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Strength and Conditioning Considerations for Hurling: An Amateur Gaelic Games Sport

ABSTRACT

HURLING IS A HIGH INTENSITY, INTERMITTENT, AMATEUR GAELIC GAMES SPORT. A RISE IN THE NUMBER OF STUDIES HAVE BEEN CONDUCTED ON THE BIOMECHANICAL, PHYSIOLOGICAL, AND INJURY EPIDIMOMOLOGY CHARACTERISTICS OF HURLING ATHLETES, AND THIS REVIEW PROVIDES THE STRENGTH AND CONDITIONING PROFESSIONAL WITH GUIDELINES ON KEY PARAMETERS RELATING TO THE NEEDS ANALYSIS OF HURLING. A PROPOSED FITNESS TESTING BATTERY AND PROGRAM DESIGN FOR THE REDUCTION OF INJURIES AND ENHANCED PHYSICAL PERFORMANCE IS PROVIDED.

Key Words: Needs analysis, fitness testing, program design

INTRODUCTION

Hurling is an Irish-based Gaelic games sport which is believed to be one of the fastest field sports worldwide (48), and is played on a grass pitch 40% larger than most soccer fields (length: 130-145m; width: 80-90m) (8). It has a similar playing configuration to that of other stick and ball sports such as hockey and lacrosse and encompasses a wide spectrum of physical characteristics such as strength, change of direction, and aerobic capacity (17,47,48,49). The game consists of two teams of 15 who play for 35 minutes each half. Each team consists of a goalkeeper, 2 rows of defensive players (3 players per row), 2 midfielders, and 2 rows of forwards (3 players per row) (Figure 1). Each end contains goalposts similar to those found in rugby but inclusive of a net as well. The object of the game is to outscore your opponent by either striking the ball over the crossbar (1 point) or into the net (3 points). The sport is played with a piece of ash called a hurley (0.6kg, 83-93cm) and a ball called a sliotar (equivalent to the size of a tennis ball) which can travel up to 100 metres per second (m/s) during match play (11,15,19,48) (Figure 2).

The hurling season spans over 10 months from early November to the following September depending on performance, with participants training up to 4 nights per week from gym workouts to skill sessions (31,35). Typically, matches take place at weekends, with some games played mid-week during heavily congested periods of the season. Hurling has a very strong tradition reaching back to 1272 B.C and it's deemed to be one of the oldest present-day sports; however, over the years the physicality of the modern game has changed placing a greater emphasis on strength and power orientated training (36,48). Hurling remains to be an amateur sport and is regulated by the Gaelic Athletic Association (GAA) with an estimated 150,000 people participating every year (21). **Owing to being an amateur sport, except intercounty teams, many junior club teams do not have the revenue to employ a full-time strength and conditioning (S&C) coach**, which leaves players to primarily take ownership of their own training regimes. Thus, it is almost certain that training prescription and adaptation are not being fully maximised, which may render reduced physical performance (46). Consequently, a guideline for optimal physical preparation in hurling is warranted and is the primary aim of this paper. Despite the limited body of evidence compared to other field-based sports, a needs analysis inclusive of the movement mechanics, physiology, and injury epidemiology has been provided. This provides an evidence-based rationale for the proposed physical testing battery and suggested training programmes on how best to optimize physical training in club hurling.

*** INSERT FIGURE 1-2 ABOUT HERE ***

NEEDS ANALYSIS

Movement Mechanics

During match play, the variety of the skills outlined in Table 1 are executed at high-speed, and the high standard of athleticism in hurling presents strenuous demands upon the athlete. In addition, the demand for performance is subjected to differences between playing positions (12). The analysis of swing mechanics can offer valuable information for practitioners (18); however, there is currently little data for the sport of hurling.

Up to 97% of total distance travelled during match play is without the sliotar (40). However, unique movement patterns as outlined in Table 1 can play a key role on the physiological strain placed on athletes (11,19,48). Ball et al. (1) suggested that long distance aerial striking (over 50-60 metres) is the most important skill, as it is the most common method of passing and scoring within the game (Figures 2 and 3). It was acknowledged that on average 270 strikes occur in match play, with the aerial strike being the most prevalent (68%) (1). This correlates to a study by Gilmore (25) whom also found the aerial strike the most frequently used skill, accounting for 72.8% of all strikes.

*** INSERT TABLE 1 ABOUT HERE ***

*** INSERT FIGURES 3-5 ABOUT HERE ***

Physiology

The lack of research on hurling in comparison to other 'stick and ball' sports such as lacrosse and field hockey has resulted in practitioners retrieving information from comparable sports. Gaelic football is considered its 'twin' and has similar pitch dimensions; thus, physiological strain has been suggested to be comparable to this sport as well (48). The development of technology has allowed for accurate assessment of physical demands during game play using heart rate (HR) monitors with studies reporting an average heart rate for both first and second half of game play of 84% and 82% of HR maximum respectively (12,24).

Research into the work rate profile of players has revealed that a strong aerobic capacity is required to aid recovery between high-intensity efforts (on average every 22sec) (12). No significant difference was reported in activity levels between the first and second half in 15 elite level players, with 95% of total game time spent below 85% of HR maximum. Significant differences were found between various playing positions (Table 2) which indicated that players work rate depended on

where they were situated on the pitch (12). Players in the centre of the field (midfielders) covered notably greater distances and perform greater amounts of high-intensity activity. Therefore, from a training perspective, conditioning for players based in the centre of the field (half back, midfield and half forward) requires careful consideration so that they can cope with the increased physical demands of their playing position. It was concluded that hurling players need to possess high levels of aerobic capacity to be competitive and to perform at the highest level, given distances of ~9km can be covered in matches (12).

*** INSERT TABLE 2 ABOUT HERE ***

In a similar study O'Donoghue et al. (40) also reported that playing position has a significant effect on player work rate reporting with 7.5% of total game time involving repeated high intensity efforts (running, shuffling, and game related). 92.6% of total playing time consisted of light-to-moderate activity (stationary, walking, and jogging), with only 3.1% spent in possession of the sliotar (Table 3). Across all Gaelic sports, it was found that high intensity efforts last < 6 seconds (s); this number decreasing to 4.2 s specifically in hurling (40). This information is important to consider when designing training programs for hurling players as it demonstrates the importance of explosive strength and the requirements for proficient acceleration and deceleration ability.

*** INSERT TABLE 3 ABOUT HERE ***

Although limited, this research highlights that both aerobic and anaerobic development should be prioritised to meet the physical demands of the modern game (12,32,33,34,40). To the authors' knowledge, a limited number of studies have been completed on more advanced forms of physiological analysis; thus, more research is warranted into areas such as blood lactate values, work to rest ratios, and prescribed training interventions to enhance on-field performance.

Injury Epidemiology

Given the full contact nature of hurling, and potential mismanagement of training loads, injuries are common in the sport (8,10,41). Lower limb injuries are notably higher compared to the upper limb

(68.3% for lower limb) with 60% of total injuries also being non-contact in nature (37,43). Murphy et al. (37) reported a high incidence of acute injuries (82.1%) and Blake et al. (3) demonstrated an average of 76.7 injuries per 1000 hours for match-play and only 3.87 injuries per 1000 hours for training over a consecutive 3-season period. The prospective observational study demonstrated that elite match play injuries were 19 times more common than training related injuries. Lower limb injuries were the most predominant injuries (68-70.5%), with upper body accounting for 16.6-24% of total injuries. Muscle tissue injuries were the most frequent type of injuries (35.5-42.2%) with the hamstring group being the most common region (15.7-16.5%) (3). A prospective epidemiological study by O'Malley et al. (42) which included 21 elite hurling teams ($n = 696$) recorded a total of 560 lower limb injuries over a 4-year period. Injury incidence during match play was significantly higher ($p < 0.05$; 18 times higher) than training injuries (37.6/1000 hours vs. 2.1/1000hrs) with the hamstring being the most common injury site (23.6%) (42). The most common mechanism for injury was found to be sprinting (34.1%). These data provide useful information that highlights there may be a justification for more invasion-type training protocols (such as small-sided games), which may better prepare hurling players for the demands that occur in competition.

O'Connor et al. (41) undertook an injury analysis in youth hurling players and reported that 26.5% of injuries were considered 'overuse' in nature with lower limb most commonly affected (58%). The total number of match injuries was higher in comparison to training injuries with 8.3% being early recurring injuries (within 2 months of return to play). This rate of early recurring injury may suggest that hurling players are returning to competition before adequate return to play protocols have been implemented (41). This is supported by Murphy et al. (37) who reported that 14.6% of total injuries were recurrent which may also indicate a lack of appropriate interventions during player rehabilitation. In addition, these studies have also speculated that inadequate lower body conditioning may be an influential factor given injuries to this area are significantly higher than the upper body (3,37,41,42,43,60) (Table 4). Given the paucity of literature surrounding prescribed training interventions for hurling athletes, further interventions are warranted.

*** INSERT TABLE 4 ABOUT HERE ***

DEVELOPING PHYSICAL QUALITIES

Anthropometry

Research has revealed the height of the average player ranges between 177-182 cm and weight ranging from 78.5-89.5 kg (10,30,31,32,33,34,35,36). The rationale for measuring an athlete's body composition is to regulate body fat and encourage weight management to maximise performance (13). The most common method to determine body fat percentage is through skinfold testing which has reported strong reliability (intraclass correlation coefficient = 0.7-0.9) (26,58). Body fat percentages in elite hurling have ranged from 8-18% with no significant differences found between players (10,36). Intuitively, a higher body fat percentage is not a desirable characteristic as it is likely to negatively affect player acceleration and aerobic capacity, which are important traits in hurling (11,40,49).

Strength and Power

Performance at elite level involves the ability to generate explosive movements such as jumps and cuts during regular match play and success in these movements are underpinned by the ability to produce maximal levels of force (3,37,42,48). Therefore, it can be argued that one repetition maximum (1RM) testing is a valid measure of force production as it has been stated the gold standard in regards testing upper and lower body strength (2). Studies have found 1RM normative data for hurling players ranging from 63-69kg (back squat) (36,40). Familiarity with these tests is imperative to ensure safety and reduce the risk of injury, and if the coach is not familiar with 1RM testing it is recommended that these tests are not performed. As an alternative, clubs with very little resources or funding can make the use of the squat jump test (SJ) through the smartphone application 'My Jump' (56). The application is low in cost and may be the most suitable choice for clubs with limited financial budgets. Gallardo-Fuentes et al. (22) investigated intersession and intrasession reliability and validity and found the phone application provided very good within-subject reliability ($\alpha = 0.94-0.99$; CV = 3.8-7.6) and interday reliability ($r = 0.86-0.95$). Explosive power has been acknowledged as an essential trait due to the fast-paced nature of the game (17,36,47) and the use of the countermovement jump (CMJ) alongside with the drop-jump test have been found to be valid lower body power and reactive strength tests among hurling players (9). The drop-jump test to calculate reactive strength index (RSI) is particularly useful for developing a reactive strength profile and to individualise drop height during jump training (9,20). This may prove

beneficial as improvements in reactive strength can lead to improvements in jump height, rate of force development, and change of direction (50).

Speed, Acceleration, and Change of Direction Speed

Explosive power is a very important characteristic in field sports (13), with hurling success influenced by the ability to accelerate over 20m both in offensive and defensive positions (9). Furthermore, the ability to acceleration over 5m may prove to be fundamental as over half of the strikes (52%) are performed within 1m of the opposition (1). Time motion analysis reveal that players perform a large number of accelerations, performing one every 22 seconds (189 ± 34) per match, similar to Gaelic football (184 ± 40) (12). Therefore, it seems evident that the ability to accelerate and reach high speeds is of great importance, and testing linear speed seems logical (8,13,36). Budget restrictions may again limit the possibility of obtaining timing gates, so another viable option may be to purchase the 'My Sprint' smartphone application (51). This inexpensive and valid application determines power, force, and velocity properties with a low typical error between trials (<5%) highlighting a strong level of reliability (51).

Change of Direction is defined as "the skills and abilities needed to explosively change movement direction, velocities, and modes" and has been stated as a key factor in many team sports including hurling (11,32,33,34,39,40,47,48). Rapid accelerations, decelerations, and cuts have been noted to exist within the game through the high number of bursts ($n = 71.6$); therefore, it would be deemed wise to assess a players' CODS ability (40). The Change-of-Direction and Acceleration Test (CODAT) may be considered the most applicable to the sport due to the importance of accelerating over 5m (1), and its practical relevance to field based sports (29). A technical evaluation of COD may also be carried out using video analysis, giving the coach a qualitative impression as well as quantitative measures (39).

Aerobic Capacity

It has been suggested that aerobic and anaerobic performances correlate to success in team sports with advanced level players achieving greater distances in the Yo-Yo intermittent recovery test level 2 (54). Previous studies have made comparisons in aerobic capacities between soccer and hurling players, with values for Gaelic games players reported to range from 53.8 to 58.6 ml kg (36). Owing to the physiological stresses during match play (70% and 72% of maximum oxygen uptake) one can see the importance of aerobic development in the sport of hurling (36).

Studies have shown that hurling players which have been exposed to aerobic conditioning tend to recover faster in between high intense bouts of exercise (10). Therefore, it is recommended that the Yo-Yo intermittent sprint test (YYIR) is used to assess the aerobic and anaerobic capacity of hurling players (16,36). The use of the YYIR test is the test of choice as it is easy to administer and a practical option for measuring aerobic capacity in large numbers (2,13,36).

FITNESS TESTING BATTERY

A hurling testing battery must evaluate the many physical demands of the sport and many of the tests selected have also been utilised in other codes such as Gaelic football, soccer, and hockey and are quite common across field-based S&C programs (table 5). (8,10,36,38,57). The implementation of a testing battery is an essential component of S&C as it helps the coach monitor the progression of an athlete throughout the season. To evaluate a training program of a player effectively, a testing battery must first be in place to assess the physical characteristics of an athlete (38). Specific to the sport and based on the need analysis provided in this article, strength, speed, and change of direction are few of many traits required for elite hurling play. The aim of the testing battery provided is to assist S&C Coaches and managers alike on the most appropriate tests for the sport, and the order in which this has been presented is the most appropriate order (least fatiguing first) leading to optimal testing efficiency (45). The accumulation of testing data is of utmost importance to provide a more in-depth analysis on the physical demands of the sport.

*** INSERT TABLE 5 ABOUT HERE ***

PRACTICAL APPLICATIONS

Owing to the lack of research in the sport, the development of an S&C program will require a review of general S&C guidelines among other codes such as Gaelic football, soccer, and ice hockey (8,38,56). The macrocycle presented (Table 6) shows the development of a club level hurling athlete through various mesocycles (anatomical adaptation (AA), maximum strength, and power) (table 7) which also have been applied to other Gaelic sports (8). The authors acknowledge that individual and younger participants will have distinctive requirements and will respond differently to a given training program; therefore, may need a supplementary program (52). As such, club players may have the ability to train in the weight room twice a week which should be enough to ensure minimal

losses in strength and power qualities throughout the season if periodized appropriately (23); and will be discussed next.

Program Design

The preparation phase begins with a preparatory mesocycle, which aims to establish a solid base and prepare the athlete for higher training intensities later in the preparation phase (62). To begin this phase a 4-week anatomical adaptation (AA) phase should be carried out (table 8), as it has been documented that this phase is required to prepare the body for heavier loads further along into the season (6). The anatomical adaptation (AA) phase is described as a phase which prioritises the improvement of motor patterning, reduction of injuries, and increased work capacity (62). It was also noted that a strength program of this nature should also concentrate on the core musculature such as the abdominals, lower back, and spinal column (61). The program described uses a selection of exercises that target all muscle groups, at an intensity of 12RM down to 8RM. These rep ranges will expose hurling athletes to enough volume, in various training planes to improve overall coordination (62). Towards the end of the AA phase, the load reached should allow the athlete to make a smooth transition into the max strength phase (62).

A 4-week maximum strength phase will follow the AA phase, allowing for improvements in maximal strength and coordination (table 9). An intensity of 2-6RM has been selected, in accordance with research (27,62) to ensure strength adaptations will materialise. Gym sessions have been designed to be completed in less than 60 minutes to ensure an optimal hormonal training setting is maintained (51). The maximum strength phase involves a 3:1 paradigm which included a 1-week deload microcycle. This week will see a gradual reduction in training volume between 50-75%, with intensity and frequency remaining the same (52). Many studies have shown this deload method helps maximise strength and power (5,52).

Power training for hurling players is presented in the form of Olympic lifts derivatives and ballistic based movements (14) (Table 10). Varying the intensity placed on the athlete during this phase allows for training of the whole force-velocity curve (55). Strength training during the power phase is recommended to maintain high levels of strength which are very important for the production of power (14,44,62).

Collins et al. (10) has outlined that elite hurling players must possess high levels of aerobic capacity to be successful. Over an 8-week period, Helgerud et al. (28) discovered that using the 4x4 method significantly improved $\dot{V}O_2\text{max}$ in football players by 7.5–10.8% (28,57,59). Therefore, the use of the

4x4 method outlined by Helgerud et al. (28) may prove beneficial to significantly improving hurling players' aerobic capacity which may have a positive impact on match performance (10,28) (Table 11). This method of interval training requires participants to run at 90-95% of maximal heart rate (180-190 bpm) for 4 minutes followed by 3 minutes of active recovery of 70% maximal heart rate. This 7-minute period would represent one full repetition and would be completed a further three times to complete the full conditioning session (28). Realistically, this is probably easier to conduct in a gym setting on a treadmill where heart rate can be more easily monitored throughout.

*** INSERT TABLES 6-13 ABOUT HERE ***

CONCLUSION

Owing to its amateur status and absence in research many teams are restricted by lack of finance and resources, which may lead to improper strength and conditioning protocols being implemented. In response to the lack of research, the aim of this article was to provide a needs analysis of the sport with a focus on the key physiological aspects and movement mechanics. Furthermore, based on the evidence provided, this article has presented the strength and conditioning professional with a subsequent testing battery along with a full pre-season S&C program that would be practical for the adult hurling athlete. Hurling players must possess high levels of aerobic conditioning, strength and power. It is recommended that these characteristics are developed using aerobic development, heavy resistance training, and ballistic style weightlifting. It is important to take into consideration that this programme will not fit with all players but sections of this programme can be utilised by the strength and conditioning professional to develop their athletes. If participation in hurling is to grow across the globe, there will be a need for further research in various areas such as biomechanics to establish further evidence based S&C programs for the athlete.

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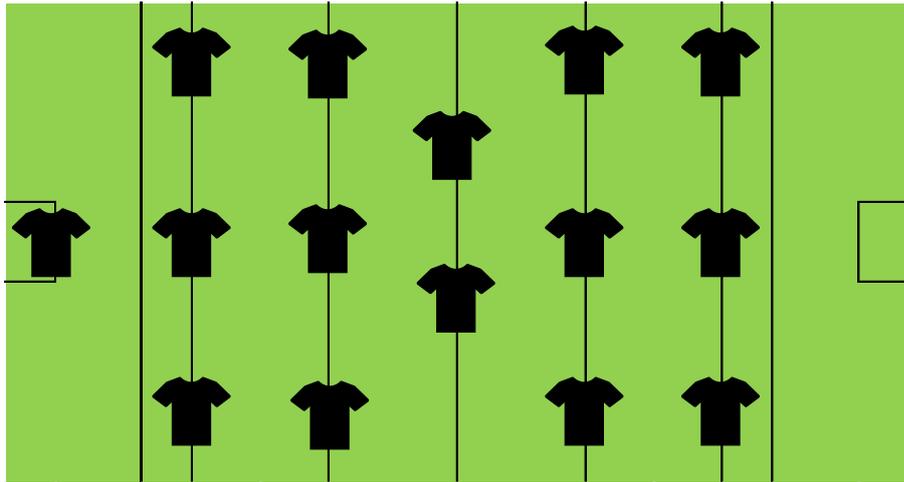


Figure 1: Positional layout used in the game of hurling.



Figure 2: A hurley and sliotar used in the game of hurling

Table 1: Key Biomechanical Movements Specific to hurling (adapted from Gilmore. 2008)

Movement	Operational Definition
Aerial Strike (static)	Similar in nature to a baseball swing as the sliotar is tossed up into the air to shoulder height and the struck with the boss of the hurley (figure 1).
Aerial Strike (running)	The sliotar is tossed up into the air and the struck with the hurley while the player is running (figure 2).
Strike from the ground	The sliotar is struck on the ground with the hurley in one or both hands whilst not being pushed or flicked (figure 3). The strike from the ground is very similar to an ice hockey swing.
Soloing (balancing ball on hurley)	The sliotar is balanced on the hurley and is primarily used by the player in possession who wishes not to pass or strike the ball.
Blocking an opponent	As the opponent throws the sliotar up into the air, the player lunges forward with the hurley placed in front and blocks down on the sliotar and hurley.
Hand pass	The sliotar is thrown up and struck with the palm of the hand in the direction of the receiver.
The pick-up	Keeping eyes on the static ball, the lifting position is adopted by bending knees and back. The hurley which is almost parallel to the ground is pushed under the sliotar to raise it into the air to be caught, struck or travelled with. The pick-up is very similar to the pick-up used in Lacrosse.
Catching from the air	The sliotar (ball) is caught overhead by the non-dominant hand to gain possession when the sliotar is approaching above head height. The hurley is also raised overhead to protect the catching hand from oncoming opponents.



Figures 3-5: Player performing a stationary aerial strike, aerial strike on the run and from the ground

Table 2: The positional difference in work-rate of elite hurling match-play (adapted from Collins et al. 2017)

Position	Total Distance (m)	95% CI	High Speed Running Distance (m)	95% CI	Sprint Distance (m)	95% CI	Accelerations	95% CI
Full-Backs (n=22)	6548 ± 786*^a	6199 - 6896	880 ± 204*^	789 - 970	291 ± 90	251 - 331	162 ± 28*^a	149 - 175
Half-Backs (n=22)	8046 ± 686*	7742 - 8350	1043 ± 245*	934 - 1151	275 ± 124*	220 - 330	198 ± 26	186 - 209
Midfield (n=16)	8999 ± 676	8639 - 9360	1571 ± 371	- 1768	404 ± 166	41 - 316	223 ± 25^	209 - 236
Half-Forwards (n=20)	7975 ± 845*	7589 - 8370	1249 ± 262*	- 1371	348 ± 127	288 - 406	194 ± 28*^	181 - 207
Full-Forwards (n=14)	6530 ± 1112*a	5888 - 7172	1008 ± 359*	823 - 1192	292 ± 105	231 - 352	163 ± 24*^a	149 - 177

* Significantly different ($p < .05$) from the midfield 388

^ Significantly different ($p < .05$) from the half-forward line 389

a Significantly different ($p < .05$) from the half-back line

Table 3: A breakdown of the physiological actions occurring in game-time (adapted from O'Donoghue et al. 2004)

Variable	Percentage (SD)	Variable	Time
Stationary	20.2 (9.5)	Bursts (frequency)	71.6 (26.7)
Walking	45.4 (9.9)	Duration of bursts (s)	4.2 (1.5)
Backpedalling	10.2 (7.3)	Duration of recovery (s)	55.1 (19.0)
Jogging	16.8 (7.2)		
Running	3.1 (1.8)		
Shuffling	1.3 (1.1)		
Game related	3.1 (1.4)		

SD = Standard Deviation; s = seconds

Table 4: Injury sites for hurling players

Author	Injury	Percentage (%)	Total Injury Rate (Training)/1000hr	Total Injury Rate (Match Play)/1000hr
O'Connor et al. (41)	Ankle/Foot/Toes	12		
	Knee	20		
	Hamstring	4		
	Quadriceps	4		
	Groin	10		
	Shoulder/Elbow/Wrist	14		
	Lower Back	22	2.29	4.39
O' Malley et al. (42)	Hamstring	23.6		
	Knee	19.3	2.1	37.6
Blake et al. (4)	Concussion	0.8		
	Fracture (nose)	0.3		
	Fracture (maxilla)	0.08		
	Contusions	0.8	n/a	0.19
Blake et al. (3)	Lower Limb	68-70.5		
	Upper Limb	9.2-14.7	3.87	76.6
Murphy et al. (37)	Head/Neck	5.4		
	Shoulder/Arm/Elbow	2.9		
	Wrist/Hand	12.2		
	Trunk/Spine	9.3		
	Hip/Groin/Thigh	38.7		
	Knee	7.4		
	Shin/Ankle/Foot	24.0	5.3	102.5
Watson et al. (60)	Hamstring	12		
	Contusions	16.3		
	Finger	13		
	Back	11		
	Head	9		
	Knee/Ankle	9	n/a	n/a

Table 5: A suggested fitness testing battery for a hurling team

Variable	Fitness Test	Rest interval	Reference
<i>Gym Tests</i>			
Anthropometry	Weight and height, 3 sites BF%	n/a	Brick and O'Donoghue (7)
Grip Strength	Hand grip dynamometer	n/a	Brick and O'Donoghue (7)
Power	Countermovement Jump	5 mins intervals	Byrne et al. (9)
RSI	Drop Jump Test		Byrne et al. (9)
Upper body strength	1RM Bench		Brick and O'Donoghue (7)
Upper body strength	1RM Prone Row		
Lower Body strength	1RM Squat or Squat jump		
<i>Field Tests</i>			
Change of direction speed	CODAT	5 min intervals	Lockie et al. (29)
Linear Speed and Acceleration	5, 10, 20m	5 min intervals	Strudwick et al. (53)
Aerobic Power	YYIR	n/a	McIntyre (36)

BF = body fat; RSI = Reactive Strength Index; 1RM = 1 Repetition Maximum; YYIR = Yo-Yo intermittent recovery

Table 6: Hurling strength and conditioning macrocycle example

Month	Nov	Dec	Jan	Feb	Mar	Apr	Ma y	Jun	Jul	Aug	Sep	Oct
Season Phase	Prep				Competitive				Off-season			
Training Phase	Aero, AA, Max Str, P				Maintenance				Recovery			
Gym Focus	AA	Max Str	P	Maintenance of Str and P				Recovery				
On Field Focus	Spd/Ag 1	Spd/Ag2	Spd/Ag 3	Maintenance of Accel/MSpd and Ag				Recovery				
Duration (weeks)	4	4	4	Range from 20-32 weeks depending on success				4				

Prep = Preparation; Aero = Aerobic; AA = Anatomical Adaptation; Max Str = Maximum Strength; P = Power; Tech = Technique work; Spd/Ag = Acceleration, Maximum Speed & Agility development.

Table 7: General guidelines on the implementation of an S&C program for hurlers.

Anatomical Adaptation	Maximum Strength	Power	Maintenance
Intensity: 67-80% of 1RM	Intensity: 85-95% of 1RM	Intensity: 60-85% of 1RM	Intensity: 60-80% of 1RM
Reps: 8-12	Reps: 2-6	Reps: 4-6	Reps: 1-3
Sets: 2-3	Sets: 3-4	Sets: 3-5	Sets: 2-4
Rest: 1-2 mins	Rest: 2-3mins	Rest: 2-3mins	Rest: 2-3mins
Freq: 3 days per wk	Freq: 2 days per wk	Freq: 2 days per wk	Freq: 2 days per wk

RM = repetition maximum, Freq = Frequency.

Table 8: Example anatomical adaptation program for hurling players

Mesocycle		Anatomical Adaptation							
<i>Duration</i>		<i>4 weeks (3:1)</i>							
Microcycle 1					Microcycle 2				
Exercise	Sets	Reps	% 1RM	Rest	Exercise	Sets	Reps	% 1RM	Rest
Back Squat	2-3	8-12	67-80%	1-2 mins	Deadlift	2-3	8-12	67-80%	1-2 mins
Split Squat	2-3	8-12	67-80%	1-2 mins	Lateral Split Squat	2-3	8-12	67-80%	1-2 mins
Push ups	2-3	8-12	BW	1-2 mins	Prone Row	2-3	8-12	BW	1-2 mins
Assisted Pull ups	2-3	8-12	BW	1-2 mins	Seated Shoulder Press	2-3	8-12	67-80%	1-2 mins
Iso Hamstring Bridge	2-3	30sec	BW	1-2 mins	Iso Hamstring Bridge	2-3	30sec	BW	1-2 mins
Plank Complex	2-3	45sec	BW	1-2 mins	Plank Complex	2-3	45sec	BW	1-2 mins

1RM = 1 Repetition Maximum; Mins = Minutes; Iso = Isometric; BW = bodyweight

Table 9: Example maximum strength program for hurling players

Mesocycle		Maximum Strength							
<i>Duration</i>		<i>4 weeks (3:1)</i>							
Microcycle 1					Microcycle 2				
Exercise	Sets	Reps	% 1RM	Rest	Exercise	Sets	Reps	% 1RM	Rest
Back Squat	3	2-6	85-95%	2 mins	Deadlift	3	2-6	85-95%	2 mins
RDL	3	2-6	85-95%	2 mins	Bul SS	3	2-6	85-95%	2 mins
Push Press	3	2-6	85-95%	2 mins	Prone Row	3	2-6	85-95%	2 mins
Pull ups	3	2-6	BW	2 mins	Bench Press	3	2-6	85-95%	2 mins

1RM = 1 Repetition Maximum; RDL = Romanian Deadlift; Bul SS = Bulgarian Split Squat; BW = bodyweight

Table 10: Example power program for hurling players

Example Power Program for Hurling Players										
Mesocycle	Power									
<i>Duration</i>	<i>4 weeks (3:1)</i>									
	Microcycle 1				Microcycle 2					
Exercise	Sets	Reps	% 1RM	Rest	Exercise	Sets	Reps	% 1RM	Rest	
Mid-Thigh Clean	3-5	4-6	60%	3	Mid-Thigh Clean	3-5	4-6	60%	3	
Pulls				mins	Pulls				mins	
Deadlift	3-5	4-6	80-85%	3	Back Squat	3-5	4-6	80-85%	3	
				mins					mins	
Broad Jumps	3-5	4-6	BW	3	CMJ	3-5	4-6	BW	3	
				mins					mins	
Med Ball Throw	3-5	4-6	4-6kg	3	Med Ball Throw	3-5	4-6	4-6kg	3	
				mins					mins	

1RM = 1 repetition maximum; Med ball = Medicine ball; CMJ = Countermovement Jump

Table 11: Example of interval training for hurling players (protocol guided by suggestions of Helgerud et al. [28])

Training Phase	Type of Training	Protocol	Frequency
Weeks 1-8	Pitch based and treadmill running	4x4 mins runs of 90-95% MHR (3 mins rest).	2 x week

MHR = Maximum heart rate

Table 12: Example of Acceleration and Maximum Speed session for hurling players

Mesocycle	Acceleration and Maximum Speed	
<i>Duration</i>	<i>4 weeks</i>	
3 x 10m Marching A-drill	1 min rep	3 min set
3 x 10m Skipping A-drill	recovery	recovery
3 x 10m Running A-drill		
3 x 10m from push up position		
3 x 15m from supine position		
3 x 25m rolling starts		
3 x 15m acceleration plus 20m maintain		

Table 13: Example progression of change of direction speed (CODS)/agility training throughout season (training emphasis evolves from planned CODS drills to reactive agility emphasis)

Agility Training Phase	Focus	Intensity
1	Development of motor patterns	Low to Moderate
2	Closed agility drills	Moderate
3	Open agility drills	High
Maintenance Phase	Small sided games (SSG)	Maximal