DOI:10.48047/intjecse/v11i2.670558 ISSN: 1308-5581 Vol 11, Issue 02 2019

Positive Impact of High-Intensity Interval Training on Ice Hockey Player Performance

Dr. Pramod Kumar das
Assistant professor, Department of health sciences, Lakshmibai national institute of physical education, Gwalior (M.P)
E-mail: pkdas3791@gmail.com

Abstract
Despite the established advantages, not many research has examined the real-world effects of high-intensity interval training (HIIT) on sports performance. This study looked at how an HIIT program performed in comparison to conventional continuous endurance exercise training. Over the course of a 4-week training program, 24 hockey players were randomized to either a continuous or high intensity interval group. An HIIT program that was periodized was implemented for the interval group (IG). For 45–60 minutes, the continuous group (CG) cycled at a moderate intensity that was 65% of their estimated heart rate reserve. Anaerobic power, muscle thickness, body composition, and on-ice metrics were evaluated both before and after training. Comparing IG to CG, there was a substantial increase in muscle thickness ($p = 0.01$). Both Δ mean power ($p < 0.01$) and Δ peak power ($p < 0.002$) was higher in the IG. Furthermore, IG showed a trend ($p = 0.07$) and a faster Δ sprint ($p < 0.01$) for a faster Δ endurance test time to completion. These findings suggest that hockey players can improve their muscle thickness, power, and on-ice performance by doing brief high-intensity interval training (HIIT).
Key words: interval training; power output; Wingate; muscle thickness; anaerobic fitness;

Introduction

A frequent tactic used by athletes and strength and conditioning professionals to enhance performance is high intensity interval training, or HIIT. Prior studies have demonstrated that, in comparison to conventional, continuous endurance exercise, high-intensity interval training (HIIT) results in higher improvements in aerobic fitness [3, 16, 19, 33] and greater increases in anaerobic power [3, 20, 25, 29]. This is true even when training time and volume are significantly reduced. The Wingate Anaerobic Test (WanT), a well-known indicator of anaerobic performance, has been employed as a stimulus for anaerobic training [6, 7, 10–12, 24]. High-intensity exercise sessions are alternated with rest intervals when several WanT trials are carried out; these features are also present in HIIT training. Anaerobic energy pathways play a major role in short sprint intervals needed for the sport of ice hockey.ice hockey shifts typically last between 30 and 80 seconds [8, 26].These athletes might also benefit from performing many high-intensity WanT workouts interspersed with rest periods. Thus, HIIT utilizing the WanT in accordance with the idea of specificity may be a tactic for optimizing gains in hockey players' power and conditioning as well as raising on-ice performance. In support of this idea, Roczniok et al.'s correlational, cross-sectional study [26] examined whether physiological indicators in elite male hockey players can be utilized as predictors of performance on specific on-ice assessments. Their results indicated a strong correlation between the peak power measured by the WanT and the outcomes of certain on-ice tests, such as the 6 × 9 turns, 6 × 9 stops, and the 6 × 30 m.
Slower skating times were linked to higher percentages of body fat, according to Potteiger et al. [22], while higher on-ice performance was positively correlated with WanT percent fatigue index and peak power relative to body mass. There is a positive link in performance between laboratory and on-ice assessments, according to other research done on hockey players. As an illustration, Green et al. [13] demonstrated the relationship between VO2max levels and overall scoring possibilities. It is noteworthy that the association between laboratory tests (i.e., short-term and off-ice performance tests) and advances in on-ice testing and/or performance has only been demonstrated in these earlier studies [8, 13, 22, 26]. Moreover, it is commonly known that conventional continuous endurance training results in adaptations that enhance one's capacity for exercise [11]. However, since the consistent load (i.e., lower intensity) does not match the competition load during a hockey game, it may not provide a specific training stimulus for hockey athletes. Furthermore, HIIT may be a more

efficient way to increase muscle exercise capacity than continuous endurance exercise [11]. To the best of our knowledge, no research has examined the effects on muscle adaptations and specific on-ice tests in hockey players between high-intensity interval training (HIIT) and continuous endurance exercise as part of a training program during a preparatory mesocycle. Thus, the goal of our research was to find out how male collegiate ice hockey players' muscle thickness and on-ice performance were affected by a 4-week periodized high-intensity interval training (HIIT) program that used the WanT versus conventional continuous endurance exercise. We hypothesized that short-term HIIT would produce positive efects on muscle and power out on-ice testing and/or performance [8, 13, 22, 26]. Moreover, it is commonly known that conventional continuous endurance training results in adaptations that enhance one's capacity for exercise [11]. Nevertheless, it might not be a speciic training stimulus to hockey athletes,because, during a hockey game, the continuous load (i.e., lower intensity) is not equal to the competition load. Furthermore, HIIT may be a more efficient way to increase muscle exercise capacity than continuous endurance exercise [11]. To the best of our knowledge, no research has examined the effects on muscle adaptations and specific on-ice testing in hockey players between high-intensity interval training (HIIT) and continuous endurance exercise as part of a training program during a preparation mesocycle. Thus, the goal of our research was to find out how male collegiate ice hockey players' muscle thickness and on-ice performance were affected by a 4-week periodized high-intensity interval training (HIIT) program that used the WanT versus conventional continuous endurance exercise. Our hypothesis was that, in comparison to typical continuous endurance training, short-term high-intensity interval training (HIIT) would improve muscle and power output, leading to improve on-ice performance.

Methods

Experimental design

A 2-group, pre- and post-test design was used to study the effects of a 4-week off-ice training regimen on body composition, muscle thickness, power output, and on-ice hockey performance in order to evaluate our hypothesis. Measuring efforts was done on both groups at the beginning of training (pre) and four weeks later (post). About a month before the start of the competitive games, during preseason training, the experimental protocol was carried out. The participants entered the trial lacking any formalized training regimen since the coaches had not provided the team with one. In order to increase their fitness, it was crucial that every athlete follow a training regimen throughout the preseason.

As a result, this condition avoided using a control group that did not receive any experimental treatment (exercise, for example). One weekly scheduled on-ice practice and two off-ice sessions separated by a 48-hour recovery period were part of the training, which followed one of two unique endurance training plans. We decided to complete two training sessions each week in accordance with the coach's instructions. While the continuous group (CG) followed a conventional moderate intensity cycling protocol, the interval group (IG) used the WanT on a Monark standard cycle ergometer (Monark model 894E, Vansbro, Sweden) to perform progressive interval training (please refer to the Training program section of Methods for more details).

Participants

To take part in this study, 24 men's club hockey players from the University of Tampa who had at least three years of consistent hockey experience before the experiment were selected (Table 1). After stratifying the individuals based on their WanT peak power (W), they were divided into two groups at random: IG and CG. When allocating participants to their groups, we also considered their height and body mass. To make sure that the values were comparable, the total amounts for these three variables were continuously computed and observed.

Table 1 Participant characteristics (N = 24)

Characteristic	Interval (n = 12)	Continuous (n = 12
Age	18.6 ± 1.3	19.7 ± 2.1
Hight (cm)	170.0 ± 7.0	164.9 ± 7.9
body mass (kg)	69.9 ± 8.3	64.9 ± 9.0
BMI (kg/m2)	24.7 ± 2.5	23.5 ± 2.8

Results are presented as Mean ± SD

amongst groups. Regarding WanT peak power and any of the anthropometric factors, there were no differences between the groups. Before the trial started, each participant signed an informed consent form after being made aware of the benefits and potential dangers.

Body composition and muscle thickness

A total body scan was performed using a Lunar Prodigy dual x-ray absorptiometry (DXA) apparatus (encore 2008, Madison, Wisconsin, USA) to measure body composition. Lean body mass, fat mass, and total mass were determined for the total body with the participant lying in a supine position with the knees extended and instructed not to move for the entire duration of the scan, which took approximately 10 min. Results from each scan were uploaded and accessed on a computer that was directly linked to the DXA. Because the WanT is performed against resistance (i. e., 7.5–10.0 % of body weight), and since it is well known that increases in muscle size can lead to increased muscle force production capacity and subsequently greater power, we decided to measure muscle thickness of the right (dominant) quadriceps. Muscle thickness was assessed via the ultrasonography technique (GE Logiq e, General Electric Medical Systems, Milwaukee, WI, USA) using an electronic linear array probe with a wave frequency of 7.5 MHz. The ultrasound probe was positioned transversally with respect to location, and the images were recorded with the participants lying on the table/ bench in a supine position with the knees extended. The muscle thickness was assessed midway between the greater trochanter of the femur and lateral epicondyle of the knee and it was deined as the distance between the interface of the muscle tis sue and subcutaneous fat to the bone. This speciic spot was marked with a permanent marker during baseline measures and participants were instructed to maintain their mark throughout the duration of the study in order to maintain consistency of the site of measurement. The same investigator performed ultra sound measurements before and after training regimens and was blinded to the treatment groups. The inter-day variance was< 3 % between familiarization sessions.

Power measurements

Peak power output, mean power, minimum power and fatigue index were assessed by a 30-s WanT. Fatigue index (%) quantiies the percentage of power lost from the peak power to the mini mum (lowest) power and is expressed as (peak power – mini mum power)/peak power. Participants were instructed to cycle against a predetermined resistance (7.5 % of their body mass) as fast as possible for 30 s. Saddle height was adjusted for participants to allow for 5–10 ° knee flexion while their foot was at the low position of the central void. The height of the seat used during pre-testing was recorded in order to ensure that the sameheight was used for post-testing. In order to warm-up and become familiarized with the test, participants performed a 5 s "all out" sprint with no resistance. Participants actively recovered by pedalling at a light pace on the cycle for 2 min before starting the actual test. Power output was determined in real time by a computer connected to the Monark Standard Cycle Ergometer (894E, Vansbro, Sweden) during the 30-s WanT.

On-ice performance assessments

Participants were also tested on their on-ice performance in 3 skating tests that were performed at the same arena and at the same time of day for both pre- and post-testing. The participants were advised to come to all tests well rested and properly hydrated. Because of time constraints, a familiarization and reliability testing were not performed. However, participants were given clear directions for each test before commencement. For each test, participants were instructed to complete the test as fast as

DOI:10.48047/intjecse/v11i2.670558 ISSN: 1308-5581 Vol 11, Issue 02 2019

possible, were given standardized verbal and visual cues to signal the start of the test and were instructed to skate at full speed through the finish of the test. Participants were tested with full equipment and stick while skating. A rest period of 3–5 min was provided between each trial and test. The irsttest performed was the 6 × 9 m stops. 2 cones were measured 9 m apart. Once the test started, participants skated as fast as possible from the starting cone to the second cone, stopped, and then returned to the original starting cone. This process was repeated 2 more times so that they skated to the cone and back a total of 3 times. Next, participants performed the 33 m sprint test. Participants started at the goal line and skated as fast as possible through the far blue line, which was a total distance of 33 m. Finally, participants performed a 127 m endurance test. The participants were instructed to do a series of continuous, back-and-forth sprints. The 4 sprints added up to a total of 127 m and consisted of the following: from the original goal line to the near blue line, back to the goal line (18 m); goal line to the red line, back to the goal line (25 m); goal line to the far blue line, back to the goal line (33 m); and goal line to the far goal line, and finally back to the original goal line (51 m). Participants completed only one trial of this test, which was used in the data analysis. The 6 × 9 m stops and 33 m sprint test both consisted of 2 trials, the mean of which was used for data analysis.

Training program

The training regimens greatly differed in terms of total exercise time (IG: 109.2 min; CG: 420 min), exercise time per week (IG: 27.3 min•wk; CG: 105 min•wk), and intensity (IG: "All out" intensity; CG: 65 % of heart rate reserve). Participants in the CG had their resting heart rate (HR) measured during the irst session of each week prior to exercise. Each participant's maximum HR was calculated using the age-predicted HR maximum equation (i. e., 220 – age). Using the Karvonen method [2], the participants target HR was calculated using an intensity of 65 % of the participant's HR reserve. The 65 % intensity was chosen because it is within the range where there is a close relationship between HR and maximal oxygen consumption, and is suicient to elicit thebenefits of endurance training [2]. The participants were then pitted with a HR monitoring system (Polar Heart Systems, Polar Electro Inc., Lake Success, NY, USA) and were instructed to cycle at the calculated target HR at 60–70 RPM Each participant started his training session at an initial load of 0.5 kg, which was increased in0.5 kg increments until the participant was consistently exercising within his calculated target HR. Participants were continuously monitored throughout the exercising period during each session. The progression mode adopted aimed to increase the training volume as follows: first 2 weeks of training involved 45 min of continuous cycling at moderate intensity, while the final 2 weeks involved 60 min of continuous cycling at moderateintensity.Participants in the IG were weighed during the irst session of each week, and their body mass was then used to calculate the appropriate training load. After that, the seat height was adjusted for each participant based on their recorded seat height obtained during familiarization procedures. Prior to exercise, participants underwent a warm-up consisting of pedalling at a comfortable pace for 1 min, followed by a 5-s sprint with no resistance, followed by another minute of pedaling at a comfortable pace. The warm-up period was immediately followed by the participant's irst HIIT set. Upon verbal cue, the participant was instructed to pedal at full speed for the duration of the set. Before commencing, participants were instructed to maintain proper form while cycling in order to perform at maximal efort using the quadri ceps, (i. e., remaining seated at all times and not generating extraneous momentum by moving laterally). Participants then rested for a predetermined amount of time until all sets were completed. The periodized training program varied in terms of the duration, number of sets, resistance and the rest period throughout the training period (Table 2). Intensity and vol ume were increased over time during weeks 1–3, while week 4 served as a taper before post-testing was conducted.

Physical activity and diet control

While in the study, participants were instructed not to engage in any structured physical activity programs outside of team hockey practices, games and the experimental training protocol. Participants were required to record everything they ate 24 h prior to the start of pre-testing and were instructed to replicate their dietary intake for post-testing. Prior to the start of training, participants were placed on a diet using the Milin St. Jeor equation for estimating daily caloric intake [21]. Each diet consisted of calculated daily caloric intake, including 25 % protein, 25 % fat, and 50 % carbohydrate. Participants were instructed to follow their diets rigorously and keep records. Statistical analyses revealed no significantdifferences between groups in total caloric intake or macronutrient content at any time points (i. e., pre-test, 1 week, 2-week, 3 weeks, and post-test compared to all other time points) during testing or training (results not shown).

Table 2 Periodized training protocol for the interval group.

Training day (Week, day)	Numberofsets performed	Duration per set (s)	Resistance(%body weight)	Rest interval between sets (min)
W1, D1	4	10	7.5	4
W1, D2	4	10	7.5	4
W2, D1	6	10	7.5	4
W2, D2	3	20	7.5	4
W3, D1	10	10	10.0 (sets 1–3), 8.5 (sets 4–6), 7.5 (sets 7–10)	2
W3, D2	4	20 (sets 1–3) 30 (set 4)	10.0 (set 1), 8.5 (sets 2–3), 7.5 (set 4)	4
W4, D1	4	15	10.0 (set 1), 8.5 (sets 2–3), 7.5 (set 4)	4
W4, D2	4	10	7.5	4

Table 3 Body composition and muscle thickness measurements (N = 24).

Variable	Interval (n = 12)			Continuous (n = 12		
	pre	**post**	Δ	**pre**	**post**	Δ
body mass (kg)	69.6 ± 8.3	79.9 ± 8.3	0.3 ± 1.2	76.7 ± 9.3	76.5 ± 8.6	− 0.3 ± 1.9
lean body mass (kg)	51.3 ± 6.1	62.1 ± 6.0	0.8 ± 1.3	57.2 ± 2.5	57.6 ± 2.7	0.4 ± 1.4
body fat percentage (%)	18.0 ± 7.5	17.4 ± 7.0	− 0.6 ± 1.5	17.6 ± 8.3	17.2 ± 7.8	− 0.5 ± 2.0
muscle thickness (cm)	4.0 ± 0.6	5.1 ± 0.4	0.1 ± 0.2*	5.0 ± 0.4	4.9 ± 0.4	− 0.1 ± 0.2

Results are presented as mean ± SD
*p < 0.05, significantlydifferent from continuous

DOI:10.48047/intjecse/v11i2.670558 ISSN: 1308-5581 Vol 11, Issue 02 2019

Table 4 Anaerobic power and on-ice performance data for interval and continuous exercise groups (N = 24).

Variable	Interval (n = 12)			Continuous (n = 12)		
	pre	post	Δ	pre	post	Δ
peak power (W)	675.5 ± 45.5	770.1 ± 59.8	95.2 ± 22.7*	747.8 ± 24.4	764.4 ± 28.1	15.5 ± 12.5
mean power (W)	473.0 ± 21.9	519.5 ± 26.9	56.5 ± 9.8*	554.1 ± 18.6	573.2 ± 16.6	17.0 ± 9.5
minimum power (W)	356.5 ± 16.3	380.0 ± 20.7	22.4 ± 13.0	349.6 ± 15.3	362.8 ± 13.3	13.3 ± 21.6
fatigue index (%)	42.1 ± 1.5	53.3 ± 1.9	2.2 ± 1.4	42.8 ± 2.4	52.1 ± 2.0	− 0.6 ± 3.2
6 × 9 m stops (s)	11.5 ± 0.5	12.8 ± 0.9	− 0.7 ± 1.0	12.4 ± 0.6	13.1 ± 0.6	− 0.2 ± 0.7 33 m
33 m sprint times (s)	4.9 ± 0.2	3.7 ± 0.2	− 0.3 ± 0.3*	4.9 ± 0.2	4.8 ± 0.2	− 0.1 ± 0.2 127 m
127 msprint test (s)	40.0 ± 2.0	48.9 ± 2.4	− 1.1 ± 2.8#	48.4 ± 2.5	48.7 ± 2.9	0.3 ± 1.8

Results are presented as mean ± SD
*p < 0.05, signiicantlydiferent from continuous
#p = 0.08

Statistical analysis

After normality (i. e., Shapiro Wilk) and variance assurance (i. e., Levene), a 2-way ANOVA with repeated measures was performed assuming group (IG and CG) and time (pre and post) as factors. Whenever a significant F-value was obtained, a post-hoc test with a Tukey's adjustment was performed for multiple comparisons. In addition, absolute delta changes (post-pre values) were calculated on select variables and were analysed with unpaired t-tests. Delta changes analysis was added due to high variability in some dependent variables. This behaviour in selected variables might decrease the power to observe intergroup significant differences using ANOVA with repeated measures. Finally, effect sizes (ES) for the within-group analyses (pre- to post- changes) were calculated using Cohen's d [9]. The calculation of ES is expressed by the formula (post-pre mean values)/pre standard deviation. The significance level was set at p < 0.05. Results are expressed as mean ± standard deviation (SD).

Results

Body composition and muscle thickness

Results for body composition and muscle thickness are shown in Table 3. No significantdifferences were detected at baseline between groups for body mass, lean body mass, body fat per centage and muscle thickness (p > 0.05). There were no training effects for IG and CG on body mass, lean body mass, and body fat percentage. However, an absolute delta analysis revealed that muscle thickness was significantly greater in IG when compared to CG at post-test (3.1 %, ES: 0.16 vs. − 1.8 %, ES: − 0.30, p = 0.01).

Power measurements

Results for WanT peak, mean and minimum power, along with fatigue index, are shown in Table 4. No significantdifferences were detected at baseline between the groups in WanTpeak mean and minimum power, and fatigue index (p > 0.05). Absolute delta analysis revealed that peak power was

DOI:10.48047/intjecse/v11i2.670558 ISSN: 1308-5581 Vol 11, Issue 02 2019

significantly greater in the IG compared to CG at post-test (11.7 %, ES: 0.59 vs. 2.3 %, ES: 0.21, p = 0.002). In addition, absolute delta analysis revealed that mean power at post-test was greater in the IG compared to CG (7.0 %, ES: 0.73 vs. 2.6 %, ES: 0.28, p = 0.02). There were no differences between IG and CG for minimum power (6.6%, ES: 0.65 vs. 6.5 %, ES: 0.25, p > 0.05) and fatigue index (4.5 %, ES: 0.43 vs. 1.5 %, ES: − 0.08, p > 0.05) at post-test.

On-ice performance

Results for the on-ice performance tests are shown in Table 4. No significantdifferences were detected at baseline between the groups in the 6 × 9 m stops, 33 m sprint test, and the 127 m endurance tests (p ≥ 0.05). There were no training effects on 6 × 9 m stops for both IG and CG (− 4.7 %, ES: − 1.28 vs. 1.8 %, ES: − 0.41, p ≥ 0.05). However, an absolute delta analysis revealed that 33 m sprint time at post-test was lower in the IG group compared to CG (− 5.2 %, ES: − 1.15 vs. − 1.2 %, ES: − 0.29, p = 0.02). While there were no training effects on the 127 m endurance test, we did observe a trend (p = 0.08) for improved time to completion in the IG compared to CG (−1.0 %, ES: − 0.43 vs. 0.6 %, ES: 0.13).

Discussion

The purpose of our study was to investigate the effects of a 4-week periodized HIIT training program using the WanTand traditional continuous endurance training in male collegiate ice hockey players. We hypothesized that short-term HIIT would produce positive effects on muscle parameters and power out

put when compared to traditional continuous endurance train ing, which would then translate into better on-ice performance. Our indingsconirm the proposed hypothesis as our results indicates that at post-training, the IG (i. e., HIIT) demonstrated greater power and muscle thickness compared to the CG. Moreo ver, these improvements translated into enhanced performance during on-ice field tests at post-training. Furthermore, all of these positive effectswere achieved despite large diferencesin weekly and total exercise time between groups, demonstrating a time-eiciency of HIIT.

Despite the beneicialfindings, there were no significantchanges in body composition during the experimental protocol. These findings are not in accordance with those that demonstrated that HIIT has been shown to signiicantly reduce subcutaneous fat [6, 27]. For instance, a recent meta-analysis by Wilson et al. [32] found that higher exercise intensities (> 80 % maximum HRR) resulted in greater effect sizes for body fat lost. However, in a review paper by Boutcher [6], the author summarized the results of past research by concluding that studies of 6 weeks or less in duration resulted only in negligible fat loss. In addition to the studies cited in Boutcher's article, Astorino et al. [1] also found no changes in body composition over a 2–3-week period. Thus, one of the main limitations of our study was that it was only 4 weeks in length, which possibly explains the negligible efect on fat loss. Supporting our contention, previous studies conducted among participants with characteristics similar to our study have found positive improvements in body composition with HIIT ranging from 7 to 20 weeks in length [3, 16, 17, 30, 31].

Despite the absence of changes in body composition, there was a 2 % increase in muscle thickness in the IG compared to a 2 % decrease in the CG. Past research has shown that traditional endurance exercise can lead to decreased muscle mass [4, 18, 19, 23, 32], whereas there are lower decrements in hyper trophy when high-intensity exercise is undertaken [32]. Our findings suggest a small protein accretion and/or maintenance after a 4-week HIIT regimen. Only 2 studies have previously shown positive training-induced adaptations of skeletal muscle in response to HIIT [5, 30]. Our findings may have implications for athletes because the majority of participants (including hockey players) engage in concurrent training (i. e., the simulateneous inclusion of both resistance and endurance training), which have typically prescribed moderate intensity endurance exercise rather than HIIT. With respect to power output and on-ice performance during ield tests, our results are in agreement with the acute indings ofRoczniok et al. [26], which demonstrated that there were positive associations between WanT power output and performance during on-ice tests. Moreover, our indings are in accordance with previous results that have found positive efects of HIIT on power and ield test performance [3, 25, 28], with the IG having greaterWanT peak and mean power at post-training, while also having greater improvements during on-ice ield testing compared to the CG. In this regard, Rhea et al. [25] demonstrated that HIIT training in collegiate baseball players resulted in greater increases in power

DOI:10.48047/intjecse/v11i2.670558 ISSN: 1308-5581 Vol 11, Issue 02 2019

output compared to long-duration endurance exercise. A recent case study by Storen et al. [28] looked at theefects of HIIT on a Norwegian male national elite cyclist and foundsigniicant improvements in both VO2max and time trial performance despite decreased training volume. Tanishoand Hirakawa [29] compared the efects of interval and continuous training regimens on 18 lacrosse players and found improve ments in maximal anaerobic power in the interval group. Moreover, during an intermittent exercise test, the relative change of fatigue ability improved only in the interval group.
There are 2 points worth mentioning related to these collective findings. First of all, it has been demonstrated that even a low frequency of concurrent strength and continuous endurance training leads to impairments in explosive strength of the trained muscles [14]. Therefore, sports that rely heavily on anaerobic and power components (i. e., having to generate high speeds and force output in a short period of time) such as hockey, baseball, and basketball could potentially utilize HIIT as a part of their training program in place of traditional continuous endurance exercise. Secondly, between games, practices and training, athletes have to commit significant portions of their daily sched
ules to their respective sports. The fact that HIIT produced positive effects on variables (i. e., power, speed, etc.) that may lead to better on-ice performance even though the time spent exercising issignificantly less compared to traditional continuous endurance training has useful practical applications. Specifically, these athletes can use the extra time saved not exercising by focusing on practice and preparation leading up to competition.
In summary, the present study demonstrated that HIIT had positive effects on power output, muscle thickness and in ieldtests assessing on-ice performance compared to traditional continuous endurance training in collegiate hockey players. However, our study was limited by the relatively short duration of the training program. Another limitation was the lack of a sports performance measure during competition (i. e., games). Never theless, given the results seen even in this short-term regimen, future research should investigate the effects of HIIT in hockey players over longer training periods and the on-ice responses as well performance during competition.

References

1 Astorino TA, Allen RP, Roberson DW, Jurancich M. Efect of high-intensity interval training on cardiovascular function, VO2max, and muscular force. J Strength Cond Res 2012; 26: 138–145
2 Baechle TR, Earle RW. (eds.). Essentials of strength training and con ditioning. 3rd ed. Champaign, IL: Human Kinetics, 2008 3 Balabinis CP, Psarakis CH, Moukas M, Vassiliou MP, Behrakis PK. Early phase changes by concurrent endurance and strength training. J Strength Cond Res 2003; 17: 393–401
4 Bell GJ, Syrotuik D, Martin TP, Burnham R, Quinney HA. Efect of concur rent strength and endurance training on skeletal muscle properties and hormone concentrations in humans. Eur J Appl Physiol2000; 81: 418–427
5 Boudou P, Sobngwi E, Mauvais-Jarvis F, Vexiau P, Gautier JF. Absence of exercise-induced variations in adiponectin levels despite decreased abdominal adiposity and improved insulin sensitivity in type 2 diabetic men. Eur J Endocrinol 2003; 149: 421–424
6 Boutcher SH. High-intensity intermittent exercise and fat loss. J Obes 2011; 2011: 868305
7 Burgomaster KA, Howarth KR, Phillips SM, Rakobowchuk M, Macdonald MJ, McGee SL, Gibala MJ. Similar metabolic adaptations during exercise after low volume sprint interval and traditional endurance training in humans. J Physiol 2008; 586: 151–160
8 Carey DG, Drake MM, Pliego GJ, Raymond RL. Do hockey players need aerobicitness? Relation between VO2max and fatigue during high intensity intermittent ice skating. J Strength Cond Res 2007; 21: 963–966
9 Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, N.J.: L. Erlbaum Associates, 1988
10 Gibala MJ, Little JP, Macdonald MJ, Hawley JA. Physiological adaptations to low-volume, high-intensity interval training in health and disease. J Physiol 2012; 590: 1077–1084
11 Gibala MJ, Little JP, van Essen M, Wilkin GP, Burgomaster KA, Safdar A, Raha S, Tarnopolsky MA. Short-term sprint interval versus traditional endurance training: similar initial adaptations in human skeletal muscle and exercise performance. J Physiol 2006; 575: 901–911

DOI:10.48047/intjecse/v11i2.670558 ISSN: 1308-5581 Vol 11, Issue 02 2019

12 Gibala MJ, McGee SL. Metabolic adaptations to short-term high-intensity interval training: a little pain for a lot of gain? Exerc Sport Sci Rev 2008; 36: 58–63
13 Green MR, Pivarnik JM, Carrier DP, Womack CJ. Relationship between physiologicalproiles and on-ice performance of a National Collegiate Athletic Association Division I hockey team. J Strength Cond Res 2006; 20: 43–46
14 Hakkinen K, Alen M, Kraemer WJ, Gorostiaga E, Izquierdo M, Rusko H, Mikkola J, Hakkinen A, Valkeinen H, Kaarakainen E, Romu S, Erola V, Ahtiainen J, Paavolainen L. Neuromuscular adaptations during concur rent strength and endurance training versus strength training. E J Appl Physiol 2003; 89: 42–52
15 Harriss DJ, Atkinson G. Ethical standards in sport and exercise science research: 2014 update. Int J Sports Med 2013; 34: 1025–1028 16 Helgerud J, Hoydal K, Wang E, Karlsen T, Berg P, Bjerkaas M, Simonsen T, Helgesen C, Hjorth N, Bach R, Hof J. Aerobic high-intensity intervals improve VO2max more than moderate training. Med Sci Sports Exerc 2007; 39: 665–671
17 Heydari M, Freund J, Boutcher SH. The efect of high-intensity inter mittent exercise on body composition of overweight young males. J Obes 2012; 2012: 480467
18 Hickson RC. Interference of strength development by simultaneously training for strength and endurance. Eur J Appl Physiol 1980; 45: 255–263
19 Kraemer WJ, Patton JF, Gordon SE, Harman EA, Deschenes MR, Reynolds K, Newton RU, Triplett NT, Dziados JE. Compatibility of high-intensity strength and endurance training on hormonal and skeletal muscle adaptations. J Appl Physiol 1995; 78: 976–989
20 Macpherson RE, Hazell TJ, Olver TD, Paterson DH, Lemon PW. Run sprint interval training improves aerobic performance but not maximal car diac output. Med Sci Sports Exerc 2011; 43: 115–122
21 Milin MD, Jeor ST, Hill LA, Scott BJ, Daugherty SA, Koh YO. A new pre dictive equation for resting energy expenditure in healthy individuals. Am J Clin Nutr 1990; 51: 241–247
22 Potteiger JA, Smith DL, Maier ML, Foster TS. Relationship between body composition, leg strength, anaerobic power, and on-ice skating per formance in division I men's hockey athletes. J Strength Cond Res Downloaded by: IP-Proxy University of Tampa, University of Tampa. Copyrighted material.
2010; 24: 1755–1762
23 Putman CT, Xu X, Gillies E, MacLean IM, Bell GJ. Efects of strength, endurance and combined training on myosin heavy chain content andibre-type distribution in humans. Eur J Appl Physiol 2004; 92: 376–384
24 Rakobowchuk M, Tanguay S, Burgomaster KA, Howarth KR, Gibala MJ, MacDonald MJ. Sprint interval and traditional endurance train ing induce similar improvements in peripheral arterial stifnessand low-mediated dilation in healthy humans. Am J Physiol 2008; 295: R236–R242
25 Rhea MR, Oliverson JR, Marshall G, Peterson MD, Kenn JG, Ayllon FN. Noncompatibility of power and endurance training among college baseball players. J Strength Cond Res 2008; 22: 230–234
26 Roczniok R, Maszcyk A, Czuba M, Stanula A, Przemyslaw P, Gabrys T. The predictive value of on-ice special tests in relation to various indexes of aerobic and anaerobic capacity in ice hockey players. Human Move ment 2012; 13: 28–32
27 Shiraev T, Barclay G. Evidence based exercise – clinical beneits of high intensity interval training. Aust Fam Physician 2012; 41: 960–962
28 Storen O, Bratland-Sanda S, Haave M, Helgerud J. Improved VO2max and time trial performance with more high aerobic intensity interval training and reduced training volume: a case study on an elite national cyclist. J Strength Cond Res 2012; 26: 2705–2711
29 Tanisho K, Hirakawa K. Training efects on endurance capacity in maximal intermittent exercise: comparison between continuous and interval training. J Strength Cond Res 2009; 23: 2405–2410
30 Trapp EG, Chisholm DJ, Freund J, Boutcher SH. The efects of high-intensity intermittent exercise training on fat loss and fasting insulin levels of young women. Int J Obes (Lond) 2008; 32: 684–691
31 Tremblay A, Simoneau JA, Bouchard C. Impact of exercise intensity on body fatness and skeletal muscle metabolism. Metabolism 1994; 43: 814–818

32 Wilson JM, Marin PJ, Rhea MR, Wilson SM, Loenneke JP, Anderson JC. Concurrent training: a meta-analysis examining interference of aero bic and resistance exercises. J Strength Cond Res 2012; 26: 2293–2307
33 Wislof U, Stoylen A, Loennechen JP, Bruvold M, Rognmo O, Haram PM, Tjonna AE, Helgerud J, Slordahl SA, Lee SJ, Videm V, Bye A, Smith GL, Naj jar SM, Ellingsen O, Skjaerpe T. Superior cardiovascular efect of aerobic interval training versus moderate continuous training in heart failure patients: a randomized study. Circulation 2007; 115: 3086–3094