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Determining Interday & Intraday Reliability of the 10/5 Repeated Jump Test in Elite Australian Footballers

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ABSTRACT

The reactive strength index (RSI) measures the stretch shortening cycle (SSC), an important neuromuscular property for running performance, and critical for the game of Australian Football (AF). The 10/5 Repeated Jump test (RJ) is used to measure RSI, thus, the aims of the study were to determine if this test was reliable and could determine worthwhile change. Twenty-three male participants from an elite AF club completed RJ testing on two separate days of the week during the start of the preseason to determine interday and intraday reliability and determine whether smallest worthwhile change could be detected. All variables measured, (RSI, ground contact time, flight time, mean impulse and mean active stiffness) all had "excellent" ICC ratings >0.90 for both interday and intraday reliability. Mean landing RFD had "good" (ICC: 0.88) ratings for interday and "excellent" ratings for intraday reliability. Coefficient of variation ranged between 1.36-5.56% for all variables. All variables had a usefulness rating of "good", indicating ability to detect smallest worthwhile change. The RJ test, is a reliable and sensitive measure to assess reactive strength index in AF athletes.

Keywords: reactive strength index, afl, smallest worthwhile change, stretch-shortening cycle.

INTRODUCTION

The stretch-shortening cycle (SSC) is an action of the muscle-tendon unit which involves a rapid eccentric lengthening followed by rapid concentric contraction of the muscles [1-4]. This muscle action is involved in locomotion such as walking, running, and jumping. Reactive Strength Index (RSI) represents a measure of stretch-shortening cycle efficiency and is calculated by dividing the time spent in the air (flight time or jump height) by the time spent on the ground (ground contact time) [5-9]. Therefore, to have the highest RSI, individuals should aim to achieve maximum flight time, whilst having minimum ground contact time. Typically, RSI tests require a contact time of <250ms as this is the time restraints that constitute a fast stretch-shortening cycle (fSSC) action [10] that replicates the SSC demands during locomotion. Previous literature has shown that RSI has moderate to large relationships with running economy [5, 11], sprint [7, 8, 11, 12] and change or direction performance [11, 13], all of which are important locomotive requirements in sports such as Australian football (AF). Therefore, individuals with higher RSI scores appear to be more efficient at running due to their increased neuromuscular and biomechanical capacity. This suggests an assessment of fSSC ability may be an important indicator of whether an individual is athletically developed to withstand the physical demands of AF.

The drop jump (DJ) has commonly been used to assess RSI, where an individual will drop off a box of height between 20-50cm onto a force plate [7, 8, 12, 14, 15]. This test has been shown to have excellent reliability (ICC: 0.95-0.99; CV: 2.1-3.1%) [16] and be a useful measure of RSI. However, the DJ can place high eccentric load on the participants, particularly off high drop heights, as there is a greater requirement to absorb the greater impact forces associated with a higher drop [17, 18], which may impact the utility of the test in elite Australian football environments. However, the 10/5 Repeated Jump (RJ) test is a multi-hop test which can also be used to determine RSI and SSC efficiency. A participant is required to do one countermovement jump (CMJ) followed immediately into 10 continuous pogo hops [19]. The five best hops with the highest RSI are then averaged together to give the individuals RSI score. There are several advantages of the RJ. Firstly, the eccentric demands are less than the DJ, because the demand in the RJ is dependent on the jump height. This is typically lower than the drop height of a drop jump, often between 30 and 40cm [12, 14, 20-22]. Secondly, there is a decrease in invalid tests and greater opportunity to obtain optimal RSI scores as participants can hop at their own pace, meaning no metronome use is required, a method previously used for multi-hop tests in the literature [12, 23-25].Thirdly, the best five jumps are used, therefore, if an error occurs on one of the hops, it can be disregarded, meaning potentially less retest requirements.

The reliability of the RJ has been examined in previous literature, showing excellent reliability ICC >0.9 for RSI, with good reliability ICC >0.8 for flight time (FT) and ground contact time (CT). Coefficient of variation (CV) for variables in all studies have been <10%. [26-28]. However, the test has been shown to be insensitive in detecting smallest worthwhile change (SWC), as typical error has been larger than SWC score [19, 27, 28]. This potentially may due to cohort test familiarity [27]. Detecting SWC is important in a professional Australian Football environment as this could be a potential fatigue monitoring tool. Additionally, small changes in athletic output are common following a training period due to high athletic baseline.

Whilst the RJ has been explored in elite adolescent and recreational populations, further exploration is needed in an elite professional Australian football environment. Therefore, the aims of this study were to determine the interday and intraday reliability, the variation and smallest worthwhile change rating of the 10/5 repeated jump test and its associated variables. The primary hypothesis is that RSI, GCT and FT will have good to excellent reliability and coefficient of variation <10%, with remaining variables having good reliability and CV. The secondary hypothesis is that variables will have a marginal usefulness rating as SWC scores will not be detected due to a larger standard error measurement (SEM).

METHODS

Experimental Design

Athletes were required to complete two testing sessions during the initial three weeks of the AFL preseason. Due to the AFL schedule, participants who had a playing history of 2-4 years were tested a week early, as preseason started one week earlier. 5+ year players were tested the following week (see table 1). Testing sessions were completed on a Friday and following Monday in their scheduled afternoon strength sessions. On Friday, participants completed one set of the 10/5 repeated jump test, whilst on Monday two sets were completed with 30 seconds recovery between sets to assess intraday reliability. These days of the week were selected as this part of the week had the most consistency in training schedule. No activity occurred on the previous day of testing, with regular field training occurring in the morning beforehand. There was no significant difference in total volume and high speed running distance (>18km/hr) between weeks 1 and 2. No familiarization session was required for athletes as they had all been regularly exposed to the test during the previous two football seasons.

Table 1. Testing Timeline

Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Week 1	1-4yrs Return On-field Training	OFF	On-field Training	OFF	On-field Training 1-4yrs RSI Test #1	OFF	OFF
Week 2	5+yrs Return On-field Training 1-4yrs RSI Test #2	OFF	On-field Training	OFF	On-field Training 5+yrs RSI Test #1	On-field Training	OFF
Week 3	On-field Training 5+yrs RSI Test #2	OFF	On-field Training	OFF	On-field Training	OFF	OFF

RSI = Reactive Strength Index

Subjects

Twenty-three participants from a professional Australian football team volunteered for the study (Age: 23.9yrs, Weight: 89.4kg, IMTP Peak Force: 35.1N/kg). Athletes either competed in the national competition, the Australian Football League (AFL) or the reserves competition. All the athletes were full-time and had the same training and playing schedule. Additionally, all athletes had at least 12months strength, power and plyometric training experience at the club, and were all physically fit at time of testing.

Gatekeeper approval from the club and player consent was attained for permission to participate and analyse data. Ethics approval was granted for this study by the university's ethics committee, application - 2021/HE001957.

10/5 Repeated Jump Assessment

Participants performed an initial countermovement jump followed by 10 consecutive reactive hops. The results from the best five jumps (highest RSI scores) were then averaged to create the participants final value of variables. RSI (derived from dividing flight time by ground contact time), ground contact time (ms), flight time (ms), mean landing rate of force development (RFD) (absolute newtons of force divided by the time taken to stabilize landing), mean impulse (newtons of force multiplied by time in seconds), and active stiffness (peak force divided by maximum centre of mass displacement) were variables collected from test and used for analysis. Athletes were verbally cued to "jump as high as possible, whilst minimizing ground contact time". Athletes were also instructed to hop using their ankles whilst keeping hips and knees stiff and having hands positioned on their waist (Vald Performance, 2021). All data was collected using standalone force platforms (Vald Performance Force Deck Dual Platform FD4000 (Newstead, Queensland, Australia)) at a sampling rate of 1000Hz; capacity: 2000kg; resolution: c.15g/0.15N. Force-time data was automatically analysed on Vald Force Decks software at time of testing. Raw unfiltered data was used to calculate all variables used for analysis.

Statistical Analysis

To determine both inter-day and intraday reliability, intraclass correlation coefficients (ICC) was calculated with 95% confidence intervals. ICC ratings were interpreted using the following criteria: <0.5 (poor), 0.5-0.75 (moderate), 0.75-0.9 (good), >0.9 (excellent) [29]. Coefficient of variation (CV) was calculated using the following formula: (SD[Trials 1-2]/average[trials 1-2] x 100). The average CV for squad was then calculated for both interday and intraday tests, which was expressed as a percent. Acceptable reliability was classified as ICC >0.8 and a CV <10% [30]. Usefulness of test is a measure used to determine whether a small effect size change can be detected by the test. This is done by comparing whether the Standard error measurement (SEM) is smaller than the SWC [31]. Test had a usefulness rating of "good" at detecting SWC if score was greater than SEM, "Ok" if they were similar, or "marginal" if less than SEM [31]. SEM was calculated by dividing the between subject SD by the square root of the number of data points. SWC was calculated by multiplying between subject SD by 0.2. For between group comparisons, Shapiro Wilks test was used to determine normality of data distribution, with paired sample t-tests used to compare means for parametric data, whilst Wilcoxon signed rank test was used for non-parametric data. All statistical analysis was completed using Rstudio (Rstudio Team, 2015), with the added package "irr" used to assist with analysis.

RESULTS

Interday Reliability

Descriptive statistics, reliability analysis, SEM and SWC for the 10/5 repeated jump test are summarized in table 2 for tests done on different days. The variables derived from the RJ test all met acceptable reliability criteria ICC >0.8 with a CV <10%. When comparing distribution of data samples, RSI, GCT and mean impulse all had normal distributions, whilst mean landing RFD and active stiffness were not normally distributed. From this, it was found that all variables except for mean impulse and flight time had no significant difference (p>0.05) between day 1 and day 2. There was a significant interday difference in flight time and impulse (p<0.05).

Intraday Reliability

Descriptive statistics, reliability analysis, SEM and SWC for the 10/5 repeated jump test are summarized in table 3 for tests done on the same day. The variables derived from the RJ test all met acceptable reliability criteria ICC >0.8 with a CV <10%. When comparing normality distributions of variables, GCT, mean landing RFD, and active stiffness were parametric, whilst non-parametric variables were RSI, FT and mean impulse. were found to be non-parametric. Between group comparisons found that no significant differences (>0.05) were found between any of the variables.

DISCUSSION

The purpose of this study was to determine the interday and intraday reliability of the 10/5 Repeated Jump (RJ) test. The findings of this study support the primary hypothesis, as RSI and other variables associated with the RJ all had acceptable levels of reliability and coefficient of variation for both interday and intraday measures. However, this study rejected the secondary hypothesis as the RJ was able to detect the smallest worthwhile change of all the variables, opposing previous literature that the RJ test could not detect SWC and had a marginal usefulness of test rating.

The results of this study suggest that RJ is a reliable test to assess RSI and its associated variables (GCT, FT, Landing RFD, Impulse & Active Stiffness) in professional Australian football players. All variables had ICC values of >0.8 and a CV <10% which has been determined as an acceptable reliability levels [30]. RSI had an "excellent" interday reliability rating (0.93), which is consistent with previous literature, finding scores of >0.9 [26-28]. Interday CV for RSI was 2.5%, which is lower than previous research that has seen CV sit between 6.3-10%. Furthermore, GCT and FT were found to have "excellent" ICC rating (both 0.90), and CV values of 2.22% and 2.66% respectively. Whilst still reliable, the results in this study had greater reliability and less variation than previous literature, which found "good" ICC rating (0.81-0.85) with CV values between 4.9-5.2% [28]. To the author's knowledge, this is the first study to examine additional variables derived from the RJ, such as Landing RFD, impulse, and active stiffness, all of which can help provide further information to help determine the neuromuscular characteristics of the participant. These three variables were found to be a reliable interday measure, with Landing RFD having an ICC rating of "good" (0.88) and a CV of 5.56%, whilst both impulse and active stiffness had an ICC rating of "excellent" (0.90 & 0.91 respectively) with CVs of 2.71% and 4.64% respectively.

The intraday reliability assessment has been included as previous studies have used two sets of the RJ test to determine the best RSI score to be used for analysis [27, 28]. Determining the between set variance will help determine whether multiple sets are required to gain accurate scores for the RJ test. All variables in this study were found to have "excellent" ICC ratings, with all CV values <3%; RSI (0.96, 1.92%), GCT (0.95, 1.36%), FT (0.91, 1.85%), Landing RFD (0.97, 2.95%), Impulse (0.95, 1.42%), Active Stiffness (0.97, 2.85%). These findings suggest that only one RJ set is needed to determine a participant's best score. This concurs with previous literature that also determined one set of 10 reps are needed to determine an accurate RSI score from the RJ test, with best hops typically occurring between repetitions 7-10 [32]. Additionally, it also appears similar to intraday reliability results from the drop jump test, which has found that RSI had excellent ICC (0.95-0.99) and minimal CV (<3.1%) from drop heights of 20, 40 & 50cm [16].

The usefulness rating for detecting smallest worthwhile change (SWC) of all the RJ variables in this study were rated as "good" as the standard error of measurement for all variables was less than the SWC score. This indicates that the RJ can detect the SWC for all variables and is apparent in both interday and intraday analysis. These findings differ the most from previous literature, which has found that the RJ has not been sensitive enough to detect SWC (an effect size of 0.2), with only marginal differences between the SEM and SWC results been found [27, 28]. There are a couple of potential factors that may have influenced the difference in results. Firstly, the previous exposure to the RJ test prior to the study may influence results. In this current study, the average RSI results ranged between 2.67-2.72, whilst the study by Baker et al [28], had similar average results (RSI=2.74-2.81). In both studies, participants had already familiarized to the RJ test, through frequent exposure as part of their regular training assessments. Studies that required athletes to familiarize to the RJ test displayed poorer results (RSI=1.2-1.59) [27]. Secondly, the variance in usefulness scores may be population specific based off training history. In both studies where usefulness ratings were marginal, participant information may lead to speculate that participants may not have reached an optimal relative strength with participants only being 14.4 years of age [28], or having only 8 months strength and plyometric training history [27]. In this current study, participants are professional athletes with at least 12 months strength training and plyometric history and a relative lower body strength of 35.1N/kg Peak Force derived from the Isometric Mid-Thigh Pull.

Table 2. Interday Reliability Results

Metric (mean)	Test 1	Test 2	ICC	95%CI	ICC Rating	CV	SEM	SWC	Usefulness Rating
RSI	2.67 ± 0.48	2.72 ± 0.48	0.93	0.85 - 0.97	Excellent	2.55%	0.07	0.10	Good
GCT (ms)	172 ± 20	176 ± 20	0.90	0.77 - 0.95	Excellent	2.22%	2.88	3.91	Good
FT (ms)	456 ± 66	472 ± 59	0.90	0.78 - 0.96	Excellent	2.66%	9.19	12.48	Good
Landing RFD (N/s)	85,958 ± 30,617	88,840 ± 28,031	0.88	0.75 - 0.95	Good	5.56%	4284	5812	Good
Impulse	543 ± 80	566 ± 70	0.90	0.77 - 0.95	Excellent	2.71%	11.12	15.08	Good
Active Stiffness	47,959 ± 12,149	47,305 ± 12,587	0.91	0.81 - 0.96	Excellent	4.64%	1804	2447	Good

ICC= Intra-class Correlation; CI = Confidence Interval; CV = Coefficient of Variation; SEM = Standard Error Measurement; SWC = Smallest Worthwile Change; RSI - Reactive Strength Index; GCT = Ground Contact Time; FT = Flight Time; ms = milliseconds; N/s = Newtons per second

Table 3. Intraday Reliability Results

Metric (mean)	Set 1	Set 2	ICC	95%CI	ICC Rating	CV	SEM	SWC	Usefulness Rating
RSI	2.72 ± 0.48	2.69 ± 0.42	0.96	0.91 - 0.98	Excellent	1.92%	0.066	0.090	Good
GCT (ms)	176 ± 20	177 ± 18	0.95	0.89 - 0.98	Excellent	1.36%	2.79	3.78	Good
FT (ms)	472 ± 59	471 ± 48	0.91	0.80 - 0.96	Excellent	1.85%	7.80	10.58	Good
Landing RFD (N/s)	88,840 ± 28,031	86,167 ± 25,217	0.97	0.92 - 0.99	Excellent	2.95%	3892	5279	Good
Impulse	566 ± 70	568 ± 63	0.95	0.88 - 0.98	Excellent	1.42%	9.74	13.21	Good
Active Stiffness	47,305 ± 12,587	47,187 ± 11,856	0.97	0.92 - 0.99	Excellent	2.85%	1783	2418	Good

ICC= Intra-class Correlation; CI = Confidence Interval; CV = Coefficient of Variation; SEM = Standard Error Measurement; SWC = Smallest Worthwile Change; RSI - Reactive Strength Index; GCT = Ground Contact Time; FT = Flight Time; ms = milliseconds; N/s = Newtons per second

There are a few limitations that need to be considered with this study. Firstly, whilst the sample size of 23 was adequate for the purposes of determining the reliability and SWC for the study, a larger sample size could help ascertain a more representative value for the larger professional Australian Football population. Secondly, being able to have had a third testing day could have provided a more rigorous information on between-session variance.

The RJ is an appealing test for practitioners as it does not create as high eccentric forces as the drop jump and the movement of the test is more specific to running tasks. Alternatively, practitioners now may have a selection between RSI test protocols depending on whether they want to determine an athlete's reactive strength under higher eccentric stress. The results of this study show that completing one set of the 10/5 Repeated Jump test is a reliable measure of reactive strength index. Strength and conditioning practitioners working in elite Australian Football can use the RJ to determine the reactive strength, and its underlying variables with excellent reliability with an ability to determine smallest worthwhile change by completing one set of the test.

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CONFLICTS OF INTEREST

Authors report no conflict of interest.

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