The use of strength and conditioning for ice hockey in the UK

Ice hockey in the UK is a minority sport, despite having several professional and semi-professional leagues. Physical fitness for most teams is worked 'on the ice': off-ice conditioning is often disregarded or left for players to work on individually. This article is designed to educate coaches and players about the benefits of off-ice conditioning for ice hockey players and to provide an example of a comprehensive year-long conditioning programme for adolescent and adult players.

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Introduction

Ice hockey is a high-intensity, intermittent, full contact team sport.[7] Games last for 60 minutes, and are divided into three 20-minute periods. Teams are made up of around 17 to 22 players, split by positions into forwards, defenders, and goalkeepers. At any one time, five players plus a goalkeeper are allowed on the ice from each team. Throughout the game, unlimited rolling substitutions are made, keeping the intensity of the game very high. To succeed, players need well-developed, all-round fitness, including strength, power, speed, acceleration, balance, and agility.[5, 8]

Although it is a major sport in the US and Canada, ice hockey remains a minority sport in the UK. Only one league can be considered truly 'professional', with a number of semi-professional and development leagues below. With this in mind, most teams do not have the resources to employ strength and conditioning coaches, and most do not have adequate – if any – work-out facilities at their arenas. Therefore, local fitness and leisure centres are regularly used by the athletes.

The typical ice hockey schedule in the UK sees games starting in September and finishing around March/April. Depending on the league, teams can be expected to compete in between 36 and 54 games in this time. Games are played on weekend evenings, with occasional midweek fixtures in some leagues. Training on the ice will consist of around two to five sessions a week, leaving little time for off-ice training.

It is clear to see that a structured training programme would need to promote maximal gains and maximal recovery, while fitting in with a busy on-ice schedule. The aim of this article is to present a justified, realistic, fitness testing battery and an off-ice periodised work-out schedule for ice hockey players in the UK.

Needs analysis

PHYSIOLOGY

Ice hockey is played at high intensity, due to the rolling substitutions made during a game. In-game studies have shown the working heart rate of athletes to be at around 90% of maximum heart rate, with athletes spending around 20% of game time at this intensity.[26] Average in-game blood lactate values have been recorded at 8.2 mmol.L-1, and reaching up to 13.7 mmol.L-1.23 The energy demands are met primarily through anaerobic glycolysis, with a smaller contribution from aerobic metabolism.[8] Time motion data from several studies have shown that 'shift' time ranges from around 60-90 seconds, with players completing around 15 shifts per game.[5,23] This would suggest a work to rest ratio of around 1:4.

BIOMECHANICS

The biomechanics of ice hockey skating strides has been discussed at length by Manners.[20] Ice hockey S&C coaches should consider these specific elements of skating when designing a programme, as there are several differences to normal running technique.

In the wind-up phase of forward skating, the push-off foot and leg is externally rotated to around 60°. This creates acceleration in the posterolateral plane, using the hip extensors and abductors. As the weight is shifted to the glide leg, hip and knee flexors and extensors co-contract to maintain stability and balance. In the cross-over step, Manners[20] also highlights the importance of the adductors, which are activated to push against the outside edge of the skate and propel the body sideways.

Injury analysis

As ice hockey is a full contact sport, injuries are common. In-game injuries occur eight times as often as practice-related injuries,[1] and player-player contact is the leading factor in recorded injuries.[1, 13] Knee internal derangements, concussions, and shoulder ligament trauma are the three most common in-game injuries, and groin strains are the most common practice injuries.[1, 13]

Tyler[28] investigated the influence of the hip adductor/abductor concentric strength ratio on groin injuries, and found a significant increase in hip injury occurrence in players with a large difference. The study concluded that an adductor:abductor ratio of less than 1:1.25 was a significant factor in increasing the occurrence of injury.

Fitness testing and success markers

Several studies have looked at the relationship between fitness measurements and future success. Burr et al[9] found that vertical jump performance had a moderate but significant correlation with NHL draft entry, and Peyer et al[24] found repeated sprints, chin ups, bench press and leg press all to be moderately significantly correlated to a player's success, measured with the ice hockey-specific plus/minus system. This simple scoring system allows a running total to be kept for each player over a game, a series of games, or a whole season as a measure of overall 'success'. The system allocates one point – a 'plus' – to each player on the ice when a goal is scored for their team, or deducts one point – a 'minus' – if the goal is scored against them. A higher plus/minus score may indicate the player has been influential in scoring goals whilst also defending their goal.[22]

Other studies have found direct correlations between fitness measures and sport-specific parameters. Wu et al[29] found a significant correlation between one repetition maximum bench press and slap shot velocity, and Farlinger et al[11] found a strong significant correlation between vertical jump performance and skating speed. Therefore, it can be concluded that muscular strength, muscular endurance, power, aerobic endurance and anaerobic endurance are all important fitness components which need to be addressed through focused training.

FITNESS TESTING

When designing a testing battery, several elements had to be considered. The needs analysis provided a base of information on the movements, specific muscle actions, and injury factors to be taken into account. Consideration also had to be given to the equipment available to coaches, and the time they had with their teams.

An appropriate testing protocol should include on-ice and off-ice tests. This is due to inconsistencies in current research when comparing off-ice performance to on-ice performance.[2,6,10,17] To remain specific to ice hockey, the components that should be measured are acceleration, speed, anaerobic and aerobic power, upper and lower body strength, change of direction ability and body composition. It is also recommended that the protocol should avoid retesting similar components (eg, off-ice sprints and on-ice sprints). This will avoid over-testing the athletes, and will reduce overall testing time. The chosen tests have been used in previous ice hockey studies and have been recommended previously by the author,[22] due to their high reliability (Table 1).

Finally, the tests chosen in the battery have been chosen to be as practical as possible. The tests do not require much in the way of equipment, and due to their short duration it is realistic to test a whole team over two sessions. To be as specific and applicable as possible, the author feels that acceleration,

Table 1. A suggested fitness testing battery for an ice hockey team

FITNESS COMPONENT	FITNESS TEST	MODALITY	INTRACLASS R	REFERENCE
Acceleration	6.1 m sprint	On-ice	0.80	Bracko[5]
Speed	35 m sprint	On-ice	0.98	Farlinger *et al*[11]
Change of direction	Cornering S test	On-ice	0.95	Farlinger *et al*[11]
Aerobic power	30-15 IIT	On-ice	0.96	Buchheit *et al*[7]
Anthropometry	Height/Weight/Body fat %	Off-ice	↗ 0.96	Geithner *et al*[16]
Anaerobic power	Vertical Jump (CMJ)	Off-ice	0.99	Burr *et al*[9]
Upper body strength	1 Rep Max bench press	Off-ice	Not reported	Ransdell and Murray[25]
Lower body strength	1 Rep Max front squat	Off-ice	Not reported	Ransdell and Murray[25]

Figure 1: A season long macrocycle for ice hockey

MONTH	JUN		JUL		AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Season phase	Preparatory					Competitive								Off season
Training phase	Strength, maximum strength and power					Maintenance								Recovery
Working on	GS	MS	U	MP	U	Maintain strength, power and power endurance								Maintain O_2 levels
Duration (wks)	3	4	1	4	1	35								4

GS = General Strength MS = Maximum Strength MP = Maximum Power U = Unloading

speed, aerobic power and change of direction ability should be tested with on-ice tests, whereas anaerobic power, anthropometry and upper and lower body strength should be tested off-ice.

Strength and conditioning

A periodised strength and conditioning macrocycle can be seen in Figure 1. The focus of this programme is for athletes who have reached a certain level of physical maturation, marked by peak height velocity.[19] According to Lloyd and Oliver,[19] it is at this point in an individual's physical state that the 'window of opportunity' for training the significant components of ice hockey (speed, power, hypertrophy and strength) is presented. The authors acknowledge that younger athletes will have different training needs, but feel that this is beyond the scope of the current article. It is also acknowledged that even as adolescents and adults, individual athletes will respond differently to any given training programme,[27] and therefore there may be a need to further individualise the programme presented.

The presented macrocycle shows the development of general strength, maximum strength, and maximum power periods in the preparatory or 'preseason' phase, with a maintenance period for the duration of the competitive season. It is realistic to assume that athletes will be able to train off-ice twice a week; furthermore, this is recommended by Gamble.[15] The individual microcycles include one heavy session and one lighter session each week. These are interchangeable and can be used to best fit in with an individual team's schedule, and to encourage maximum returns due to the recovery adaptation principle outlined by Stone et al.[27]

Additionally, due to the physically stressful nature of a full contact sport, a light training session is recommended during 'in-season' weeks to promote recovery and minimise the impact of muscle tissue damage on quality and volume of training sessions.[14]

Off-season phase

Due to the length of playing season, and physical nature of the sport, it is vitally important that players ensure a period of active rest during the 'off-season' (for clarity, the period after competitive matches have finished and before structured pre-season training begins). Many players choose to play alternative sports in this period, which can be beneficial. Golf is a popular choice, which helps to maintain hand/eye coordination, and squash is also recommended for an alternative metabolic conditioning exercise. These alternative exercise methods are seen as important to limit the monotony of the training ground environment.[15] Importantly, the duration of this period should be monitored to ensure that players do not become detrained.[14]

Preparatory phase

The programme begins with a preparatory mesocycle. The aim of this is to establish a solid physical base, allowing the athlete a better tolerance to the increased training intensity of the competitive phase.[4]

To begin the preparatory phase, a three week general strength microcycle should be completed (Figure 2). This general programme is made up mostly of single joint exercises, at an intensity of three sets at 10RM. This is designed to aid neural and physical development,[15] and will lay foundations for the proceeding maximal strength microcycles.

Figure 2: General strength cycle

CYCLE: General Strength	DURATION: 3 weeks	REST: 2 mins between sets
Sets/Reps: 3 x 10 @ 10RM		
WEEK 1	**WEEK 2**	**WEEK 3**
Day 1	**Day 1**	**Day 1**
Front squats	Split squats	SL RDLs
BB bench press	One arm row	Chin ups
Deadlifts	Leg press	Calf raises
Seated row	BB incline bench press	Seated shoulder press
Hammer curls	Back extensions	Leg extension
Day 2	**Day 2**	**Day 2**
Split squats	Back squats	Front squats
Seated shoulder press	Supine DB pull overs	BB bench press
Calf raises	EZ bar bicep curl	Deadlift
Lat pull downs	Tricep extensions	Bent over row
Tricep extensions	Upright row	Bicep curl to shoulder press

Remaining in the preparatory mesocycle, a four week maximum strength microcycle (Figure 3) should be started following the general strength weeks. The purpose of this cycle is to build maximal strength before progressing on to developing power, due to positive correlation between these components.[3] Additionally, maximal strength training returns high fast twitch muscle fibre recruitment, and also inhibition of antagonist muscles, resulting in better synchronisation and coordination.[3] One of the particular features of the strength cycles is the inclusion of exercise which match sport specific movement patterns. Front squats and 45° dumbbell lunges have been included due to their similarities with the muscular recruitment patterns of ice skating.[20,25]

At the end of the maximum strength phase, there is a one week unloading microcycle (Figure 4). Stone et al [27] justify the use of unloading weeks, where intensity is maintained but volume is dropped, as studies have shown that this method maximises increases in strength and power.

Following on from the strength cycle, a four-week power and power endurance cycle will take place. Power is one of the most important fitness components in ice hockey, and due to the repeated nature of the sport, the ability to perform power movements repeatedly means that power endurance is also an important factor.[3]

In this microcycle (Figure 5), strength exercises can still be seen, as maximal strength can only be maintained for around two weeks without training.[12] Also, plyometric exercises have been introduced between resistance exercises on the heavy training day. The use of plyometric exercises in this way, known as 'complex' exercises, can be justified in two ways. Complex training induces high levels of lactic acid build-up, which mirrors the high anaerobic demands of ice hockey. Training in this way can improve an athlete's tolerance to this build-up.[3] As Gamble[14] notes, complex training can induce peripheral adaptations including improved lactate handling, acid/base buffering and high energy resynthesis. Additionally, this training method has been shown to improve power production,[21] and has become popular in programmes where time is limited.[14]

Figure 3: Maximum strength cycle

CYCLE: Maximum strength	
DURATION: 4 weeks	
REST: 2 mins between sets	
SETS/REPS: 3x5, except chin ups (timed – 3x45 seconds) and ab crunches (3x20)	
INTENSITY: All exercises performed at 5RM except chin ups, abdominals, and 45° lunges (50% body weight)	
Day 1 (Light)	**Day 2 (Heavy)**
Front squat	Back squat
Push press	Seated row
Wide grip chin ups	Bench press (BB)
Ab crunches	45° lunges (DB)
	Lat pull down
	Seated shoulder press (DB)

DB= Dumbbell; BB= Barbell

Figure 4: Unloading

CYCLE: Unloading	
DURATION: 1 week	
REST: 3 mins between sets	
SETS/REPS: 2x4 (P); 3x4 (S)	
INTENSITY: 85% 1RM (P); 4RM (S); jump squats (body weight)	
Day 1	**Day 2**
Power snatch (P)	Power clean (P)
Bench press (BB) (S)	Jump squats (P)
Seated row (S)	Lat pull down (S)
Split squats (S)	Seated shoulder press (DB) (S)

Figure 5: Power/endurance cycle

CYCLE: Power	
DURATION: 4 weeks	
REST: 3 mins between sets for power (P) exercises, 2 mins for strength (S) exercises	
SETS/REPS: 3x3 (P); 3x5 (S); 1x8 between each set (C)	
INTENSITY: 85% 1RM (P); 5RM (S); except single leg bench jumps and jump squats (body weight), 45° lunges (60% body weight) and MB slams (6kg).	
Day 1 (Light)	**Day 2 (Heavy)**
Power snatch (P)	Power clean (P)
Front squats (S)	Jump squats (P)
MB diagonal slams	Bench press (BB) (S)
Single leg bench jumps (P)	MB chest pass (C)
	45° lunges (DB) (S)
	Russian hops (C)
	Seated row (S)
	Cycle split squats (C)

(C) = Complex exercise

At the end of the power phase, there is another one week unloading microcycle (Figure 4).

Competitive phase

At this stage, players will have completed the pre-season training phase and should be at peak strength and power levels. Throughout the competitive season, the S&C coach should be focussing on maintaining the levels of strength and power developed in pre- season, and therefore an undulating non-linear model is suggested. Maintaining strength levels throughout the season is vital to prevent significant losses in strength, power, and body mass,[14] which is particularly important for contact sport athletes. A training

frequency of two sessions a week, and a training intensity of around 80% 1RM has been recommended to maintain strength during the competitive phase in a contact sport.[18]

Two alternating programmes, each lasting two weeks (Figures 6 and 7), will include maximal strength exercises, upper and lower body power exercises and plyometric complexes, as seen in the preseason power cycle. The unloading week previously presented (Figure 4) can be used intermittently throughout 'in-season' training to alleviate the monotony that can develop over a long competitive season.[14] Also, studies have shown increases in overall strength and power when an unloading week is included in an undulating non-linear model.[27] This approach may also be adapted to taper a team, either in preparation for a strong opposition, or for a concentrated period of games. Ratios of 1:1, 2:1 or 3:1 loading:unloading weeks could be used at the discretion of the S&C coach depending on the specific demands of the team.[14]

Conclusion

Ice hockey is a high intensity, full contact sport which requires high levels of strength, power and endurance. In the UK, many ice hockey teams are restricted by a lack of resources. This article has attempted to demonstrate a full-season strength and conditioning programme that would be practical for teams and athletes. Although not all aspects/exercises put forward in this programme will fit with all teams, it is hoped that sections of this programme can be used by S&C coaches to help develop their athletes in the future.

Figure 6: Maintenance cycle 1

CYCLE: Maintenance 1
DURATION: 2 weeks
REST: 3 mins between sets for power (P) exercises, 2 mins for strength (S) exercises
SETS/REPS: 3x3 (P); 3x5 (S); 1x8 between each set (C); Chin ups (3x45s)
INTENSITY: 85% 1RM (P); 5RM (S); except single leg lateral cone hops and jump squats (body weight), 45° step ups (60% body weight) and MB slams (6kg).

Day 1 (Light)	Day 2 (Heavy)
Power snatch (P)	Power clean (P)
Back squats (S)	Jump squats (P)
MB diagonal slams	Shoulder press (DB) (S)
Single leg lateral cone hops (P)	MB chest pass (C)
	45° step ups (DB) (S)
	Russian hops (C)
	Wide grip chin ups (S)
	Cycle split squats (C)

Figure 7: Maintenance cycle 2

CYCLE: Maintenance 2
DURATION: 2 weeks
REST: 3 mins between sets for power (P) exercises, 2 mins for strength (S) exercises
SETS/REPS: 3x3 (P); 3x5 (S); 1x8 between each set (C); Chin ups (3x45s)
INTENSITY: 85% 1RM (P); 5RM (S); except single leg bench jumps and jump squats (body weight), 45° lunges (60% body weight) and MB slams (6kg).

Day 1 (Light)	Day 2 (Heavy)
Power split snatch (P)	Power split clean (P)
Front squats (S)	Jump squats (P)
MB diagonal slams	Bench press (DB) (S)
Single leg bench jumps (P)	MB chest pass (C)
	45° lunges (DB) (S)
	Russian hops (C)
	Seated row (S)
	Cycle split squats (C)

References

1. Agel, J, Dompier, T, Dick, R and Marshall, S. Descriptive epidemiology of collegiate men's ice hockey injuries: National Collegiate Athletic Association injury surveillance system, 1988-89 through 2003-04. *J Athletic Training*, 42: 241-248. 2007.

2. Behm, D, Wahl, M, Button, D, Power, K and Anderson, K. Relationship between hockey skating speed and selected performance measures. *J Strength Cond Res*, 19: 326-331. 2005.

3. Bompa, TO and Carrera, MC. Periodization training for sports (2nd Ed). Champaign, Ill: *Human Kinetics*. 2005.

4. Bompa, TO and Haff G. Periodization: Theory and methodology of training. Champaign, Ill: *Human Kinetics*. 2009.

5. Bracko, MR. On-ice performance characteristics of elite and non-elite women's ice hockey players. *J Strength Cond Res*, 15: 42–47. 2001.

6. Bracko, MR and George, JD. Prediction of ice skating performance with off-ice testing in women's ice hockey players. *J Strength Cond Res*, 15: 116–122. 2001.

7. Buchheit, M, Lefebvre, B, Laursen, P, and Ahmaidi, S. Reliability, usefulness, and validity of the 30-15 intermittent ice test in young elite ice hockey players. *J Strength Cond Res*, 25: 1457-1464. 2011.

8. Burr, JF, Jamnik, RK, Baker, J, Macpherson, A, Gledhill, N and McGuire, EJ. Relationship of physical fitness test results and hockey playing potential in elite-level ice hockey players. *J Strength Cond Res*, 22: 1535–1543. 2008.

9. Burr, JF, Jamnik, RK, Dogra, S and Gledhill, N. Evaluation of jump protocols to assess leg power and predict hockey playing potential. *J Strength Cond Res*, 21: 1139-1145. 2007.

10. Durocher, JJ, Jensen, DD, Arredondo, AG, Leetun, DT and Carter, JR. Gender differences in hockey players during on-ice graded exercise. *J Strength Cond Res*, 22: 1327–1331. 2008.

11. Farlinger, CM, Kruisselbrink, LD and Fowles, JR. Relationships to skating performance in competitive hockey players. *J Strength Cond Res*, 21: 915–922. 2007.

12. Fleck, SJ, and Kraemer, WJ. Designing Resistance Training Programs (3rd ed). Champaign, Ill: *Human Kinetics*. 2004.

13. Flik, K, Lyman, S and Marx, R. American collegiate men's ice hockey. An analysis of injuries. *Am J Sports Med*, 33: 183-187. 2003.

14. Gamble, P. Strength and Conditioning for Team Sports. Oxon, UK: *Routledge*. 2010.

15. Gamble, P. Periodization of training for team sports athletes. *Strength Cond J*, 28: 56-66. 2006.

16. Geithner, CA, Lee, AM and Bracko, MR. Physical and performance differences among forwards, defencemen, and goalies in elite women's ice hockey. *J Strength Cond Res*, 20: 500-505. 2006.

17. Gilenstam, KM, Thorsen, K and Henriksson-Larsen, KB. Physiological correlates of skating performance in women's and men's ice hockey. *J Strength Cond Res*, 25: 2133–2142. 2011.

18. Hoffman, JR, and Kang, J. Strength changes during an in-season resistance training program for football. *J Strength Cond Res*, 17: 109-114. 2003.

19. Lloyd, R and Oliver, J. The youth physical development model: A new approach to long-term athletic development. *Strength Cond J*, 34: 61-72. 2012.

20. Manners, TW. Sport-specific training for ice hockey. *Strength Cond J*, 26: 16-21. 2004.

21. Milihak, J, Libby, J, Battaglini, CJ, and McMurray, R. Comparing short term complex and compound programs on vertical jump height and power output. *J Strength Cond Res*, 22: 47-53. 2008.

22. Nightingale, SC, Miller, S and Turner, A. The usefulness and reliability of fitness testing protocols for ice hockey players: A literature review. *J Strength Cond Res* (2012). 27(6):1742-1748. 2013

23. Noonan, B. Intragame blood-lactate values during ice hockey and their relationships to commonly used hockey testing protocols. *J Strength Cond Res*, 24: 2290-2295. 2010.

24. Peyer, KL, Pivarnik, JM, Eisenmann, JC and Vorkapich, M. Physiological characteristics of national collegiate athletic association division I ice hockey players and their relation to game performance. *J Strength Cond Res*, 25: 1183–1192. 2011.

25. Ransdell, LB, and Murray, T. A physical profile of elite female ice hockey players from the USA. *J Strength Cond Res*, 25: 2358-2363, 2011.

26. Spiering, BA, Wilson, MH, Judelson, DA and Rundell, KW. Evaluation of cardiovascular demands of game play and practice in women's ice hockey. *J Strength Cond Res*, 17: 329-333. 2003.

27. Stone, MH, Stone, ME, and Sands, W. Principles and Practice of Resistance Training. Champaign, Ill: *Human Kinetics*. 2007.

28. Tyler, T, Nicholas, S, Campbell, R and McHugh, M. The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. *Am J Sports Med*, 29: 124-128. 2001.

29. Wu, T, Pearsall, D, Hodges, A, Turcotte, R, Lefebvre, R, Montgomery, D and Bateni, H. The performance of the ice hockey slap and wrist shots: The effect of stick construction and player skill. *Sports Engineering*, 6, p.31-39. 2003.

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