 \pm 8.5\%$  ( $p < 0.001$ )

4. Discussion

Our study examined laboratory and on-ice testing in elite hockey players during the final summer training for the autumn part of the league season. The results show that aerobic capacity, reflected by  $\text{VO}_{2\text{max}}$ , is associated with performance in simulated repeated sprints. Aerobic capacity played an increasing role across repeated bouts during the modified anaerobic cycling test. While  $\text{VO}_{2\text{max}}$  explained only 5% of workload variation in the first bout, it explained 35% in the last bout.  $\text{VO}_{2\text{max}}$  was also correlated with recovery parameters predicting lactate levels at the 10th minute of recovery. However, the shared variance between  $\text{VO}_{2\text{max}}$  and recovery lactate was only about 10%. Although our data are seemingly supporting the role of  $\text{VO}_{2\text{max}}$  evaluation, the significance of the association between the laboratory RSA and the  $\text{VO}_{2\text{max}}$  is clearly insufficient for the assessment of an individual ice hockey player anaerobic performance. As a standalone indicator,  $\text{VO}_{2\text{max}}$  has limited predictive value for physiological predispositions in ice hockey. This is further supported by the observed lack of relationship between on-ice repeated sprints testing results and  $\text{VO}_{2\text{max}}$ . The low correlation may be due, for example, to different movement patterns used in testing (cycling vs. ice skating), as well as the involvement of different muscles, skill dependence, and pacing strategies. This finding agrees with previous reports [2,3]. However, these findings were recently put to test by Peterson et al. [7]. showed opposing results. It should be noted that the on-ice repeated shifts used in their study were substantially longer (about 23 seconds) than repeated sprints used in our study. These longer shifts may be more dependent on aerobic fitness. In addition, the participants performed up to 8 maximal skating bouts. Our laboratory testing results indicated that the relationship between aerobic fitness and simulated sprint results strengthens with increasing number of sprint repetitions. This hypothesis is supported by close relationship observed between “30-15 intermittent on-ice test” and  $\text{VO}_{2\text{max}}$  in the study by Buchheit and co-workers using 30 seconds shuttle skating interspersed with 15 seconds of passive recovery periods [18].

Another possible explanation for the different relationships between on-ice and laboratory testing could be the method used to measure  $\text{VO}_{2\text{max}}$ . Cycling on an ergometer does not reflect the typical physical effort of skating.  $\text{VO}_{2\text{max}}$  measured on ice has been shown to be higher than in laboratory settings, with no correlation between the two methods [11]. The positive results reported by Peterson et al. [7] were based on a skating treadmill and prolonged on-ice efforts. However, even this approach showed only a relatively weak relationship between  $\text{VO}_{2\text{max}}$  and on-ice measurements.

Many on-ice protocols have been proposed to test the ability of ice hockey players' in their natural environment [3,7,18]. We used a modified anaerobic strength testing protocols of short, repeated sprints in the laboratory settings and on ice [15]. Although both tests comprised similar duration length of effort and recovery times, the relationship between the two was only weak and nonsignificant. The absence of correlation between on-ice and laboratory testing may have been due to the different magnitude and complexity of the task [21]. The validity of RSA testing protocols requires careful consideration. These protocols differ substantially in design, duration, and recovery intervals, which affects their reliability and validity. In ice hockey, repeated sprint ability is influenced by factors such as skating technique, changes in direction, and game-specific fatigue patterns. Laboratory RSA tests may reduce variability between athletes but often fail to replicate the physiological and biomechanical demands of ice hockey.

Both tests represented anaerobic effort, as indicated by recovery lactate levels. However, on-ice testing was associated with higher blood lactate and appeared much more intense than efforts on the ergometer. In contrast, performance decrement over repeated sprints was significantly lower on ice than in the laboratory. This difference could be hypothesized to reflect the involvement of different muscle groups with distinct strength, energy handling, and metabolic characteristics shaped by prior training. This observation agrees with findings by Durocher et al. [11], who reported higher heart rate, lactate thresholds, and  $\text{VO}_{2\text{max}}$  during on-ice testing compared to laboratory conditions, with no correlation. Another interesting observation of our study arises from lactate measurements performed during the recovery. After 5 minutes of rest none of the hockey players showed lactate levels below 6 mmol/L and 50% of them had levels above 10 mmol/L. This suggests that during a typical match, players are unable to fully recover between shifts. Most game efforts are therefore performed at very high blood lactate levels. This observation agrees with intra-game measurements reported in hockey [20], rugby [21], and boxing [22]. It also indicates that repeated shifts during a game differ substantially from testing conditions, where tests usually start after a brief or fully aerobic warm-up.

The aim of our research was to analyze the test results of elite hockey players; for this reason, and given the scope of the study, we decided not to conduct separate analyses for the junior team and the two senior teams. Separate analyses, followed by a comparison of the results, could yield new insights into the differences in performance between juniors and seniors in the tests conducted.

There were several limitations to our study. Voluntary participation in on-ice testing introduces potential selection bias because on-ice test was completed by 28 field players, which may have reduced the statistical power and could partly account for the lack of a significant correlation. The merging of the analysis of the test results for juniors ( $n=19$ ) and men ( $n=45$ ) may have influenced the interpretation of the results. The 2–9 day interval between laboratory and on-ice testing may affect comparability. The short time between RSA testing and  $\text{VO}_{2\text{max}}$  testing may have affected  $\text{VO}_{2\text{max}}$  results due to residual fatigue. While the laboratory testing was performed within ideal conditions, the on-ice evaluation may have suffered by individual warm-up and uneven equipment and motivation of the players [23,24]. We should also admit the potential negative role of reduced number of players who gave their consent with the on-ice testing, decreasing the statistical power of the study. However, the main limitation may be related to the length of on-ice skating shifts chosen, including only a straight-line movement. Based on the recently published data, longer and more complex skating intervals may be more dependent on aerobic exercise fitness [7,18,25].

## 5. Conclusions

The results from our laboratory and on ice testing data confirm the role of aerobic fitness as assessed by maximum oxygen uptake ( $\text{VO}_{2\text{max}}$ ) capacity for the prediction of repeated anaerobic sprint ability and recovery. However, the shared variation of the different parameters with  $\text{VO}_{2\text{max}}$  did not exceed 35% making the individual prediction of subjects' anaerobic performance from  $\text{VO}_{2\text{max}}$  unreliable. Since we did not find any correlation between RSA and lactate levels during ice testing or



VO<sub>2 max</sub> values, we question the validity of VO<sub>2 max</sub> as a key parameter for assessing the fitness of ice hockey players in the context of the tests we conducted.

It seems that on-ice testing would bring more relevant data for a more accurate assessment and training modifications. To obtain optimal results, the relationship between different tests and long-term performance should be evaluated.

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**Availability Statement:** Data can be obtained from the corresponding author upon reasonable request.

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Abbreviations

The following abbreviations are used in this manuscript:

|                     |                         |
|---------------------|-------------------------|
| RSA                 | repeated sprint ability |
| VO <sub>2 max</sub> | maximum oxygen uptake   |
| WT                  | Wingate Anaerobic Test  |

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