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Original Article

Effect of the off-season training on the physical profile in U18 elite male ice hockey players

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Abstract
This retrospective study evaluated the effect of the off-season training on the physical performance changes in elite male ice hockey players U18 (junior team under 18 years). The present study secondarily established the physical profile of these players according to their playing position. The off-ice tests: 60 m sprint (s), 6x9 m run (s), 400 m run (s), 1500 m run (s), standing long jump (cm) and 1 RM bench-press (kg) were assessed before and after of training. In addition, individual values of the monitored parameters were divided and compared according to gaming position. Off-season intervention led to significant improvements in running performance in 6x9 m (P<.001; d=0.86), 400 m (P<.001; d=0.41), and 1500 m (P=0.001; d=0.38). The forwards demonstrated significant improvements in 6x9 m (P<.001; d=1.29), 400 m (P=0.001; d=0.39), and 1500 m run (P=0.002; d=0.62) following off-season training. The defenders demonstrated significant improvement only in 400 m run (P=0.03; d=0.45) following off-season training. Pre to post-season changes (Δ) in 6x9m (P=0.01; d=0.55) were found between forwards and defenders. The off-season training seems to be an effective training regimen inducing significant improvements in running performance. However, this training failed to show significant improvements in physical performance in other tests. Results of this study identify physical factors that need to be improved in the pre-season period in players.
Key Words: off-ice tests, physical performance, positional physical profile, off-season, retrospective study

Introduction

The off-season period in elite players is usually brief about 6 weeks and generally involves an individual or club-determined conditioning programs (Burke et al., 2006). Off-season training is an integral part of year-round preparation and it has a relevant role in maintaining high level of performance during the entire hockey season (Cox et al., 1995; Buck, 2013). Off-season conditioning is the training phase that is structured to enhance lean muscle mass, peak strength, peak power, peak aerobic and anaerobic profiles (MacLean, 2008). In addition to enhancing performance, off-ice training also provides a much-needed break from the ice after a long season (Géczi, 2009). Studies dealing with ice hockey vary in seasonal timing. There is no doubt that off-season training has become more advanced, but there is a paucity of studies reporting the effect of this training on the physical profiles in elite hockey players (Leiter et al., 2015). Only one study was conducted exclusively in women hockey players (Geithner et al., 2006). However off-season training was performed according to their own programs and time constraints.

Testing of players is most often conducted during the off-season period. Due to the reduced availability of ice time during the off-season, off-ice tests are routinely used to evaluate general physical performance. Speed, upper and lower body strength, aerobic and anaerobic energy systems and agility are most often evaluated in players (Tarter et al., 2009). Evaluation of physical performance in elite hockey players is valuable both, practically and scientifically. It can assists as the predictor of on-ice performance (Mascaro et al., 1992; Bracko & George, 2001; Burr et al., 2007; Henriksson et al., 2015; Rice, 2015), as the determinant of selection process (Vescovi et al., 2006a; Douglas, 2015), for positional performance profiling (Geithner et al., 2006; Vescovi et al., 2006b; Ransdell et al., 2013), assessment tool for the effect of season on physical performance (Green, & Houston, 1974; Buck, 2013) or can assists in identify issues with conditioning that can be improved through training (Bracko & George, 2001). Studies dealing with off-season performance or positional differences in physical characteristics among junior elite male hockey players are limited (Greer et al., 1992; Geithner et al., 2006). Therefore the aim of this study was to retrospectively evaluate the effect of club-determined off-season strength and conditioning training on physical performance in elite male ice hockey players U18. Secondarily, this study established the physical profile of these players according to their playing positions.

Materials and methods

Participants

A total of twenty-four elite ice hockey players participated in this study. They were divided according to their positions to forwards (n=16) or defenders (n=8). Goalkeepers were excluded from this study due to the

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different positional work tasks and different nature of physical preparation compared to skating players. All players were members of U18 (junior team under 18 years) Slovak national team in 2010. Category U18 is the lowest age category, in which World Championship is organized (IIHF World Junior Championship). Baseline anthropometric characteristics are presented in Table 1. In elite-level players, physical testing is ordered by the Slovak Ice Hockey Federation and it is an obligatory part of training process in these players. Therefore, all parents supported their child in taking part in the testing process. All procedures were in accordance with the ethical standards on human experimentation. This study includes only those players who completed pre-season assessment, off-season training and post-season assessment.

Table 1. Baseline anthropometric characteristics.

	All players (n=24)	Forwards (n=16)	Defenders (n=8)
Age (years)	16.3±0.6	16.4±0.7	16.3±0.6
Height (cm)	176.7±6.7	177.6±6.4	176.3±7.0
Weight (kg)	67.8±10.7	68.4±11.8	67.4±10.5
BMI (kg/m^2)	21.8±3.7	21.6±3.5	21.7±0.7

Values are presented as the mean ± standard deviation.

Procedure

Data from off-season 2010 were used for retrospective analysis. In Slovakia, the off-season period in elite players is typically held from May to June and it is characterized by club-organized strength and conditioning program with off-ice testing. Physical performance testing was performed by certified strength and conditioning coaches. One day before testing players completed anthropometric measurements of body weight (kg) and height (cm). Following, BMI was calculated as weight divided by the square of the height (kg/m^2).
Testing was conducted at the beginning (pre) and end (post) of the off-season. All players were informed about the purpose of the testing. Players were initially tested on 4th May 2010. The off-ice test battery was conducted based on the recommendations of the Methods Department of Slovak Ice Hockey Federation for season 2010 as follows: 60 m sprint (s), 6x9 m run (s), 400 m run (s), 1500 m run (s), standing long jump (cm), 1RM bench-press (kg). Day after initial testing session, the players underwent well-established 8-week off-ice training program (39 training sessions: strength development (41%), endurance (23%), speed and agility development (18%) and small side games (18%)). Each session lasts for 90 minutes. Output testing was conducted on 29th June 2010 using the same test battery. A battery of tests was administered to all players one day prior to the training and one after the end of the training.

Running tests (60 m, 6x9 m, 400 m, 1500 m) were performed on an outdoor running track. Before testing, all players undertook a thorough individual warm-up routine. Starting-blocks for the start of the race were used for 60 m and 400 m test. Standing start was used for 6x9 m sprint and 1500 m run. Players were asked to perform the sprints with maximal effort as in a competition. The running speed was recorded by two examiners (hand-timed) with a precision of 0.1s. Values were averaged. Standing long jump and 1RM bench-press were assessed according to Harman & Garhammer (2008). From each test, one attempt was taken and evaluated except of standing long jump (two attempts were taken and averaged).

Statistical analysis

Statistical analysis of the collected data was performed using the Statistica program (version 10, StatSoft, Inc., Tulsa, OK). The effect of off-season training (pre to post-season differences) on physical performance was assessed using the Wilcoxon test. The Mann–Whitney U test was used to assess the between-group differences. All data are presented as the mean and standard deviation. The criterion for significance was set at $P < .05$. The effect size was evaluated using Cohen's d (large effect $d > 0.8$, medium effect $0.5 \leq d \leq 0.8$, small effect $d < 0.5$).

Results

Pre-season

No significant pre-season differences were found in height (P=0.81; d=0.20), weight (P=0.60; d=0.09) and BMI (P=0.63; d=0.03) between forwards and defenders.
No significant pre-season differences were found in 60 m (P=0.42; d=0.48), 6x9 m (P=0.36; d=0.30), 400 m (P=0.90; d=0.19), standing long jump (P=0.97; d=0.04), 1500m (P=0.24; d=0.47) and 1RM bench-press (P=0.71; d=0.02) between forwards and defenders.

Post-season

Players (altogether) presented significant improvement in 6x9 m, 400 m, and 1500m after the training (Table 2). Forwards significantly improved their performance in 6x9 m, 400 m, and 1500 m after the training (Table 3). On the other hand, defenders improved their performance only in 400 m after the training (Table 3).

After the season, no significant differences were found in 60 m (P=0.52; d=0.50), 6x9 m (P= 0.07; d=0.88), 400 m (P=1.00; d=0.14), standing long jump (P=0.62; d=0.18), 1500 m (P=0.83; d=0.15) and 1RM bench-press (P=0.81; d=0.01) between forwards and defenders.

Pre to post-season (delta change)
Pre-to post-season changes (Δ; delta change) were calculated for each test in each group separately and then were used for comparison between forwards and defenders.
Significant difference was found only in the 6x9 m run test (P=0.01; d=0.55). On the other hand, no significant differences were found in any other tests: 60 m (P=1.00; d=0.05), 400 m (P=0.88; d=1.16), standing long jump (P=0.36; d=0.61), 1500m (P=0.44; d= 0.49), 1RM bench-press (P=1.00; d=0.09).

Table 2. Test performance characteristics prior to and after the off-season in all players.

	All players (n=24)			
	Pre-season	Post-season	P	d
Fitness tests				
60 m sprint (s)	8.4±0.6	8.4±0.6	0.38	0.00
6x9 m run (s)	15.7±0.7	15.1±0.7	**<.001***	**0.86**†
400 m run (s)	71.2±6.2	68.7±6.0	**<.001***	0.41
Standing long jump (cm)	220.9±16.1	221.0±16.6	0.86	0.00
1500 m run (s)	383.6±48.6	355.0±36.8	**0.001***	0.38
1 RM bench-press (kg)	67.7±13.4	68.8±14.3	0.43	0.08

*P ≤ .05. †Large effect. Values are presented as the mean ± standard deviation.

Table 3. Test performance characteristics prior to and after the off-season in forwards and defenders.

Forwards (n=16)				Defenders (n=8)			
Pre-season	Post-season	P	*d*	Pre-season	Post-season	P	d
8.5±0.7	8.5±0.7	0.41	0.00	8.2±0.4	8.3±0.4	0.78	0.25
15.8±0.7	14.9±0.7	**<.001***	**1.29**†	15.6±0.6	15.5±0.7	0.46	0.15
71.6±6.7	69.0±6.6	**0.001***	0.39	70.4±5.2	68.1±5.1	**0.03***	0.45
220.7±17.9	222.0±17.4	0.55	0.07	221.4±12.9	218.9±15.9	0.25	0.17
391.2±52.1	356.9±39.2	**0.002***	0.62	368.3±39.4	351.3±33.7	0.26	0.31
66.9±15.5	68.1±15.3	0.44	0.08	67.3±17.8	68.3±19.7	0.71	0.05

*P ≤ .05. †Large effect. Values are presented as the mean ± standard deviation.

Discussion

The main goal of the off-season period is to enhance physical performance. The aim of this study was to determine if an off-season training program was effective in improving fitness performance in U18 elite hockey players. In addition, individual values of the monitored parameters were divided and compared according to gaming positions.

In all players, off-season intervention led to significant improvements in running performance in 6x9 m (3.8%), 400 m (3.5%), and 1500 m (7.5%). These improvements were enhanced by significant improvements observed in forwards (5.7%, 3.6% and 8.8%). Defenders improved performance only in 400 m (3.3%). Moreover, significant pre-to post-season changes (Δ) were found between forwards and defenders in 6x9m.

It is difficult to compare our results with others, because there is a great variation among studies in used off-ice tests (Mascaro et al., 1992; Geithner et al., 2006; Burr et al., 2008; Ransdell & Murray, 2011; Ransdell et al., 2013; Henriksson et al., 2015). Moreover, above mentioned studies are conducted predominantly in elite women ice hockey players. Only two studies (Géczi, 2009; Kokinda et al., 2012), assess fitness performance in U18 elite male players using the same tests as in our study. However, these studies do not assess the training effect. Moreover, it is not clear when was testing conducted.

Ice hockey is a “start and stop” sport involving repetitive short sprint situations (Domer, 2005), high intensity intermittent skating and rapid changes in direction (Twist & Rhodes, 1993). This could lead conditioning experts incorporated pro agility shuttle (20 yard shuttle test) to the fitness testing protocol NHLED combine in 2014. Despite these facts, agility shuttle run tests are largely ignored in studies dealing with the off-ice fitness performance in elite hockey players. In our study, we used 6x9 m test – running and turning (shuttle) test at maximum speed which reflect the specific demands on on-ice performance. All players significantly improved their time about 0.6s. Forwards achieved significantly lower time about 0.9s following training. This may resulted in significant pre to post-season changes (Δ) between forwards and defenders. Approximately one fifth of training volume was focused on speed and agility development, one fifth was dedicated to small side games and almost half of overall training volume was focused on strength development. It was found that small side games improve agility performance (Young & Rogers, 2014; Young et al., 2015). Running and rapid change of direction performance is associated with force application ability from each lower limb during each foot contact (Randell et al., 2010). Performance in 6x9 m sprint correlates with skating-related factor of lower body explosive strength (Kokinda et al., 2012). This may resulted in significant improvement in 6x9 m sprint.

Both, the aerobic and anaerobic energy systems are important for ice hockey performance. All players significantly improved their aerobic performance in 1500m about 28.6s after the off-season training. Forwards presented significantly lower time about 34.3s following training. Moreover, our players presented better aerobic performance (lower time) in comparison with other junior elite players (Géczi, 2009; Kokinda et al., 2012). Well developed aerobic system in ice hockey is characterized by decreased recovery time between shifts, reduced fatigue in the latter stages of a game and builds a base necessary to handle more anaerobic training (Twist & Rhodes, 1993). As it was above mentioned, one fifth of overall training volume was dedicated to small side games, which are considered as an effective tool for aerobic training (Balsom et al., 1999) and may be physiologically beneficial for athletes with relatively high initial aerobic fitness levels (Halouani et al., 2014).

The anaerobic energy system is important to hockey due to the nature of the sport (Twist & Rhodes, 1993). In all players, forwards and also defenders significant improvement was observed in 400 m after the off-season training (about 2.5s, 2.6s and 2.3s). This test assesses the anaerobic power - about 1 minute performance of maximal intensity. In ice hockey, game performance is characterized by relatively short but intense work intervals from 30-60 seconds. In other words, 400 m is not appropriate test which reflect on-ice performance.

Anthropometric characteristics are mainly used as the predictors for positional or team selection in elite-level sport. Current NHL defenders are significantly higher and heavier than NHL forwards (Sigmund et al., 2016). In our study we found no significant differences in anthropometric characteristics between forwards and defenders. Similar findings were observed in the study of Kutáč & Sigmund (2015); in which no significant differences were found among positions for height and weight in elite male players (ELH, KHL). Agre et al., (1988) reported significant positional differences for weight and no significant differences for height in elite male players. In study of Vescovi et al., (2006b), elite male defenders were significantly heavier and taller than elite male forwards. Using of weight and height as the predictors for team or positional selection in U20 and lower categories can be problematic, as it does not take into account the effect of physical growth on performance. The average weight gain for adolescent males ranges from 6–12,5 kg per year and average height ranges from 7-12 cm per year (Needleman, 2000). Full physical maturity is reached by most adolescents in 16-20 years of age (Brown et al., 2017)

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Conclusion

Off-season training led to significant improvements in running performance. All players, forwards and also defenders presented improved physical performance following off-season training (except of 60 m). Even a small improvement (statistically significant or not) in physical performance (i.e. faster reaction, shorter time) can influence the performance or score. Results of this study identify important physical factors for junior players and coaches that they need to be improved in the pre-season.

Conflicts of interest

The authors report no conflicts of interest.

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