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Reliability of Sprint Acceleration Performance and Three Repetition Maximum Back Squat Strength in Hurling Players

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Abstract: *The purpose of this study was to estimate the inter-day reliability of 5, 10 and 20-meter sprint time and three repetition maximum back squat strength in male hurling players. Eighteen male hurling players volunteered to participate and performed 20- meter sprint trials and a three repetition maximum back squat strength test at each test session, on three separate occasions, a minimum of 48 hours apart. Participants performed three sprints over 20-meters, including split times at 5 and 10-meters. The three repetition back squat strength test was performed after the sprint test. The results displayed acceptable levels of reliability for sprint performance times (Intra class correlation coefficient single measure range: 0.76-0.89; Coefficient of variance range: 1.0 – 2.0%) and absolute and relative three repetition maximum back squat strength (Intra class correlation coefficient single measure: 0.98; CV 0.8%). Furthermore, sprint performance times and three repetition maximum back squat strength measures estimated feasible minimum a priori sample sizes from limits of agreement (5-meter:0.01 ± 0.08 s; 10-meter:-0.01 ± 0.12; 20-meter:-0.007 ± 0.15s; three repetition maximum (kg): 1.11 ± 4.19kg; three repetition maximum (kg/BW): 0.01 ± 0.06) random error therefore showing acceptable reliability. Sprint performance over 5, 10 and 20-meters and three repetition maximum back squat strength are reliable measures in male hurling players and can be used to estimate feasible minimum a priori sample sizes for sport science research.*

Keywords: *Reliability; limits of agreement; sample size; sprint testing; strength testing; hurling*

1. INTRODUCTION

Hurling has been described as one of the world's most dynamic and skilled field sports.[1] The play in hurling is rather unique as it can change rapidly from one end of the pitch to the other due to the large distances the ball can travel and requires players to contest for possession aerially or on the pitch surface.[2] Time motion analysis has shown that hurling comprises intermittent exercise where unpredictable bouts of high-intensity activity are combined with periods of low-intensity activity.[3]A recent global positioning system (GPS) study by Collins et al[4] provided evidence that elite players during match-play perform intense activity every 22 seconds which led to on average 62 high speed / sprint running accelerations been performed. Therefore, the ability to accelerate over distances up to approximately 20-meters is a key athletic component for success in hurling. The ability to accelerate over these distances in offensive and defensive situations is critical as the accelerations occur close to the hurling ball and can determine the outcome of crucial events during the game.[2] To assess the ability to accelerate over distances up to 20-meters, it is necessary to have reliable tests available for the coach and sport science practitioner working with hurling players. To date, a distinct lack of research exists in estimating the reliability of sprint performance tests over 5, 10 and 20-meters in male hurling players.

Previous research has investigated the reliability of 10-meter sprint performance in conjunction with different photocell heights and starting positions in university sports students and junior rugby players.[5, 6] These studies reported a low coefficient of variation (CV) of 1%. In terms of 20-meter sprint performance in junior rugby league players, CVs were reported to be 0.7 – 1%.[7] A study that assessed 20-meter sprint in team sport players with a walking rolling start, reported a CV of 4.2%.[8]

Acceleration over these distances is underpinned by kinetic and kinematic factors. In terms of kinematics, field sport athletes require appropriate stride frequencies and ground contact times to produce high velocities during acceleration.[9] When kinetic factors are considered, this may be explained by evidence that peak ground reaction forces and impulse are strong determinants of sprint performance.[10, 11] Previous studies have demonstrated the relationship between strength and sprint performance, showing that stronger athletes produce faster sprint performances.[12, 13]

Previous research has examined the relationships between the ability to accelerate over distances of 5, 10 and 20-meters and back squat strength. Wisloff et al[13] reported significant relationships in soccer players between back squat absolute maximal strength and 10-meter sprint time (r = 0.94). Cunningham et al[14] has shown a significant relationship between 10-meter sprint time and relative back squat strength (r = -0.55) in rugby union players. Comfort et al[15] assessed the relationship between 1RM back squat strength and 5, 10 and 20-meter sprint performance. They reported significant relationships between relative strength and 5-meter sprint performance in well-trained athletes and recreationally trained individuals. Furthermore, they found that relative strength was related more to 10 and 20- meter sprint performance, in recreationally trained individuals. From the evidence of these relationships it is important to assess the reliability of 3RM back squat strength so that the sport science practitioner, working with male hurling players, can be confident in the tests they use to assess the impact of weight training programs on hurling players due to the effect strength can have on sprint performance.

When examining the reliability of back squat strength testing, a study by McCurdy et al[16] investigated the reliability of unilateral 1RM and 3RM back squat strength in untrained and trained males and females. The study reported high levels of reliability based upon an intra class correlation coefficient (ICC) (untrained: 0.87–0.97; trained 0.94–0.97). Seo et al[17] investigated the reliability of a number of strength training exercises including the back squat in healthy females and males. They reported high levels of reliability with a test-retest design over two sessions (ICC: 0.97-0.99; CV: 0.53%- 0.34%).

To the best of our knowledge, our study is the first to have included Bland and Altman's 95% limits of agreement (LOA) for estimating the absolute reliability and to employ the LOA to estimate sample size for sprint performance (5, 10 and 20 m) and 3RM back squat strength. Furthermore, this is the first study to have estimated reliability of sprint performance and back squat strength in male hurling players. Therefore, the purpose of the current study was to estimate the inter-day reliability of sprint performance over 5, 10 and 20 meters and 3RM back squat strength in male hurling players.

2. Materials and Methods

2.1 Participants

Eighteen male hurling players (age (mean ± SD): 21.2 ± 2.1 years; mass: 79.2 ± 6.5 kg; height: 179.5 ± 3.7 cm) competing in the Irish collegiate hurling league season and at club level, volunteered to participate in this study during their in-season. Subjects were hurling training on average three times per week and playing a match once per week. Participants were also involved in weight training on average twice per week. Participants had a minimum of one year's weight training experience and were encouraged to undertake their normal training during the study. No orthopedic or musculoskeletal injuries to the lower extremities in the previous six months were reported during medical screening. Written consent was sought and obtained from subjects. Ethical approval was attained from the institutional ethics committee.

2.2 Procedures

This study used a repeated measures design where male hurling players completed three test sessions to determine inter-day reliability of 5, 10 and 20-meter sprint performance times and 3RM back squat strength (Absolute and relative 3RM back squat strength). These hurling players received a familiarization session prior to the commencement of test sessions. After a warm-up comprising of cardiovascular activity and dynamic stretches for the three test sessions, subjects performed three 20-meter sprints (including split times at 5 and 10-meters) followed by a 3RM back squat protocol to determine absolute and relative 3RM back squat strength. The best 5, 10 and 20-meter sprint times and the highest absolute and relative 3RM back strength measures from the three test re-test sessions were used to estimate inter-day reliability.

Participants were familiarized with the 5, 10, 20-meter and 3RM back squat strength testing protocols during one session. Subjects were tested at the same time of day (2-4pm) to account for diurnal variations and testing took place indoors. The same footwear was required to be worn for all tests. A dynamic warm-up that comprised five minutes of self-paced low intensity jogging and dynamic stretches were used prior to the commencement of testing at each test session.[18]The five dynamic stretches targeted the gluteals, hamstrings, adductors, quadriceps and gastrocnemius. These dynamic stretches were performed in the order stated, with two sets of fifteen repetitions completed on both legs in total over a 10-meter distance.

2.3 Measures

2.3.1 Sprint Performance Testing

Sprint testing over 20-meters (Including split times at 5 and 10-meters) was performed on the same day as the 3RM maximum back squat strength testing. Participants performed three trials of 20-meters, three minutes apart and the best trial was recorded. Participants started their sprint in a static upright position 0.5 m behind the first photocell (Microgate, Bolzano, Italy).

2.3.2 Three Repetition Maximum (3RM) Back Squat Strength Testing

Participants completed the 3RM back squat strength test after a five-minute recovery period placed between the end of 20-meter sprint testing and the start of the 3RM back squat strength. Participants performed a modified form of a three repetition maximum (3RM) protocol as used by Cunningham et al[14]. Warm-up sets comprising of two sets of eight repetitions of 50% of their predicted 1RM followed by four repetitions at 70% of the predicted 1RM. A previous 1 RM score was used as the predicted 1RM to calculate to 50% and 70% loads for the warm-up sets. After completing the four repetitions, attempts at performing three repetitions at a 3RM load commenced. A two minute recovery period and a five minute recovery were used between warm-up sets and 3RM attempts respectively. The 3RM trials continued until the subject was unable to complete the lift through the designated range of movement. Participants were required to squat down until their thighs were parallel with the ground. This position was set by a bench placed behind the participant. The orientation of the bench was tailored for each participant. One repetition maximum was estimated using a chart published by Baechle and Earle[19]. Relative strength was calculated from the following equation: relative strength = 1RM (kg)/body mass (kg).

3. Statistical Analysis

Means and standard deviations were calculated for all measures. A repeated measures analysis of variance (ANOVA RM) was used to identify systematic bias (e.g. fatigue or learning effect) between trials for each measure. Pair-wise *post-hoc* tests using a Dunn-Sidak adjustment were conducted on only absolute and relative 3RM back squat strength to show significant pair wise differences between test session 1 and test session 2. Relative reliability was assessed using an intra class correlation coefficient (3.1, 2-way mixed model with consistency and single effect measure) and 95% confidence intervals. Average measures from this ICC model and Cronbach's alpha were also reported to compare with values from previous work. Absolute reliability was assessed using Bland and Altman's 95% limits of agreement (LOA), coefficient of variance (CV %) and standard error of measurement (SEM). Random error of the limits of agreement was determined using the following equation ($s=\sqrt{(2 \times s_w^2)}$) for all measures except absolute and relative 3RM back squat strength.[20]Absolute and relative 3RM back squat strength random error, was calculated by multiplying the SD of the differences between test session 2 and test session 3 by 1.96. LOA random error of the measures was used to estimate the feasible minimum sample size for ANOVA RM. Estimated feasible minimum sample size was calculated using G*Power software (Version 3.1.7, University of Kiel, Germany). Effect size for ANOVA RM in G*Power software was calculated using LOA random error of the measures and previous research with power and alpha levels set at 0.8 and 0.05 respectively. The SEM was calculated from $1.96 \times \sqrt{MS_E}$ for sprint performance.[21] SEM for 3RM back squat strength was calculated as follows: $SEM = SD \times \sqrt{(1 - ICC)}$.[22] The CV was calculated as follows: CV% = (within-subject SD)/(mean*100).[23] The first criterion was the ICC single measure had a minimum acceptable relative reliability of ≥ 0.70.[24] The second criterion was for the CV to be $\leq 10\%$ for the measure to be reliable.[25] The third reliability criterion was for the authors to judge if LOA random error estimated minimum sample sizes to be feasible in magnitude. The tests / measures were deemed to have acceptable reliability when the three criteria were met. A statistical significance of $P < 0.05$ was used and statistical analyses were conducted using Statistical Package for Social

Sciences Version 20 (SPSS Inc., Chicago, Illinois).

4. Results

A repeated measures ANOVA showed systematic error ($P < 0.05$) for absolute and relative 3RM back squat strength only. As systematic error was identified for these two measures, the first trial was discarded for analysis. Sprint performance and 3RM back squat strength measures displayed acceptable levels of relative reliability (ICC) by meeting the criteria of ≥ 0.70.[24] ICC (single and average measures), Cronbach's alpha and ICC 95% confidence intervals for measures are displayed in Table 1.

Table1. *Intra class correlation coefficients (model (3.1) 2-way mixed model with consistency and single and average measures), 95% confidence intervals (CI) and Cronbach's alpha for 5-m, 10-m and 20-m sprint performance times and absolute and relative 3RM back squat strength.*

		ICC			
Measures	**Cronbach's α**	**Single measure**	**95% CI**	**Average measure**	**95% CI**
5 m (s)	0.90	0.76	0.55 - 0.89	0.90	0.79 – 0.96
10 m (s)	0.95	0.85	0.71-0.94	0.95	0.88 – 0.98
20 m (s)	0.96	0.89	0.78 – 0.95	0.96	0.92 – 0.98
3RM (kg)	0.99	0.98	0.95 – 0.99	0.99	0.98 – 0.99
3RM (kg/BW)	0.99	0.98	0.96 – 0.99	0.99	0.98 – 0.99

CV values for the sprint performance and 3RM back squat strength measures had acceptable levels of absolute reliability and were equal to or less than three percent. Table 2 displays three trial data, SEM, CV and absolute limits of agreement for the sprint performance and 3RMback squat strength measures. SEM was estimated to have an acceptable level of absolute reliability for the sprint performance and strength measures as the LOA random error estimated feasible minimum sample sizes for an ANOVARM.

Table2. *Three trial data for 5-m, 10-m and 20-m sprint performance times and absolute and relative 3RM back squat strength and standard error of measurement (SEM), coefficient of variance (CV) and 95% limits of agreement (LOA).*

Measures	Trial 1	Trial 2	Trial 3	SEM	CV (%)	95% LOA
5m (s)	1.06 ± 0.07	1.08 ± 0.06	1.09 ± 0.06	0.06	2.04	0.01 ± 0.08
10m (s)	1.81 ± 0.09	1.83 ± 0.08	1.84 ± 0.07	0.08	1.65	-0.01 ± 0.12
20m (s)	3.13 ± 0.14	3.13 ± 0.14	3.14 ± 0.12	0.10	1.06	-0.007 ± 0.15
3RM (kg)	103.61 ± 18.46	107.5 ± 18.73	108.61 ± 18.21	2.52	0.81	1.11 ± 4.19
3RM (kg/BW)	1.30 ± 0.26	1.35 ± 0.26	1.37 ± 0.26	0.04	0.77	0.01 ± 0.06

Estimation of minimum sample size for the sprint performance and 3RM back squat strength measures are displayed in Table 3.

Table3. *Estimation of minimum a priori sample size for a repeated measures ANOVA for 5-m, 10-m and 20-m sprint performance times and absolute and relative 3RM back squat strength using G*Power from LOA's and previous work.*[26,27]

Measure	Sample size (n =1, 2, 3,..)
5 m (s)	26
10 m (s)	10
20 m (s)	17
3RM (kg)	9
3RM (kg/BW)	7

The measures for sprint performance and 3RM strength produced feasible minimum *a priori* sample sizes when using LOA random error to estimate the sample sizes from previous work.[26, 27]

5. Discussion

The sprint performance measures of 5, 10 and 20-meters and 3RM back squat strength measures in the current study were estimated to have achieved acceptable relative and absolute reliability as the conditions for the three criteria were met. The estimation of relative and absolute reliability was based upon the acceptance of the outcomes of statistical tests (ICC and CV) and the estimation of sample size for ANOVARM using LOA random errors. Sample sizes determined for ANOVARM using G*Power were found to be practical for the measures in question (see Table 3). Systematic bias was found to be non-significant for the sprint performance and 3RM back squat strength measures after trial 1 of the 3RM back squat was discarded due to a significant difference ($P = 0.05$) found between trials 1 and 2. The SEM was estimated to have acceptable reliability in terms of hurling players through the estimation of a minimum sample size for an ANOVARM that is feasible in size.[21] When examining relative reliability in isolation based upon an ICC (3, 1 single measure, average measure and Cronbach's alpha), sprint performance and 3RM back squat strength measures were found to have acceptable levels of relative reliability (see Table 1). This is based upon these ICC values been ≥ 0.70, a minimum acceptable level of reliability.[24]ICC average measures and Cronbach's alpha were included so as to compare with those from previous studies. When examining the CV, all measures were equal to or less than 2% meeting the criteria set of a CV ≤ 10%.[25] The current study is the first to estimate the test-retest reliability of 5, 10and 20-meter sprint performance and absolute and relative 3RM back squat strength in male hurling players. Furthermore, this is the first study to have calculated LOA to estimate minimum *a priori* sample size for these measures. The value of estimating reliability of these measures in male hurling players provides a knowledge of the measurement error in these tests to be able to determine the true effect of interventions that seek to cause improvements in maximum strength and the ability to accelerate in match situations. The importance of maximum strength and its relationship to sprint performance in research investigating field sports closely linked to hurling have shown that stronger athletes produce faster sprint performances.[12, 13]

Previous research on sprint performance over distances up to 20-meters have reported reliability and are comparable to the current study. The current study reported a CV of 1.7% for 10-meter sprint performance. Previous research reported CV values of 1% when examining the effect of different photocell heights and starting positions.[5,6] In terms of 20-meter sprint performance, CVs were reported to be 0.7 – 1%.[9] However, Hopker et al[8]reported a CV of 4% for 20-meter sprint performance with a walking rolling start. As the current study used a standing two point start, this may have led to a lower CV percentage.

To estimate minimum sample size for sprint performance research that is feasible in size, LOA was employed. SEM was also reported for researchers to use as a means to compare future studies for hurling and other field and court sports.[28] To the best of our knowledge, one study has reported LOA for sprint velocities over 10, 20, 30 and moving 10- meters.[7] To compare these LOAs to those of the current study is difficult as it is velocity versus time. However, the sprint time LOAs of the current study have acceptable reliability based upon a minimum estimated sample sizing that is feasible (see Table 3). When comparing SEM, the current study reported an SEM of 0.08 s for 10-meters whereas Duthie et al[6] reported an SEM of 0.01 s. A possible reason for the lower SEM in Duthie et al[6] is that junior elite rugby players were studied and had been training for a minimum of two months in an elite structured training program whereas the participants in the current study were club and college level players who were not at elite level.

The findings of the current study for 3RM back squat strength are comparable to two previous studies. When examining the reliability of back squat strength testing, a study by McCurdy et al[16] investigated the reliability of unilateral 1RM and 3RM back squat strength in untrained and trained males and females. The study reported high levels of reliability based upon an ICC (untrained: 0.87 – 0.97; trained: 0.94 – 0.97). Seo et al[17] investigated the reliability of a number of strength training exercises including the back squat in healthy females and males. They reported high levels of reliability with a test-retest design over two sessions (ICC: 0.97-0.99; CV: 0.53%- 0.34%).

When considering LOA and SEM for 3RM back squat, it was not possible to compare our results to previous studies as this is the first study to our knowledge to employ LOA as a statistical test, however for the measure of SEM there were studies available for comparison. The SEM value for absolute 3RM back squat strength in the current study (2.52 kg) is similar to that of a previous study who reported a SEM value of 1.68kg for a unilateral back squat in trained men.[16] However, Seo et al[17] reported a SEM of 10.6kg for the re-test in a 1RM back squat. The subjects were healthy males who had performed weight training for a continuous period of 3 months over two years. In the current study and the study by McCurdy et al[16], male participants had to have at least one year's weight training experience to participate in the study. This additional time experience suggests that the measurement error in terms of SEM becomes reduced as the individual is aware of their strength capacity in terms of respective exercises such as the back squat.

Hurling players who participated in the current study produced the lowest ICC single values for 5-meter sprint performance when compared to the two other distances measured. A possible reason for this may be due to these players using a variety of sprint techniques. Varied technique may be explained by the application of peak forces over this distance to overcome the inertia of body mass. Previous work has demonstrated that stronger athletes produce faster sprint performances and therefore should be able to apply greater peak forces.[12,13] Furthermore, varied stride frequency in male hurling players, a kinetic determinant of sprint performance, may have affected acceleration over 5 and 10 meters.[9]

One of the limitations of the study was the significant difference between trial 1 and 2 means for the 3RM back squat strength test. This may have been due to the varied time gaps as to when participants had performed maximal strength testing or were not in a maximal strength testing phase in their current weight training programs prior to participating in the current study. This possibly led to the need for two sessions of 3RM testing before reliable data was achieved during trials 2 and 3.

As the ICC single measure was the lowest for 5-meter sprint performance, future studies should examine the effect of coaching cues on 5-meter sprint performance during a number of familiarization sessions to improve reliability of this particular test. Furthermore, the examination of relationships between maximal strength and sprint performance over 5, 10 and 20-meters in male hurling players would be valuable. In terms of 3RM back squat testing in male hurling players, the number of familiarization sessions needs to be considered when estimating levels of reliability or the effect of a training intervention.

When considering the practical applications of the current study, male hurling players can be reliably assessed for sprint performance from distances from 5 to 20-meters. Furthermore, their lower limb maximum strength can be reliably assessed in terms of absolute and relative 3RM back squat strength. The value of these findings in practical terms means that sport science practitioners, coaches and players involved in hurling have reliable measures to assess and monitor strength and speed development acutely and over short to long-term conditioning programs. A means to detect actual changes in performance can be determined by using the SEM or CV% to calculate the real change that has taken place after a conditioning program. When relating the reliability of these measures to a research setting, it was found that minimum sample size estimation was feasible in terms of subject recruitment to achieve a significance at a power level of 0.8 at an α level of 0.05 (see Table 3).

6. Conclusion

The current study was the first to have estimated acceptable relative and absolute inter-day reliability for 5, 10 and 20-meter sprint performance and absolute and relative 3RM back squat strength in male hurling players. Furthermore, this was the first study to calculate LOA for these measures. Coaching and conditioning approaches should be considered to improve the level of relative reliability for 5-meter sprint performance in hurling players. The acceptable levels of reliability were based upon the acceptable single measure ICC values, CV% ≤ 10% and sample size estimation where these measures estimate minimum *a priori* sample sizes that are feasible to test for the effect of an intervention with regards to an ANOVA RM. The reliability of these tests needs to be determined in other field sports such as soccer and rugby union at various levels of competition.

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