©Journal of Sports Science and Medicine (2019) **18**, 680-694
http://www.jssm.org

Research article

Off-Ice Agility Provide Motor Transfer to On-Ice Skating Performance and Agility in Adolescent Ice Hockey Players

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Abstract
Agility plays a crucial role in ice hockey training, and it can be developed directly on the ice or by additional off-ice training. Since the effectiveness of on-ice and off-ice training on players' agility have not been previously described, the purpose of this research is to compare the effects of on-ice and off-ice agility training on skating performance. Fourteen ice hockey players performed agility training on-ice for 4 weeks and off-ice for 4 weeks in a crossover design; they were tested before the agility program, after the first month and after finishing both training programs. The players were randomly assigned into one of two groups (n = 7 in each group), either performing the on-ice training protocol first (Ice1) followed by the off-ice agility training or performing the off-ice protocol first and the on-ice training second (Ice2). The test battery included straight sprints to 6.1 m and 35 m and the S corner test, test with break, weave agility with puck test and reactive agility test. The magnitude based decision showed the effect of agility training in both groups in the weave agility (Ice1, 2.9±2.8% likely improvement; Ice2, 3.1±2.5% possible improvement) and reactive agility tests (Ice1, 3.1 ±2.5% likely improvement; Ice2, 1.7±2.1% possible improvement), where the Ice1 protocol resulted in a likely positive change and Ice2 resulted in a possible positive change. The comparison of the training effect resulted in a possibly harmful change of performance in Ice2 protocol (-0.5 ± 8.9%) compared to Ice1 protocol (-1.0 ± 5.1%). On-ice training is more effective in the development of specific types of agility in adolescent U16 players. However, there is evidence that off-ice agility have motor transfer to on-ice agility. Therefore, we recommend developing on-ice agility with additional off-ice agility training during the ice hockey season.

Key words: Ice hockey, agility, training, youth, change of direction, physiology, sports training.

Introduction

Skating performance and change of direction speed are some of the basic skills in ice hockey (Brocherie et al., 2018; Montgomery et al., 2004), because players need to be quick, fast and physically ready for numerous game situations. Examples of fundamental ice hockey skills include cutting maneuvers, turns, weave agility, breaks, hits and acceleration, and all these skills might be performed with or without a puck. The on-ice testing of sprints, cutting maneuvers, breaks and weave agility have been described in previous studies (Farlinger et al., 2007). However, the normative values of selected physiological tests have been presented only for aerobic fitness (Petrella et al., 2007; Roczniok et al., 2016; Stanula et al., 2014) and anaerobic performance (Montgomery, 2006; Vescovi et al., 2006), but not for players' agility.

We can understand agility as a hybrid movement ability to rapidly and accurately change movement directions and speed based on the game situation (Hojka et al., 2016). The use of agility in ice hockey is realized in the high speed of movement, often in contact with opposing players, which is the rationale as to why agility plays a crucial role in on-ice hockey training. To the best of our knowledge, descriptions of methods for developing ice hockey agility, as well as for deciding whether the agility program should be performed only on-ice, are typically based on empirical data rather than evidence-based data. Since agility comprises physical, technical and cognitive constraints (Hojka et al., 2016; Young et al., 2015), there is a good probability that off-ice training has motor control transfer to on-ice skating performance (Dæhlin et al., 2017; Farlinger and R. Fowles, 2008; Lee et al., 2014). It has been already shown that the Edgren side shuffle agility (r = -0.53) and Pro-agility (r = 0.75) tests correlate with on-ice S cornering agility and horizontal power measurements (Farlinger et al., 2007; Janot et al., 2015). Furthermore, off-ice strength training, plyometric training and skating imitation training increases on-ice skating sprint speeds (Dæhlin et al., 2017; Farlinger and R. Fowles, 2008; Lee et al., 2014). However, no previous study has compared whether an off-ice agility intervention might directly support on-ice skating performance.

Skills and agility should be generally developed from simple fundamental tasks to more difficult specific tasks (Clark and Metcalfe, 2002), where off-ice training might represent the fundamental skills and on-ice training represents the specific performance task. However, the on-ice movements are very specific to the use of skates (boots with a 3 mm skate blade) and motor tasks based on a slide with push-off, which does not appear in any conventional movement off-ice. Therefore, the off-ice movement patterns should not be understood as fundamental variations of on-ice movements. This brings the question of whether on-ice agility might benefit from off-ice agility development, or whether on-ice agility skills are independent movement tasks with a possible development only on-ice.

To the best of our knowledge, the effect of additional agility training for ice hockey players has not been investigated. Therefore, the purpose of this study is to

Received: 02 April 2019 / Accepted: 09 September 2019 / Published (online): 19 November 2019

compare the changes of on-ice agility performance after a combination of on-ice and off-ice agility development. We hypothesized that off-ice agility training followed by on-ice agility training would result in a higher increase in agility performance compared to the reverse order of training.

Methods

The participants were randomly split into two experimental groups that performed two different additional agility training protocols along with their regular training schedule in a X-over design. One group (Ice1, n = 7) performed additional on-ice agility training for four weeks, followed by two weeks of rest and four weeks of off-ice agility training (Figure 1). The second group (Ice2, n = 7) performed additional off-ice agility training for four weeks, followed by two weeks of rest and four weeks of on-ice agility training (Figure 1). Along with X-over design the effect of two subsequent agility trainings were analyzed in parallel group design pre-test and post-test (post-test 2 in Figure 1), where Ice1 and Ice2 groups were compared after 8 weeks of both intervention in conversely order of on-ice and off-ice agility trainings (Figure 1). Both groups were familiarized with both training protocols and all testing procedures one month prior to the training pre-test. The familiarization procedure included three trials of each test once a week (always on Monday) performed at the end of the warm up and three trials of each exercise per week, which were randomly included in off-ice and on-ice training in a regular weekly cycle. After the participants performed the first part of the agility training followed by the first post-test (Post1), they had one week of rest, then they performed the second part of the agility training and the final (second) post-test (Post2). The entire experiment was performed during a competition cycle between September and December 2017.

Participants

All participants (n = 14, age 14.8 ± 0.45 years, body mass index 61 ± 10.43 kg; height 168.93 ± 9.72 cm; training experience 9.07 ± 0.75 years) were members of the same ice hockey team; they played in the highest youth league, performed the same training program, were in the post peak height velocity period of maturation and had the same scholarship. The research and informed consent form were approved by the institutional ethics committee of the Charles University Faculty of Physical Education and Sport in accordance with the ethical standards of the Helsinki Declaration of 2013, and a signed informed consent form was obtained from the parents of all players who participated in this study.

Regular training program

The participants' regular in-season program consisted of weekly cycles, which included one competitive match per week, four regular 60 min ice hockey training sessions, three 90 min physical education lessons, three additional 20-30 min agility sessions and one day off (Sunday). Regular ice hockey training sessions were focused on individual game activities, skating conditioning, individual offensive and defensive tactics, individual offensive activities and game strategies. We considered this regular training program, which is not targeted on providing additional adaptive stimuli for agility and skating skills, as a long term players' routine. Players' regular training programs before this study included skating technique training sessions twice a week for 20 min.

Testing protocols

All testing sessions (Pre, Post1 and Post2) were performed in three sessions on the same weekdays prior to the regular training sessions. The 6.1 m and 35 m straight sprints were performed on Monday and were combined into one forward sprint for 35 m. The S corner test and test with brake were conducted on Tuesday, and the weave agility with puck and reaction tests were performed on Thursday.

Each testing session began with a 10-15 min warm up of different agility skating tasks, five 5 s sprints and 6-8 trials of the tested task at a moderate intensity. Players had two all-out attempts for each testing protocol with 3-5 min of rest, and the better trial was included in the statistical analysis. With the exception of the weave agility test and the reaction test, the starting photocell sensor was placed 15 cm above the ice, and the finishing sensor was placed 108 cm above the ice (Farlinger et al., 2007; Janot et al., 2015).

Straight sprint for 6.1 m and 35 m

Both tests were measured by photocells (Brower Timing System, Utah, USA) during one measured acceleration of forward sprint skating. First, photocells recorded the start of the sprint, second, the finish of the 6.1 m sprint, and last, the finish of the 35 m sprint (Farlinger et al., 2007; Janot et al., 2015) on a straight sprint track marked diagonally across the ice hockey rink (Figure 2A, 2B). The starting photocell sensor was placed 15 cm above the ice, and both finishing sensors was placed 108 cm above the ice.

S corner test

The S corner test was performed according to Farlinger et al. (2007); participants started behind the goal line and net and skated around the two nearest faceoff circles, and were not allowed to reach or touch the line (if they cut the line

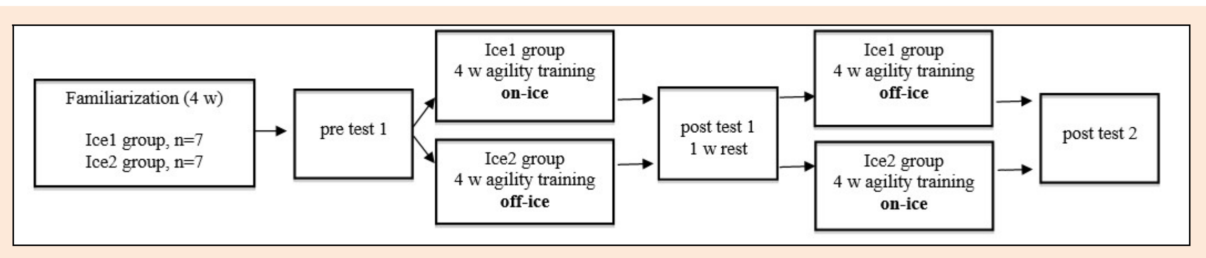

Figure 1. Methodological design of the tests and agility training protocols.

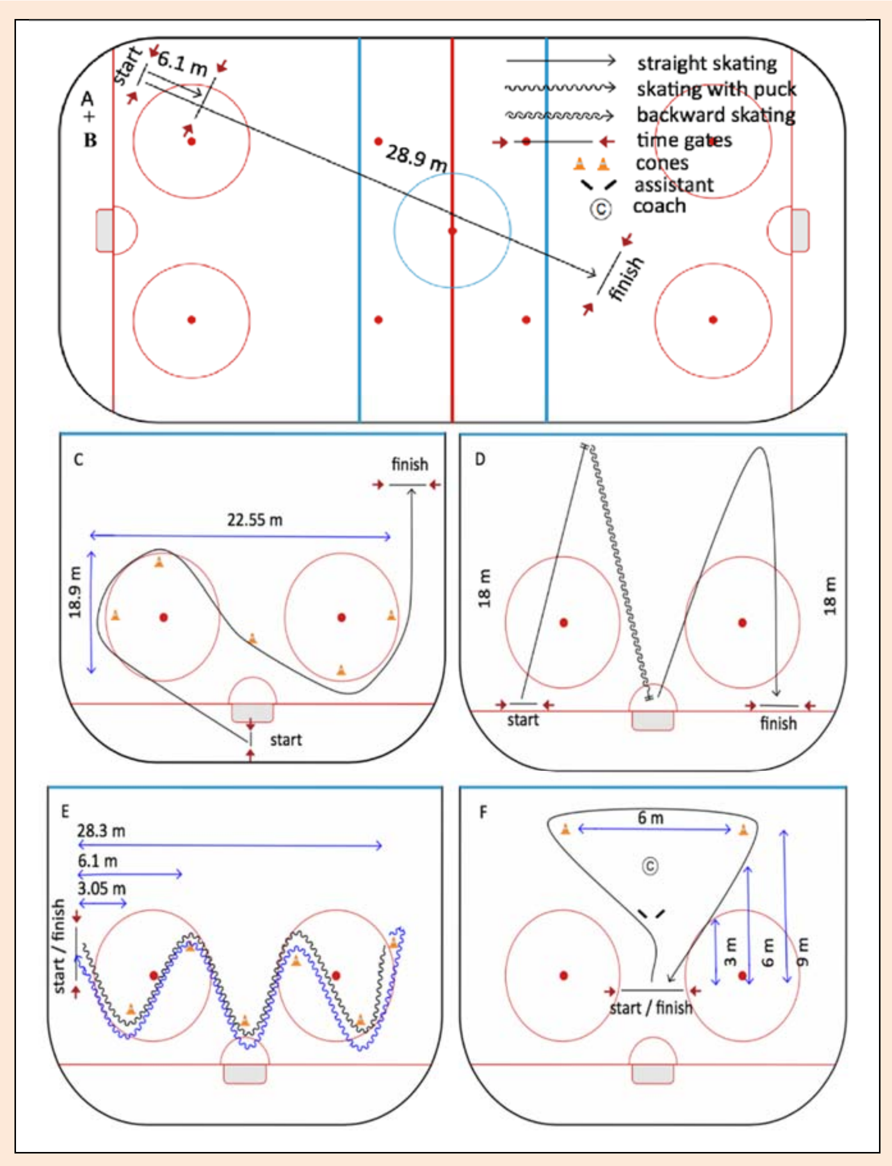

Figure 2. Graphical track and distances of agility tests. A - straight sprint for 6.1m, B - straight sprint for 35m, C - S corner test, D - test with break, E - weave agility, F - reactive agility test (for the right turn variation). Dash curve line = backward skating, weave line = forward skating with a puck.

or fell, the trial was restarted). The end of the track was the blue line (Figure 2C). The starting photocell sensor was placed 15 cm above the ice, the finishing sensor was placed 108 cm above the ice, and the players self-started behind the timing gate with their stick over the gate.

Test with brake

This test was performed according to Hulka et. al. (2017), who reported a high reliability for this test (ICC 0.98, CV 1.31%). Players started in one corner (at the goal line) and stopped at the blue line (18 m from the goal line and 2 m from the barrier), then, did 22 m of backward skating and stopped on the goal line, followed by 22 m of forward skating, and they finished with a sharp turn around the cone on the blue line (2 m from the barrier and 18 m from the goal line) and forward skated to the goal line (2D). The starting photocell sensor was placed 15 cm above the ice, the finishing sensor was placed 108 cm above the ice, and the players self-started behind the timing gate with their stick over the gate.

Weave agility - slalom with puck

This test was performed according to MacCormack (1975), where the start and finish lines were combined, and therefore, only one timing gate was used (Figure 2E). The timing gate was 15 cm above the ice, and the players self-started behind the timing gate with their stick over the gate. The track of the weave agility test was marked by the spray paint and players were instructed to finish the test with hockey stick attached on the ice.

Reaction test

For this test, the start and finish lines were combined; therefore, only one timing gate was used, 15 cm above the ice (Figure 2F), and players self-started behind the timing gate with their stick placed over the gate. The players followed the right or left track direction according to stick movements performed by a simulated defender. Players were instructed to finish the test with hockey stick attached on the ice.

On-ice and off-ice agility training intervention

All players performed additional agility training for 20-30 min, three times per week, with a progressively increasing difficulty of the agility tasks. One training was conducted with change of direction speed exercises only, one with a puck or ball and a duel competition track task, and the third training was focused on agility development during specific game exercises with a puck or ball. The group performing on-ice training used a puck in the duels and game exercises described in Appendix, and the group with off-ice training performed exercises similar to those in Appendix, but in a hall using a soccer ball for duels and games. Each separate exercise was designed to last 3-15 s with a rest interval of 1:3-1:10 with active recovery (low intensity skating) and was performed 2-6 times in 2-4 sets in a training session that contained 2-6 exercises. The work to rest intervals were selected based on knowledge that ice hockey includes repeated bouts of maximal effort with a mean sprint time of 5 s (Brocherie et al., 2018), alternated with lower intensity activities, and that players can sprint the length of an ice hockey rink (transition between defense and offense zones) in approximately 6 s (Potteiger et al., 2010; Roczniok et al., 2012; Stanula et al., 2014). Players should be able to maintain maximal power output (i.e., sprint performance) during a typical on-ice shift that usually has a work to rest ratio of 1:2-1:10 (Quinney et al., 2008). Moreover, the 5 - 20 s all out test is typically used for ice hockey anaerobic condition assessment (Quinney et al., 2008; Stastny et al., 2018).

The progression of difficulty for change of direction speed agility without a puck (or ball) was performed by adding breaks in the exercises, backward movements and combinations of the two (Appendix). The change in direction training also included corrections in skating technique (if appropriate); however, the main focus of exercises was on the speed of movement. The difficulty of duels was increased by the length and changes of direction of the track. Game agility difficulty was primarily increased by decreasing the game area, and small sided games were inspired by the Brennan manual (Brennan et al., 2009).

Statistical analysis

Since our study's aim was to determine the efficacy of treatments during interventions and the direction of causality between interrelated variables, we interpreted the intervention effects using magnitude-based decision (MBD) (Hopkins et al., 2009; Hopkins, 2017; Hopkins, 2019). Changes in the selected parameters for the two groups (Ice1 vs. Ice2) after whole 8 weeks of interventions and the ratio of the changes were analyzed using a spreadsheet for the analysis of parallel-group controlled trials. Changes in the selected parameters according to the type of training (pooled on-ice and off-ice training results) from both groups for all subjects together were analyzed using a spreadsheet for a posttest only X-over trial, which was also suitable for repeated measurements of the subjects in one group (Hopkins, 2017). The dedicated spreadsheet included calculations shown as formulas. All data were log-transformed for analysis to reduce the bias arising from the nonuniformity of errors; means of the change scores in the Ice1 and Ice2 groups, standard deviations of the change scores, and effects (differences in the changes in the means and their confidence limits) were back-transformed to percent units with respect to baseline levels. Magnitudes of the effects were evaluated using the log-transformed data via standardization. Threshold values for assessing the magnitude of standardized effects were 0.20, 0.60, 1.2 and 2.0 for small, moderate, large and very large, respectively. The uncertainty of each effect was expressed as 90% confidence limits and as probabilities that the true value of the effect was beneficial, trivial or harmful. These probabilities were used to make a qualitative probabilistic clinical inference about the true effect (Batterham and Hopkins, 2019; Sainani, 2018; Sainani, 2019); the effect was deemed unclear when the chance of a benefit was sufficiently high to warrant the use of the treatment, but the risk of harm was unacceptable. Such unclear effects were identified as those with an odds ratio of benefit to harm of <66, a ratio that corresponds to an effect that is borderline possibly beneficial (25% chance of a benefit) and borderline most unlikely harmful (0.5% risk of harm). All other effects were deemed clinically clear and were expressed as the chance of the true effect being trivial, beneficial or harmful using the following scale: 25-75%, possibly; 75-95%, likely; 95-99.5%, very likely; >99.5%, most likely.

Results

The data of both measured groups expressed as means and confidence intervals for all tests are summarized in Table 1. The MBD showed the effect of agility training in both groups in the weave agility (Table 2, Figure 3) and reactive agility tests (Table 2, Figure 4), where Ice2 protocol resulted in possibly harmful change of performance (-0.5 ± 8.9%) compared to Ice1 protocol (-1.0 ± 5.1%) (Table 2). The comparison of the training effect on-ice (together in both groups) and off-ice (together in both groups) resulted in positive changes under both conditions in the weave agility and reactive agility tests, where on-ice training resulted in a likely positive effect and off-ice training in a possible positive effect (Table 3).

Discussion

This study showed that both on-ice and off-ice additional agility training might be beneficial for agility development in youth players; however, the on-ice training results were more beneficial (Table 3). Therefore, we suggest the implementation of both kinds of agility development in youth ice hockey training programs, although on-ice training should have a priority. However, the agility training did not improve cyclic movements, such as straight sprints or S corner test performance, which might mean that our training intervention did not include enough stimuli for the physical agility constraints and had an effect only on the change in direction and reactive constraints. This is not surprising, since our program did not include an additional resistance training program or another kind of advanced power development.

Table 1. Test performance before agility training, after the first four weeks and after the second four weeks of measurement in both groups. Data are means, CL ± 95%.

Test	Ice 1 Pre	Ice 1 Post 1	Ice 1 Post 2	Ice 2 Pre	Ice 2 Post 1	Ice 2 Post 2
6.1 m sprint (s)	1.33, 1.23 - 1.43	1.30, 1.24 - 1.36	1.33, 1.19 - 1.47	1.30, 1.22 -1.38	1.28, 1.22 - 1.34	1.31, 1.25 - 1.36
35 m sprint (s)	5.27, 5.04 - 5.51	5.28, 5.07 - 5.49	5.30, 5.07 - 5.52	5.31, 5.14 - 5.47	5.37, 5.13 - 5.61	5.41, 5.19 -5.62
Test with break (s)	16.50, 15.9 - 17.09	16.41, 15.72 - 17.10	16.06, 15.43 - 16.69	16.54, 16.02 - 17.06	16.87, 16.28 - 17.46	16.31, 15.62 - 17.01
S corner test (s)	8.94, 8.62 - 9.26	8.86, 8.60 - 9.12	8.96, 8.74 - 9.17	9.03, 8.70 - 9.37	9.03, 8.77 - 9.28	9.16, 8.79 - 9.52
Weave agility (s)	17.91, 16.73 - 19.08	17.22, 16.48 - 17.95	17.03, 15.82 - 18.24	17.93, 16.71 – 19.16	17.47, 16.48 – 18.46	17.12, 16.17 – 18.07
Reactive agility (s)	5.67, 5.36 - 5.99	5.41, 5.11 - 5.72	5.40, 5.16 - 5.64	5.77, 5.47 – 6.07	5.58, 5.43 – 5.72	5.49, 5.17 – 5.81

Pre = pretest, Post 1 = post-test after the first four weeks of agility training, Post 2 = post-test after the second four weeks of agility training, CL = confidence limit and 95% confidence interval for the mean.

Table 2. Dependent variables and covariates in youth ice hockey players at baseline, and magnitude-based inferences for parallel groups Ice1 and Ice2.

Test	Group (n = 7)	Baseline Mean ± SD	Observed change Mean ± SD (n = 6)	Probability [%; %; %]	Ratio (Ice1/Ice2) Mean; ±90% CL	Ratio (Ice1/Ice2) Inference
Weave agility (s)	Ice1	17.9 ± 1.3	-4.9 ± 12.1%	[9; 14; 77]	-0.5; ± 8.9%	unclear effect
	Ice2	17.8 ± 1.2	-4.4 ± 5.3%	[1; 9; 90]		
Reaction agility (s)	Ice1	5.7 ± 0.3	-5.6; ± 5.3%	[1; 4; 96]	-1.0; ± 5.1%	harmful* [47; 31; 22]
	Ice2	5.8 ± 0.3	-4.7 ± 5.1%	[10; 4; 86]		

CL = confidence limit with 90% confidence interval for the mean. Observed changes are percentages; baseline values are expressed in measurement units. Likelihood that the true effect is substantial: *possibly. Magnitude threshold: 0.20-0.59. Numbers in brackets indicate the % probability of a harmful, trivial and beneficial effect for both probability of group change and group inference. <0.20, trivial; 0.20-0.59, small; 0.60-1.19, moderate; >1.20, large.

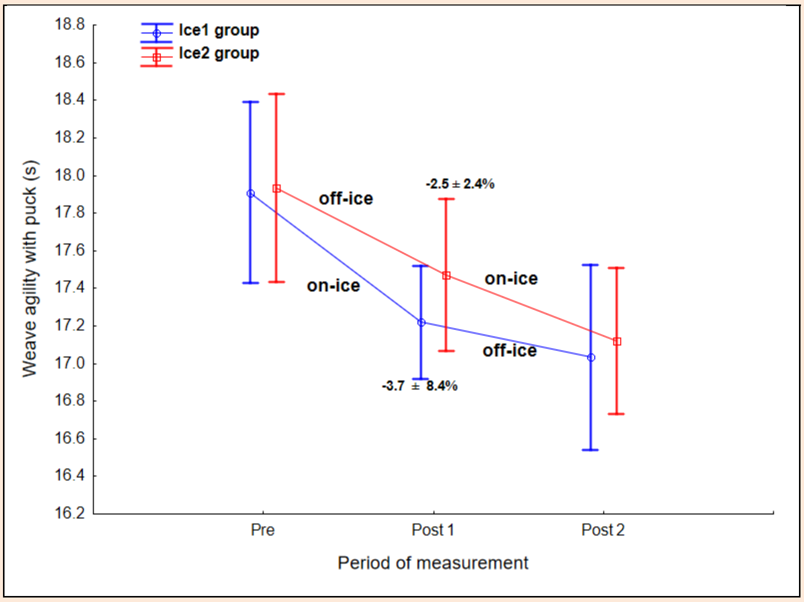

Figure 3. Results of the weave agility with puck test during all three stages of testing. Ice 1 = group that performed the on-ice agility training first, Ice 2 = group that performed the off-ice agility training first. The values are expressed as mean and SE.

Weave agility was the only test performed with a puck, where we observed improvement of players. This test improvement might be explained by increased motor control during high speeds, which was to contend with the all agility training units. The improvement in the reactive test might be related to the contend of agility training no 2 and 3 (Appendix), which included many starts on command, duel competitions and reactions to random changes in another player's movement (Appendix). Therefore, it seems that applied training improves the cognitive constraint of agility, which is not surprising, since cognitive constraint has been reported to have a strong relationship with reactive agility (Scanlan et al., 2014).

One of our study aspects was the order effect of on-ice and off-ice agility development; the Ice1 group performed the on-ice training intervention first and showed better results in reactive agility (small effect 1.0; ± 5.%). This is not in agreement with the expectation that more general skills should be developed first in order to ensure better skill development (Clark and Metcalfe, 2002). We were still able to observe the agility improvement in the second four weeks (Post2) in both training programs, although both programs resulted in greater improvements in the players' mean values after the first four weeks of training (Post1, Table 1). This shows that any new frequent agility intervention would improve players' performance and would be followed by a decrease in training efficiency.

Ice hockey requires very specific technical skills performed in hockey skates; previous research has shown a high dependence of forward skating on skating technique (Robbins et al., 2018) and differences in surface reaction forces during right and left changes of direction maneuvers (by 90°) (Fortier et al., 2014). However, most of the previous research classifies the performance level of measured players as a categorical factor requiring a certain level of skating technique, leg strength and training history (Budarick et al., 2018; Robbins et al., 2018; Shell et al., 2017). Unfortunately, previous studies did not provide a factorial model of skating speed, which would include kinematics, physical condition, anthropometric measurements, muscle activity and other factors. Since our participants were periodically trained on skating technique and well familiarized with the tests and exercises prior to the experiment, we believe that the observed changes occurred due to the improvement in motor control during players' maximal speeds.

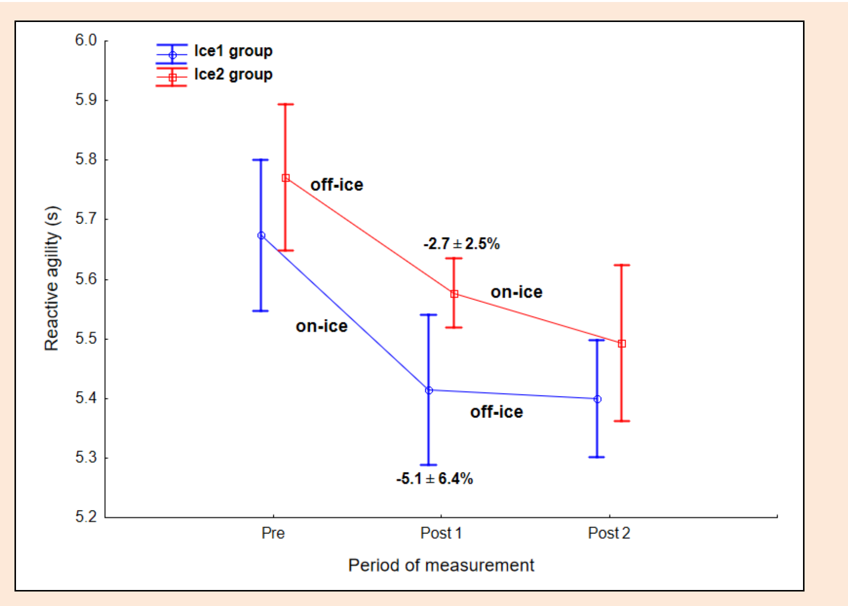

Figure 4. Results of the reactive agility test. Ice 1 = group that performed the on-ice agility training first, Ice 2 = group that performed the off-ice agility training first. The values are expressed as mean and SE.

Table 3. Changes in selected characteristics before and after the 4-week ice hockey training period in X-over design supported by on-ice or off-ice agility (n = 14).

	Condition (n = 14)	Baseline mean ± SD	Observed change	
			Mean; ±90% CL	Inference
Weave agility (s)	on-ice	17.7 ± 1.3	-2.9%; ±2.8%	small ↓ ** [1; 17; 82]
	off-ice	17.6 ± 1.1	-1.9%; ±1.8%	small ↓ * [0; 30; 70]
Reaction agility (s)	on-ice	5.7 ± 0.3	-3.1%; ±2.5%	moderate ↓ ** [1; 7; 92]
	off-ice	5.6 ± 0.4	-1.7%; ±2.1%	small ↓ * [1; 37; 61]

CL = confidence limit with 90% confidence interval for the mean. Observed changes are percentages; baseline values are expressed in measurement units. Likelihood that the true effect is substantial: *possible, **likely. Magnitude thresholds: 0.20-0.59, small; 0.60-1.19, moderate. Numbers in brackets indicate the % probability of a harmful, trivial and beneficial effect.

The lack of improvement in straight sprinting might be explained by the absence of additional strength and power conditioning during our program, by the main contend of our agility program and by the conditioning level of our study participants. The mean initial time for straight sprints was 1.31 s for 6.1 m and 5.29 s for 35 m, which is close to the mean values reported for older players in previous studies (6.1 m, 1.34 ± 0.3 s; 35 m, 5.14 ± 0.21) (Farlinger et al., 2007; Janot et al., 2015) and slower than adult second league Swedish players (6.1 m, 1.06 ± 0.12) (Gilenstam et al., 2011). Therefore, it is possible that speed development was hard to elicit through our delimited agility program. However, future research could focus on agility development accompanied by speed and strength training.

Our S corner test results (mean 8.99 ± 0.34 s) were similar to those reported for Canadian players (9.20 ± 0.21 s) (Farlinger et al., 2007) and slower than those in other studies (8.30 ± 0.26 s, 8.36 ± 0.27) (Gilenstam et al., 2011; Janot et al., 2015), which we believe is appropriate to the age of our players. However, the S corner test has been previously reported as a test of agility (Gilenstam et al., 2011;

Janot et al., 2015; Nightingale, 2014), which is highly questionable since this test includes a very obvious automatized change of direction represented by a forward crossover skating task, which relies only on physical agility constraints such as the forward skating speed. This is supported by our results that the agility intervention did not improve the S corner agility, weave agility or break test results. Since there is an association between the S corner test and the 35 m straight sprint (correlation r = 0.70 - 0.76) (Farlinger et al., 2007; Janot et al., 2015), we recommend considering the S corner test to be more likely a test of skating speed rather than ice hockey agility.

The main results of this study were found in two agility tests; our weave agility (initial mean 17.92 s) can only be compared to one older study (19.83 ± 0.96 s) (MacCormack, 1975) and our reactive agility was newly designed. Although the reactive agility decision-making task was very elementary in our protocol, the players were able to increase their performance by 0.9 s, which we believe was due to our complex training approach that included separate training of technical and cognitive (games) agility constraints. Since both reactive agility and weave agility are basic requirements on the ice, we might state that our training program improved players' preparedness for the game and that the results of this experiment can help coaches or players plan effective training programs during the season.

The greatest study limitation is the missing measurement of skating technique by kinematic analyses, which might estimate the skating technique level (mastery) (Robbins et al., 2018). However, we consider our players' skating techniques as advanced, since the players were members of the ice-hockey academy for at least two years prior to this study and had specific skating technique lessons twice a week with a coach during the regular season. This regular skating technique training was focused on improving the skating stride length by increasing hip flexion and plantar flexion (Robbins et al., 2018) followed by full triple-extension of the hip, knee and ankle (plantar flexion). Other skating skills included controlling the skate support on the medial and lateral skate blade edge, turning and pivoting. These specific skating technique lessons were absent during the duration of the experiment. Other limitations in the number of participants and missing normative values in a similar age category; e.g., our results for the break test (mean 16.52 s) were comparable only to one study done on players 17.68 ± 1.52 years of age, with a test mean of 12.43 ± 0.89 (Hulka et al., 2017). However, our approach focused on the observed changes of the players' conditioning, and we did not find a substantial lack of conditioning during the pre-test in measured players in comparison to the previously published literature.

Conclusion

Both agility training interventions resulted in an improvement in agility, although on-ice training is probably more effective in terms of reactive agility. However, there is evidence that off-ice agility might have motor control transfer to on-ice skating performance and might support on-ice agility in high school players. Therefore, we recommend the interchange of additional on-ice and off-ice agility training during the ice hockey season.

Acknowledgements
This study has been supported by Charles University grant UNCE/HUM/032, SVV grant 260466 and GACR grant GA 19-12150S. The experiments comply with the current laws of the country in which they were performed. The authors have no conflict of interest to declare.

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Key points

- Motor transfers exist from off-ice to on-ice agility.
- On-ice agility development is more effective than off-ice.
- Interchange of additional on-ice and off-ice agility training during the ice hockey training is recommended.

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APPENDIX

Training plan for on-ice and off-ice

Player were trained three times per week. Two training were with puck and one without puck. Progression between weeks was increasing difficulty.

- First training in week (1. - 4. week): exercises without puck, short sprints. In first week was straight sprints with change of direction, in second week was added brake. In third week was backward skating or running and in last fourth week all together.
- Second training in week (1. - 4. week): duels and starts for puck with shoot on the net.

Because one group had trainings on-ice (Ice1) through one month and second group had only off-ice (Ice2) trainings, so Ice2 group have not shoot on the net, so the end of exercises was to touch cone. In the first week was straight sprints and in the second week some agility like change of direction. In third week was added short slalom or longer track before duel for puck. In last week we combined all these elements.

- Third training in week (1. - 4. week): agility games or work with the puck. In this week were trainings in small area or games without puck. These games makes competing ambience, developing creativity and players. These games also working on conditions, skills and other parts of training (Brennan et al., 2009).

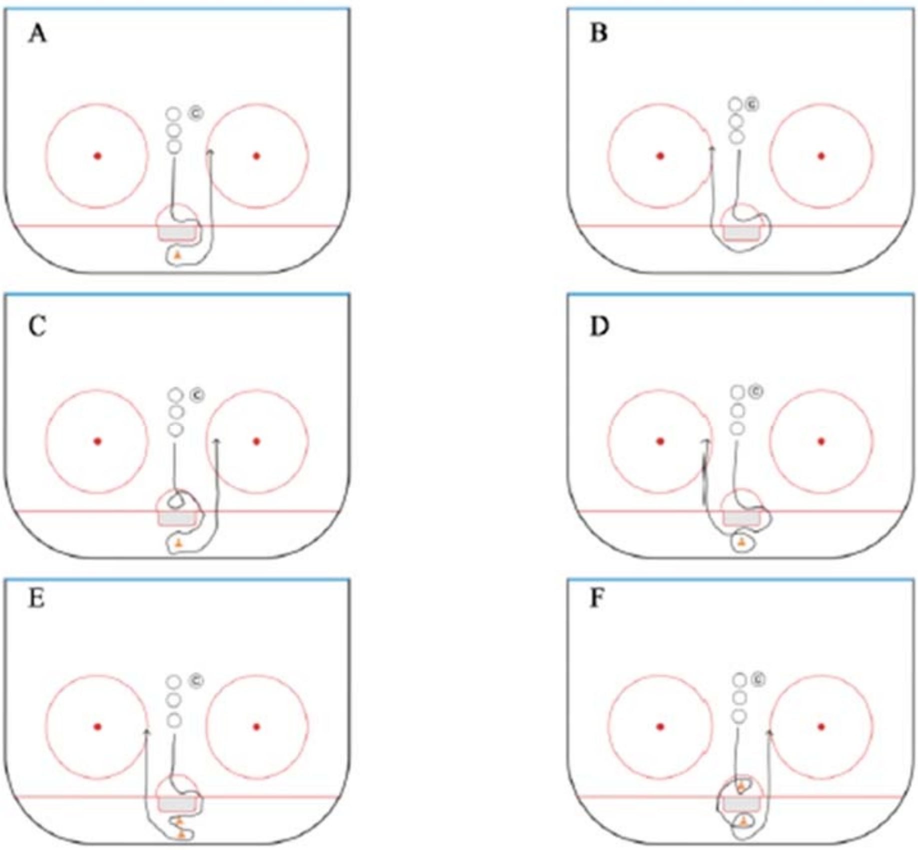
Week no. 1

Training no. 1 - exercises without puck, shorts sprints, level 1

Exercise A - F

All players start without puck. They have to make after change of directions or after turn accelerate. Another player starts after one finished this exercise. This exercise was aimed to sprint without puck with change of direction without other abilities. Other abilities like brakes, backward skating etc. were added in next weeks.

The same exercises were at off-ice trainings. Distance, turning and commands were the same.

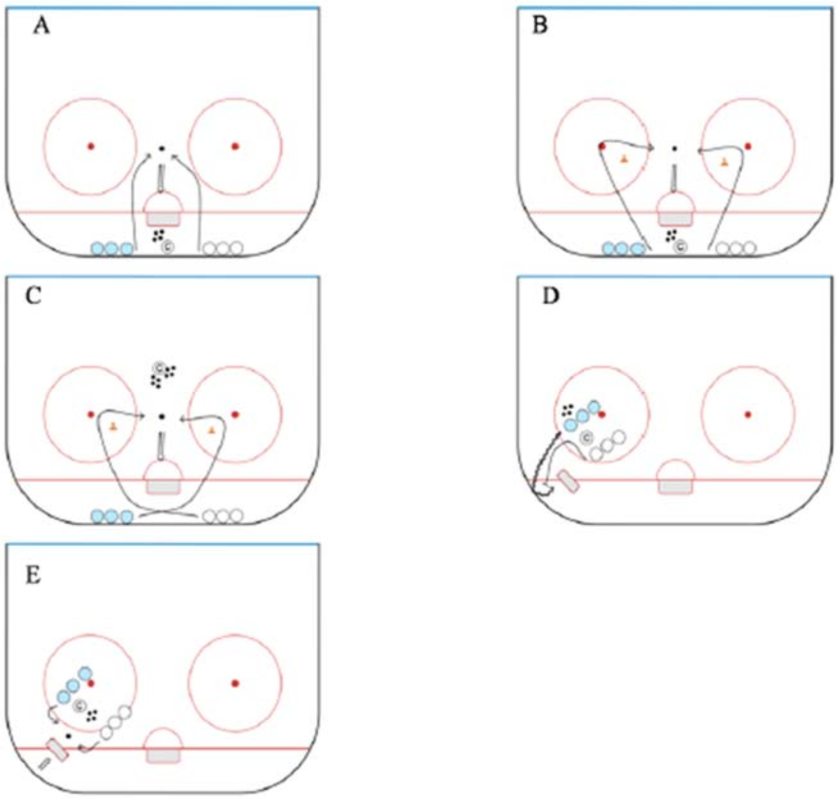


Training no. 2 - duels and starts for puck with shoot on the net, level 1

Exercise A - E

This exercise at ice was normally or at corner of rink. The net was rotated opposite. The players started on command of coach. The aim of forward player was shoot at the net, aim of defender was block or avoid shooting. Players were changed at positions.

At program on off-ice were realized at stadium area. In these exercises weren’t duel with shoot at net, but only touch the cone.



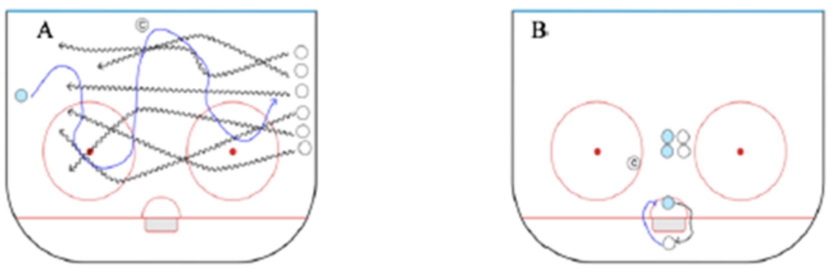
Training no. 3 - agility work or work with puck, level 1

Exercise A - B

Exercise A was game called catch the fish. At the right side of borders were players (fishes) and they have puck on stick. At left side of borders was one player (catcher), his task is skate to other side and try to take pucks from „fishes‘‘. They all started at command of coach. If catches took puck from fishes, they will be catchers. This exercise is for protecting puck.

At off-ice training, players played normal game called catch the fish. They didn‘t have pucks and stick. Exercise B was catching players around the net. This game is for two players. They are without hockey sticks. One of player have to catch other player only by touch. They play this game maximum for 15 seconds, or if one player touched another one.

At off-ice training, they play the same like on-ice.



Week no. 2

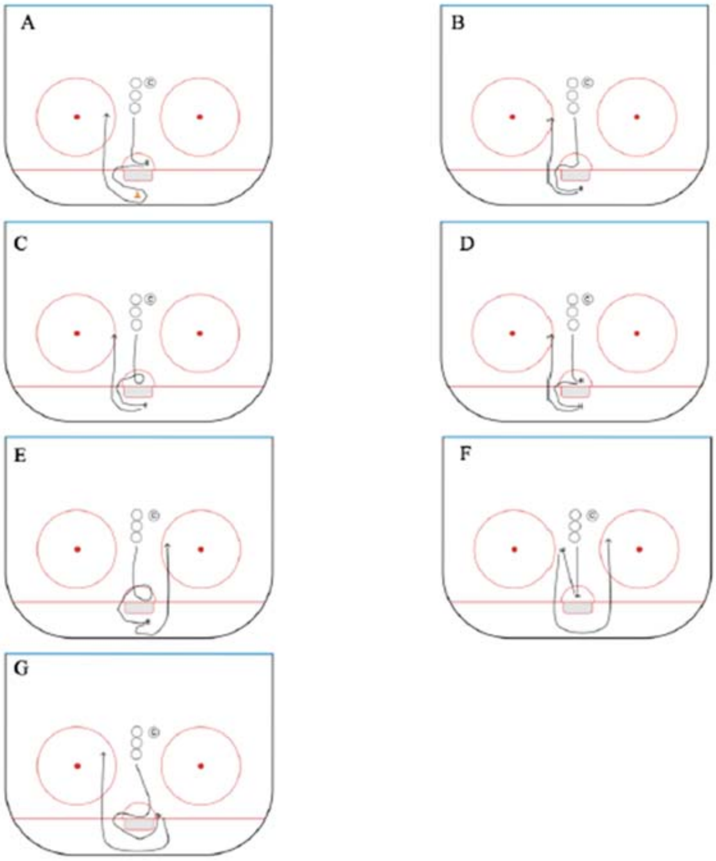
Training no. 1 - exercises without puck, shorts sprints, level 2

Exercise A - G

All player were in the crowd, about 3 meters from goal line. Aim of this exercise was skate correctly and fast as possible track what coach showed the players. In this exercise were added brake and dexterity like quick turn. At first week (level

1 of training program) were in exercise starts and change of directions.

At off-ice they did they same like on-ice.

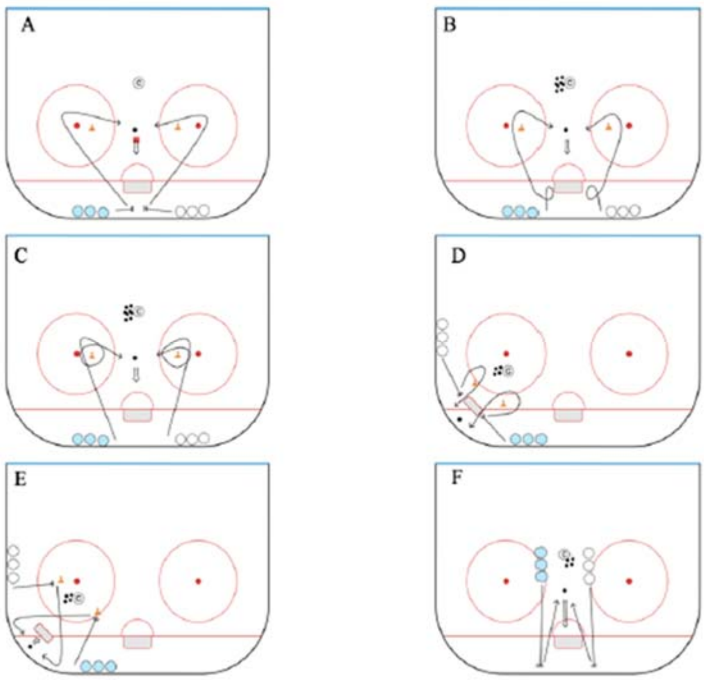


Training no. 2 - duels and starts for puck with shoot on the net, level 2

Exercise A - E

Players focusing after start for brakes, turns and shoot on the net. These exercises were like races. They started on command for one puck, they made a duel and shoot to the net. Players have to be quick as possible.

At program on off-ice were realized at stadium area. In these exercises were not duel with shoot at net, but only touch the cone.



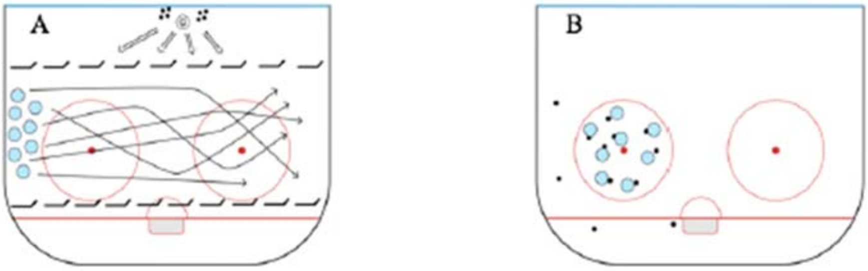
Training no. 3 - agility work or work with puck, level 2

Exercise A - B

Exercise A is called crossing. Players trying to cross from one side of borders to another one (in width). Players are without hockey sticks. My task was to hit crossing players with tennis balls (throwing). Players have to count how many times coach hit them. Same exercises was on off-ice.

Exercise B is called game in circle. This game was at one of the circle for faceoff. Every player have one puck and they have to control own puck and try to get opponents puck out of circle. They played this game for 20 seconds.

At off-ice training player play this game in circle from cones. Every player had behind shorts piece of rope (approx. 15 cm long) and tried to steal opponent‘s piece of rope. They played this game for 20 seconds.

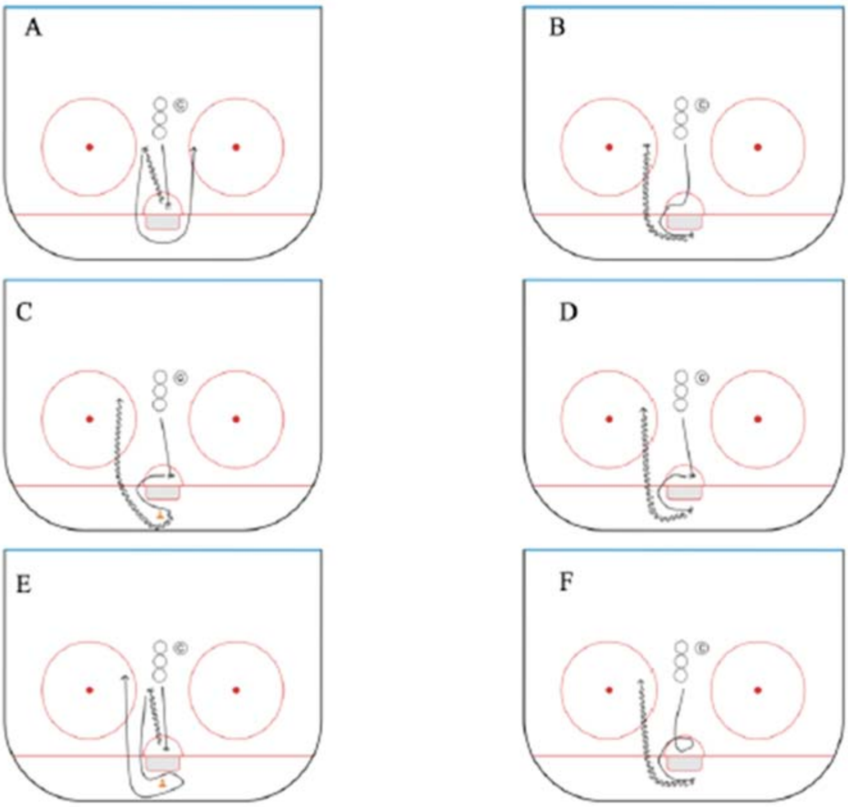


Week no. 3

Training no. 1 - exercises without puck, shorts sprints, level 3

Exercise A - F

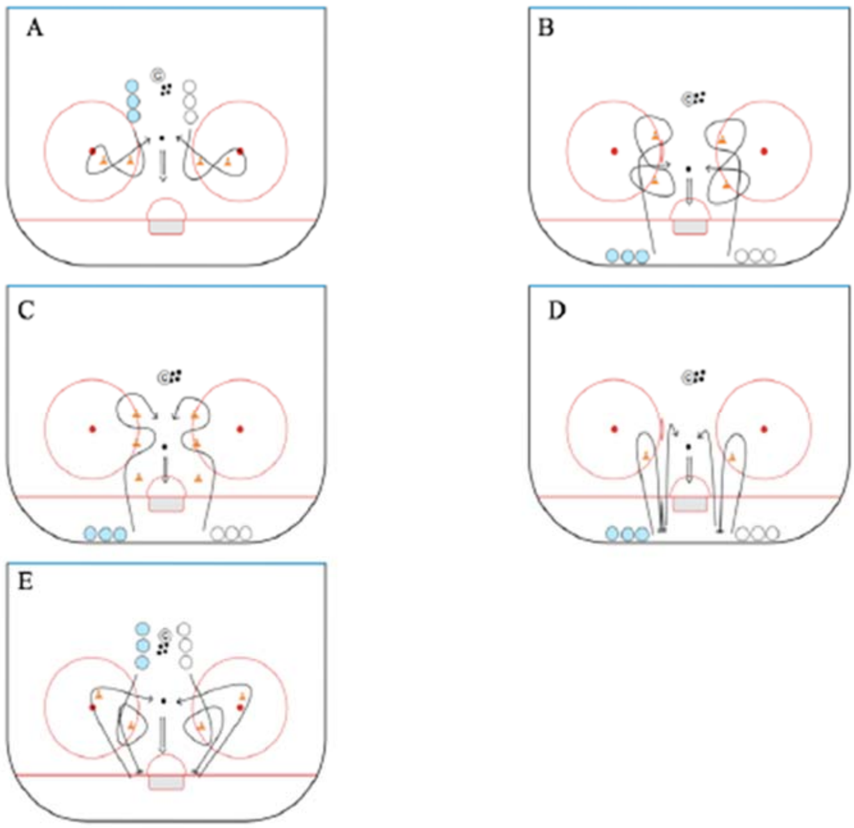
These exercises without puck was focused for backward speed after brake or after another skill like quick turn. Players were at crowd and started after player before him finished. At off-ice they did they same like on-ice.



Training no. 2 - duels and starts for puck with shoot on the net, level 3

Exercise A - E

Players started this exercise at command of coach. Players focusing at turn, brake and sprint after sprint. At program on off-ice were realized at stadium area. In these exercises weren't duel with shoot at net, but only touch the cone.

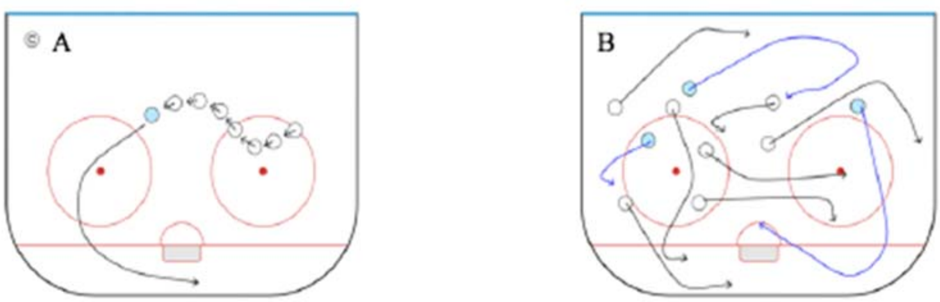


Training no. 3 - agility work or work with puck, level 3

Exercise A - B

Exercise A is called „snake''. Every player follows the first one. players have to change backward skating, forward skating, turns, brakes etc. All players are without pucks. Other players trying to do the same as first person as quick and correctly as possible. At command they will change positions. At off-ice training program they do the same as on-ice, but even without sticks.

Exercise B is called „freeze''. One of the players have to chase other players and try to touch them with stick or gloves. If he touch some player, this player have to brake and stretch his legs like A word, for release him another player have to skate under his body. . At off-ice training program they do the same as on-ice, but even without sticks.

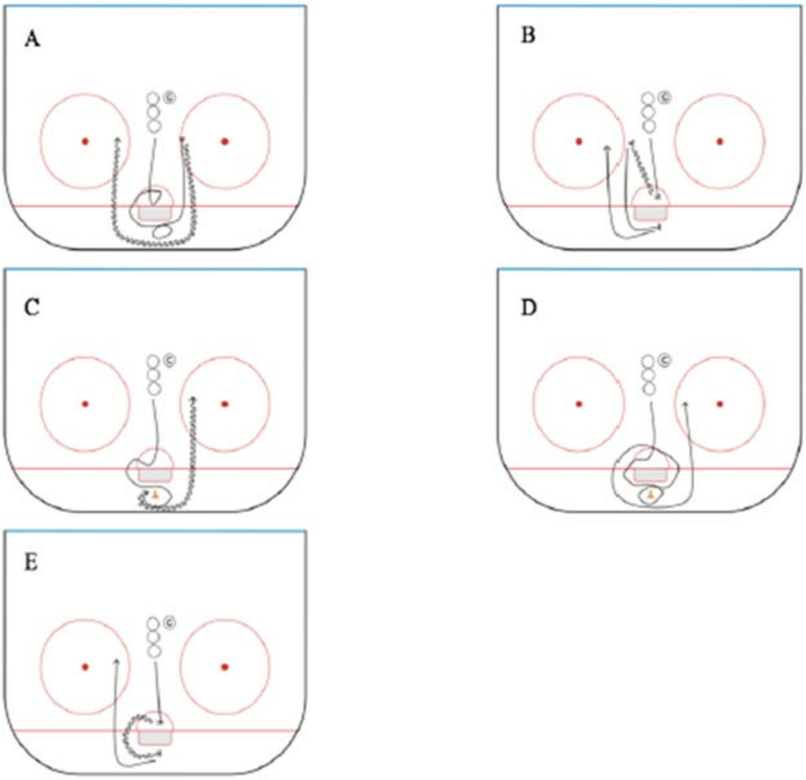


Week no. 4

Training no. 1 - exercises without puck, shorts sprints, level 4

Exercise A - E

These exercises included forward skating, backward skating, brakes and turning. Same exercises were at off-ice training program.

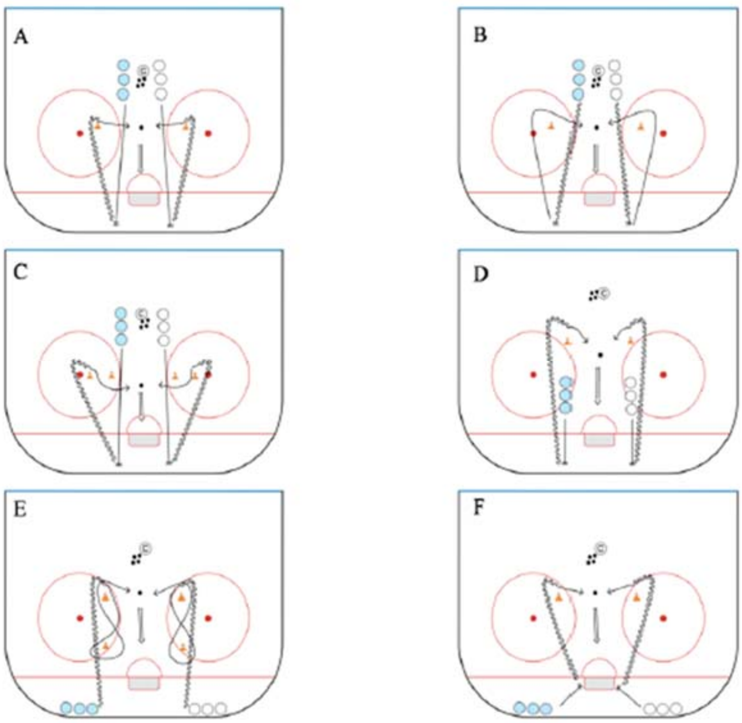


Training no. 2 - duels and starts for puck with shoot on the net, level 4

Exercise A - F

This is last level of difficulty of duels and starts for puck with shoot on the net. Players made brakes, turns, backward and forward skating finished with shoot on the net. Like all trainings number two, they must be faster than opponent.

At off-ice trainings they didn‘t shoot on the net, but finish was touching the cone.



Training no. 3 - agility work or work with puck, level 4

Exercise A - B

Exercise A was at one zone of a ring. All played against all. Players had one puck, and everyone want to score a goal. At off-ice trainings they played game called „snake‘‘, all players must follow the first one as fast as possible.

Exercise B is „go in or go out‘‘. All players skate around the circle, after command of coach (like whistle) they have to take puck from circle and skate out from circle. There is always one less puck then playing players, so after every round one player go out.