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MSc Coaching Science in Sport

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Is the 30s hopping test a valid measure of reactive strength fatigue in male soccer players?

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Declaration of Authenticity

I declare that the material contained in this dissertation is the end result of my own work and that due acknowledgement has been given in the bibliography and references to all sources, be they printed, electronic or personal.

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Confidentiality Statement

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List of Abbreviations

30s Hop = 30-second Hopping Test

CMJ = Counter Movement Jump

SAFT90 = 90-min Soccer-specific Aerobic Field Test

JH = Jump Height

CT = (Ground) Contact Time

HR = Heart Rate

RSI = Reactive Strength Index

RSF = Reactive Strength Fatigue

SSD = Soccer Simulation Drill

Sd = Standard deviation

SSD CMJ = Soccer Simulation Drill CMJ Test

SSD 10 Hop = Soccer Simulation Drill 10 Hop Test

m = Slope

BPM = Beats per minute

d = Cohen’s d

r = Pearson’s r

Abstract

Purpose

The purpose of this dissertation is to determine the validity of a common test for measuring reactive strength fatigue, the 30s hopping test, against the reactive strength fatigue experienced during a soccer-specific match simulation drill (SAFT90). Ten healthy male competitive soccer players each participated in two testing days to perform the 30s hopping test and the SAFT90 protocol which included a CMJ and 10 hop tests across the 15-minute intervals within the fitness test. This included a familiarisation session on the first testing day.

Findings

Mean HR experienced during the soccer simulation drill (SSD) was 179.2 +/-7.98 BPM. JH scores in the SSD CMJ tests decreased by 6.07% from pre-trial to post-trial, with a small effect size of d = 0.38. A mean decrease in JH of 10.37% from pre-trial to post-trial in the SSD 10 Hop, with a small effect size of d = 0.59. A decrease in JH of 10.9% was seen from start to end of the 30s Hop tests, with a moderate effect size d = 0.94. Mean Contact Times (CT) increased by 7.77% from pre-trial to post-trial in the SSD 10 Hop, with a moderate effect size d = 0.85. An increase of 1.51% was seen in CT from start to end of the 30s Hop Test, with a small effect size of d = 0.25. Mean RSI scores decreased by 15.01% from pre-trial to post-trial in the SSD 10 Hop, with a moderate effect size of d = 0.88. An average decrease of 11.49% was seen in RSI scores from start to end of the 30s Hop Test, with a moderate effect size of d = 0.84.

Results have shown a large correlation between the SSD 10 Hops and 30s Hop tests in both the RSI Scores (r = 0.727) and JH (r = 0.835) scores, and a moderate correlation in CT scores (r = 0.537). The impetus of this study was to assess the validity of the 30s Hop test to measure reactive strength fatigue. Validity coefficients rate the three variables as "Excellent" (JH), "Unacceptable" (CT), and "Good" (RSI).

Conclusion

From the results, it can be concluded that the 30s Hop test is a valid means to measure reactive strength fatigue in the lower limbs of competitive soccer players. Null hypothesis is failed to be rejected.

Keywords: Reactive Strength Fatigue, SAFT90, repeated jumps, RSI, soccer.

Introduction

Optimum performance in athletes requires the careful monitoring of acute variables to ensure all aspects within their control are in their favour and benefit them in competition. Any parameters which an athlete can control are of the highest priority in their practice and training, especially in elite performance settings. In soccer, both aerobic and anaerobic fitness are imperative for optimizing performance. Means to monitor, maintain, and improve either of these facets are one of the top priorities for consistent performances on the pitch. Reactive strength is a form of muscle contraction that is key for explosive and dynamic movements that players undertake, and the training of this form of contraction will benefit any athlete trying to improve their explosivity (Taheri, 2014). Agility, speed, and explosive power are all qualifying components of physical fitness and desirable athletic performance. They play a key role in soccer. Plyometric and resistance training can be a prerequisite for coaches and athletes' success (Zearei et al., 2013; Bandyopadhyay et al., 2013; Alam et al., 2012).

The ability to monitor this reactive strength also allows for the avoidance of overtraining. Methods to mitigate the effects of fatigue for the avoidance of overtraining and injury, and therefore perform at peak levels in competition are continually sought after. Given that soccer players require reactive strength to perform explosive and dynamic movements, and the anaerobic capacity of a player is heavily taxed in a match, it would be beneficial for a protocol to assess this measure via a common test.

As previously mentioned, reactive strength is key for explosive and dynamic movements. It has been established in literature that jump height and leg muscle power can be improved by plyometric training (Markovic, 2007) as it targets the stretch shortening cycle (SSC) which occurs when eccentric muscle movement is immediately followed by concentric movement. Soccer players will typically perform fast SSC (<250ms) exercises such as leaping, sprinting, changing pace, tackling and other dynamic movements. The reactive strength index (RSI) has been established as a measure of the fast stretch shortening Cycle (SSC) explosive strength. The index can be used to provide to compare athletes' plyometric capabilities and to monitor plyometric training progress (Flanagan & Comyns, 2008; Lehnert, 2020). Repeated jumps tests have been shown to be effective methods to monitor RSI and the lower limbs of any athlete. Several repeated jumps tests currently exist to assess the reactive strength fatigue of athletes' lower limbs. The 10 Hop test, the rebound jump test, and the Drop Jump test (DJ-RSI) are three methods of measuring Reactive Strength Fatigue in the lower limbs. The components of RSI, the jump height (JH) and the ground-contact time (CT) provide useful information to coaches. RSI can be used to assess an athlete in terms of neuromuscular fatigue, readiness to train, adaptation to the training, efficacy of any tapering or "peaking" strategies, proximity to overtraining (Flanagan & Comyns, 2008). In relation to competitive soccer players, having a procedure which measures reactive strength fatigue that can be repeated easily and allows for the close monitoring of an RSI score that is seen as a relevant marker of what a player's RSI would chart across 90 minutes, would be deemed highly beneficial. Currently, there is no protocol which uses RSI as a common test for reactive strength and reactive strength fatigue experienced in a competitive soccer match.

The energy demands in competitive soccer are well established by literature. Competitive male soccer players cover 10 to 12 km per 90-minute match, with a mean intensity of 70-75% of maximum oxygen uptake (Vo2MAX). (Bangsbo, 1994). The average intensity is close to that of the lactate threshold (80-90% of HR Max) (Hoff, 2005; Williams, 2010) It has been reported that the intensity can change up to 1,400 times throughout a match (Stolen et al. 2005; Williams 2010). Players are required to produce high power outputs and maintain or repeat them frequently, often with little time for recovery (Reilly, 2003; Williams, 2010). These actions include short explosive sprints, jumps, kicking, tackling, changing pace and dynamic multidirectional movements. Sustaining forceful contractions to maintain balance and control of the ball and to create, or oppose, pressure from the opposition is also essential. (Wissloff et al., 1998; Williams, 2010; Rampinini et al., 2007a; Mohr et al., 2003; Di Salvo et al., 2007; Akenhead, 2014). The combination of an extensive game duration and the high-intensity, intermittent nature of match play, dictate that soccer players must have a well-developed aerobic energy system to meet the endurance requirements of the game (Hoff et al., 2002; Iaia et al., 2009; Impellizzeri et al., 2006). Additionally, players must also possess a well-developed anaerobic energy system to perform repeated accelerations, changes of direction and maximal jumps (Rahnama et al., 2003; Buchheit et al., 2010a; Buchheit et al., 2010b).

Literature has also acknowledged that there has been an increasing demand on soccer players in competition over the last decade (Bradley et al., 2011; Bradley et al., 2009). It is also worth noting that there can of course be match-to-match variability in intensity dependant on competition, opposition, and external environmental factors, as well as position-specific demands. Midfielders have been found to cover the most ground; defenders perform the most lateral movement; and forwards execute the most and longest sprints (Bloomfield et al., 2007; Dellal et al., 2012; Di Salvo et al., 2007). Additionally, there can be a large inter- and intra-individual variability in work rate and physiological loading during matches (Fransson et al., 2018). With already such high demands required to perform at an athlete's peak, and the increasing demands experienced in a match, the monitoring, maintenance, and continual improvement of aerobic and anaerobic capacities are vital.

Fatigue can be described as a loss of maximal force generating capacity, a loss of maximal power output (Vøllestad, 1997) or a failure to sustain further exercise at a required level (Strojnik & Komi, 1998). It has been well established that injuries more often occur in the latter stages of sporting events when participants are in a fatigued state (Ostenberg & Roos, 2000; Zemper, 1989).

Soccer is an activity where muscle glycogen is consumed due to its high-intensity intermittent nature and is a key factor associated with muscular fatigue (Mohr, 2003). Reactive Strength uses muscle glycogen as its energy source and therefore the glycogen stores and energy expenditure are key in such explosive actions. There is minimal research on changes of RSI after soccer specific fatigue in male soccer players. However, some studies have indicated negative fatigue related effects on reactive strength (Rahnama et al., 2003; Stastny et al., 2016; Stastny et al., 2015; Lehnert, 2018). Several studies have also shown negligible effect in vertical jump tests post-90 minutes of match play (Robineau et al. 2012; Zemkova et al. 2009). One study even reported increases in jump heights. (Taufer, 2019). Due to the limited literature on reactive strength in soccer players and the magnitude of fatigue experienced, furthering the research on this topic is required.

The SAFT90 protocol has been described as a reliable procedure of inducing fatigue that is significantly correlated to a similar level of fatigue experienced in a real, competitive match. The SAFT90 (90-min soccer-specific aerobic field test) stimulates the internal and external loads that are expended during a competitive soccer match. The protocol was mapped out from over 200 elite Championship matches via match-analysis data (Prozone®) (Barnett, 2013). The protocol involves sprinting, jogging, striding, walking, and standing. It also contains a multidirectional element in two sections of the circuit. The first 5 metres requires the subject to either perform an upward jog/stride, dependant on the audio command, with a back-peddle to the line, or a side jog/stride up and back to the line. Next, the subject either jogs or stride up to the set of three poles where they must weave in and out and finally up to the 20m line. The sprints occur at this 20m line back down to the start line. By using this protocol and implementing the 10 Hop test and CMJ test upon each interval, jump heights and RSI scores can be measured to extract reactive strength data. This data will allow reactive strength experienced in a simulation of what would be elite soccer match demands.

The validity of this 30s hopping test remains unknown when attempting to assess a soccer players reactive strength fatigue in a practical setting that compares with the demands of a competitive match of soccer. Furthering the understanding of soccer players' lower limb reactive strength fatigue and the assessment of the RSI (Reactive Strength Index) relative to match-specific conditions is worth investigating. This study aims to determine the validity of a common test for measuring reactive strength fatigue, the 30s hopping test, against the reactive strength fatigue experienced during a soccer specific match simulation drill, the SAFT90. The questions this experimental study is designed to try answer are as follows.

1. Do the athletes' jump data from the SSD 10 Hop and the 30s Hop change significantly?

2. Does this change (if any) demonstrate fatigue levels typically shown in competition?

3. Is there any correlation between the SSD 10 Hop and the 30s Hop in relation to reactive strength fatigue?

4. Is the 30s Hopping Test a valid measure of this reactive strength fatigue displayed in the soccer simulation drill (SSD).

Methods

Data Collection

Participants were recruited by the test facilitators and were required to fit the specific criteria for participation as outlined here. Athletes recruited had to be adult male competitive soccer players. They had to be currently competing and have no prior injuries within the previous six months. It was also imperative that no strenuous training or competition was performed within 48 hours of the two test days to ensure accurate measurements of RSI figures and jump heights. 10 adult male soccer players participated in this study. The group age was (mean ± SD) 22.5 ± 1.35 years, height 180.4 ± 6.3 cm and mass 73.58 ± 7.72 kg. The University's research ethics board approved the study and participants all provided consent to participate. Athletes were asked to attend the performance gym on two separate occasions, with a minimum seven days between the two testing days, and a maximum of 14 days between the test days.

Baseline tests were undertaken on the first day. The athletes' height and weight were measured, and their age was noted. A brief, five minute warm up was conducted prior to any jump tests being recorded. Subjects were first familiarised with three jump tests they would be performing during the testing: the CMJ (Countermovement Jump), 10 Hops, and 30 Second Hops tests. Practice jumps were performed to ensure proper technique. Following familiarisation, three maximal CMJ tests were performed within the OptoJump sensors to measure jump height. A one-minute interval was included between each maximal jump. Subjects then performed a 10 Hop test within the OptoJump sensors to measure RSI, calculated from the subjects jump heights and ground contact times ((JH/CT) / 100). Finally, a 30 second hop test was performed at maximal effort to measure their RSI scores.

Following the undertaking of these tests, a brief familiarisation walkthrough of the SAFT90 protocol was completed with each athlete. For proper understanding of the correct tempo for each jog, stride, and sprint, and the correct execution of the circuit, the subject was asked to perform the opening five minutes of the protocol.

On the second testing day, athletes performed the SAFT90 protocol. The athlete once again completed a brief warmup. Three pre-trial CMJ tests were then performed using the OptoJump sensors which were placed at the start of the circuit for the subjects to be able to simply walk into the area and perform their jump tests between each block of 15 minutes during the trial. There was a one-minute interval between each maximal effort provided once again. One maximal 10 hop test was then performed following two minutes rest from the third CMJ test. Once these pre-trial jump tests were completed, the subject was then ready to begin the SAFT90 protocol.

A Garmin watch and chest-strap monitor was provided for the test to monitor the athlete's heart rate throughout the test. SmartSpeed timing gates were positioned at the top and bottom of the SAFT90 circuit to measure sprint speeds across 20m. The SAFT90 is split onto six blocks of 15 minutes. The subjects perform the 15-minute blocks, with a break to perform a maximal CMJ test and maximal 10 hop test between each block, followed by a two-minute recovery period before performing the next block. Three 15-minute blocks were performed before a 10-minute half time interval. Three more 15-minute blocks, totalling 90 minutes of aerobic exercise consisting of standing, walking, jogging, striding, and sprinting were performed. Heart rate was noted following each 15 minutes as a backup in case of failure of the heart rate monitor. All subjects performed this 90-minute protocol and data was collected from each trial including heart rate (HR), CMJ jump heights (JH), 10 Hop RSI scores, 10 Hop jump heights, 10 Hop ground contact times (CT), and sprint times.

Subjects	**Height (cm)**	**Weight (kg)**	**Age**	**Position**
1	190	81.6	22	CB
2	176.1	69	23	CM
3	183.4	77.6	21	CB
4	188.3	84.4	22	LM
5	185.1	76.6	23	CB
6	173.2	63.6	22	CM
7	170.6	67	26	RM
8	180.1	82.2	22	RB
9	178.3	65.8	22	RM
10	178.8	68	22	RB
Mean	180.39	73.58	22.5	
SD	6.32	7.72	1.35	

Table 1 Athlete Information

Data Analysis

Instances of take-off and landing were identified using the sensor traces for every jump performed within the OptoJump zone. Jump height (JH) was calculated as the time between take-off and landing and ground contact time (CT) was calculated as the time between foot contact and take-off. RSI was calculated as the height jumped (JH) divided by contact time (CT), divided by 100 ((JH/CT)/100). From each subject's 10 Hop test, the best 5 RSI scores were derived, and an average was calculated from these 5 scores, in alignment with the 10/5 Hop protocol by Harper (2011). The corresponding JH and CT times with these RSI scores were selected to derive means for those variables. In each subject's 30s hop test, intervals of 5 seconds were used to derive average RSI, JH, and CT data across the jump test. JH from all CMJ scores were recorded and plotted across the SAFT90 protocol.

Statistical Analysis

The three dependant variables analysed were JH, CT, and RSI. Analyses focused on between-trial (SSD 10 Hops, SSD CMJ and 30s Hop), within-subject effects (Baselines, pre- and post-trial). In the present trial a sample size of n=10 was used. Means and standard deviations were calculated across all intervals of each test. Reactive strength behaviour of the subjects' lower legs during the two tests were investigated by correlation validity analysis. The strength of the relationship between the two trials were expressed by correlation analysis, using Pearson's r. Effect size was calculated using Cohen's d, to assess significance of any fatigue changes in either test.

Results

The Results below show the assessment and effect size of all three variables: Jump Height, Ground Contact Time, and RSI Scores. The table and graphs portray the data related to the 10 Hops and 30s Hop Test, respectively. Mean scores of all ten participants are displayed across each time interval where data was recorded in both trials. Calculations of % change, effect sizes (d) and slope (m) are labelled. The mean HR of all participants experienced in the SSD was 179.2 +/- 7.98 BPM. Error bars displaying standard deviations (Sd) to each corresponding mean are present on all graphs. In addition, Correlation Graphs have been created and are displayed below. The graphs aim to assess the validity of the effects of reactive strength fatigue (RSF) in the 30s Hop Tests compared with the SSD 10 Hops. This validity test was performed using correlation analysis, where Pearson's r and the equation of all slopes were recorded.

Jump Heights JH (cm)
SSD 10 Hop vs 30s Hop

	Base 10 Hop	Pre-Sim 10 Hop	10 Hop +15	10 Hop +30	10 Hop +45	10 Hop +60	10 Hop +75	10 Hop +90
Mean	28.61	29.15	27.82	27.24	27.09	26.90	26.41	26.13
Standard Deviation (Sd)	3.11	5.10	4.45	3.53	3.10	3.84	3.27	3.35
% Change Compared to Base		1.91	-2.74	-4.78	-5.31	-5.95	-7.66	-8.66
% Change Pre- to Post -								-10.37
Effect Size (d) Base to Post-	-0.80	Moderate						
Effect Size (d) Pre- to Post-	-0.59	Small						
Slope (r)	-0.029							
	30s Hop 0-5	**30s Hop 5-10**	**30s Hop 10-15**	**30s Hop 15-20**	**30s Hop 20-25**	**30s Hop 25-30**		
Mean	27.19	26.91	26.08	24.34	24.99	24.22		
Standard Deviation (Sd)	3.16	3.21	4.11	3.03	4.70	3.60		
% Change Pre- to Post-		-1.03	-4.07	-10.46	-8.09	-10.90		
Effect Size (d) Pre- to Post-	-0.94	Moderate						
Slope (m)	-0.128							

Ground Contact Times CT
SSD 10 Hop vs 30s Hop

	Base 10 Hop	Pre-Sim 10 Hop	10 Hop +15	10 Hop +30	10 Hop +45	10 Hop +60	10 Hop +75	10 Hop +90
Mean	0.20	0.19	0.20	0.20	0.20	0.21	0.20	0.21
Standard Deviation (Sd)	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02
% Change Compared to Base		-2.03	1.02	0.51	2.03	4.06	3.55	5.58
% Change Pre- to Post -								7.77
Effect Size (d) Base to Post-	0.78	Moderate						
Effect Size (d) Pre- to Post-	0.85	Moderate						
Slope (m)	0.00015							

	30s Hop 0-5	30s Hop 5-10	30s Hop 10-15	30s Hop 15-20	30s Hop 20-25	30s Hop 25-30
Mean	0.20	0.20	0.20	0.20	0.20	0.20
Standard Deviation (Sd)	0.01	0.01	0.01	0.01	0.02	0.02
% Change Pre- to Post-		-1.51	-0.50	-0.50	-0.50	1.51
Effect Size (d) Pre- to Post-	0.25	Small				
Slope (m)	0.00012					

RSI SCORES
SSD 10 Hop vs 30s Hop

	Base 10 Hop	Pre-Sim 10 Hop	10 Hop +15	10 Hop +30	10 Hop +45	10 Hop +60	10 Hop +75	10 Hop +90
Mean	1.46	1.51	1.41	1.39	1.36	1.33	1.30	1.28
Standard Deviation (Sd)	0.18	0.26	0.23	0.19	0.17	0.24	0.20	0.25
% Change Compared to Base		3.13	-3.38	-5.06	-7.22	-9.47	-11.07	-12.35
% Change Pre- to Post -								-15.01
Effect Size (d) Base to Post-	-1.03	Moderate						
Effect Size (d) Pre- to Post-	-0.88	Moderate						
Slope (m)	-0.00231							

	30s Hop 0-5	30s Hop 5-10	30s Hop 10-15	30s Hop 15-20	30s Hop 20-25	30s Hop 25-30
Mean	1.35	1.38	1.33	1.23	1.27	1.19
Standard Deviation (Sd)	0.19	0.20	0.21	0.17	0.24	0.19
% Change from Start		2.37	-1.56	-8.60	-6.23	-11.49
Effect Size (d) Pre- to Post-	-0.84	Moderate				
Slope (m)	-0.00696					

SSD CMJ Jump Heights JH (cm)

	Base CMJ	Pre-Sim CMJ	CMJ +15	CMJ +30	CMJ +45	CMJ +60	CMJ +75	CMJ +90
Mean	39.72	40.20	38.70	38.29	38.06	38.05	37.56	37.76
Standard Deviation (Sd)	7.27	6.44	5.81	5.56	5.04	5.51	5.47	5.15
% Change Compared to Base		1.21	-2.57	-3.60	-4.18	-4.20	-5.44	-4.93
% Change Pre- to Post -								-6.07
Effect Size (d) Base to Post-	-0.27	Small						
Effect Size (d) Pre- to Post-	-0.38	Small						
Slope (m)	-0.02343							

Jump Heights

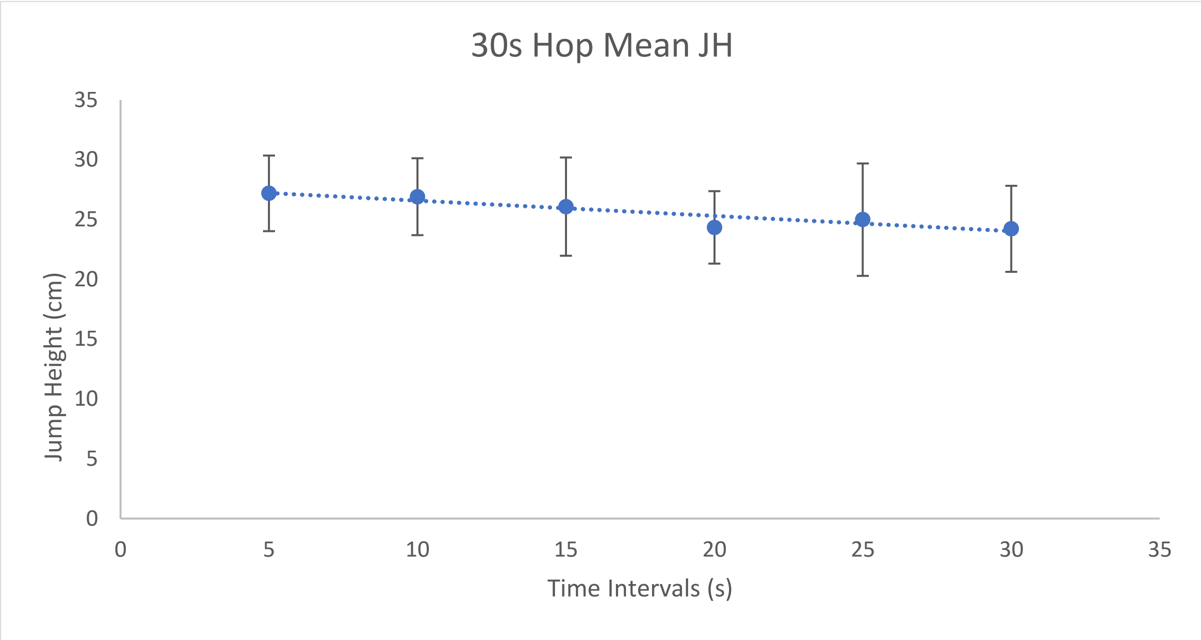

Figure 1 SSD 10 Hop Mean JH

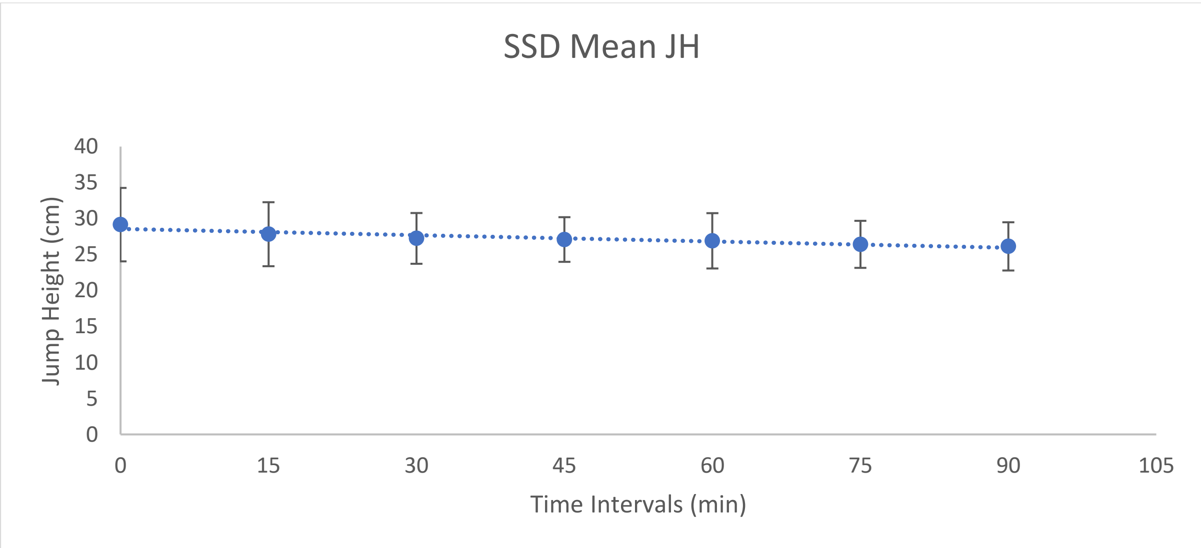

Figure 2 30s Hop Mean JH

Figures 1 and 2 above display the mean Jump Height performed by all subjects across each time interval. Figure 1 describes the JH of the 30s Hop test in each 5 second interval. Figure 2 describes the JH of the SSD 10 Hop in each 15-minute interval. Results showed a mean decrease in JH of 10.37% from pre-trial to post-trial in the SSD 10 Hop, with a small effect size of d = 0.59. A decrease in JH of 10.9% was seen from start to end of the 30s Hop tests, with a moderate effect size d = 0.938.

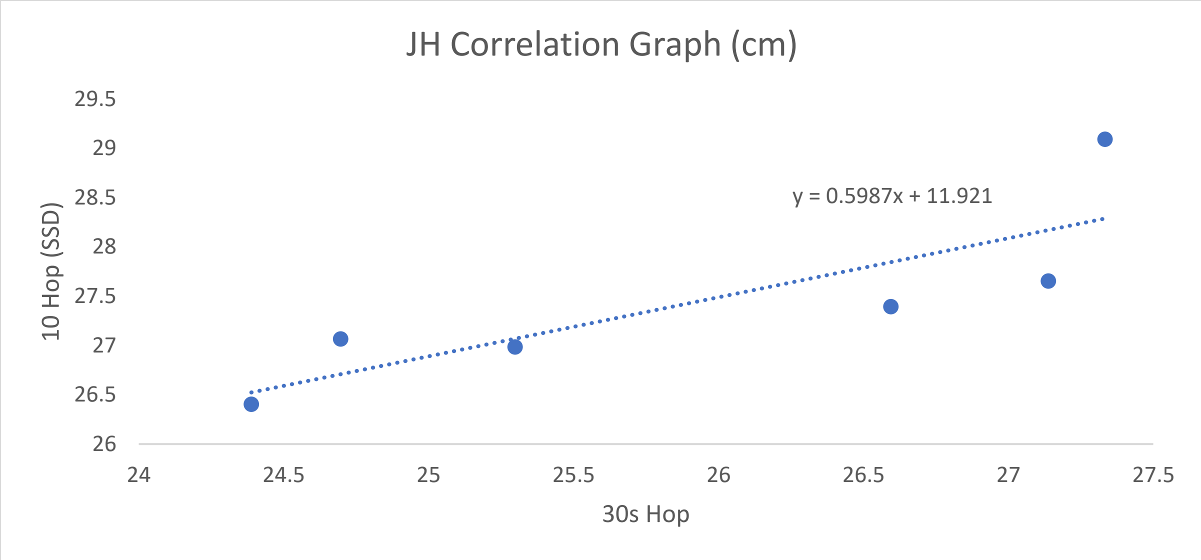

Figure 3 JH Correlation Graph

Figure 3 describes the correlation between SSD 10 Hop and 30s Hop relating to JH. Correlation analysis between the SSD 10 Hop and 30s Hop using Pearson's r displayed a score of r = 0.835. There was a strong positive correlation between both tests in Jump Height scores. The trendline can be represented by the equation y = 0.5987x +11.921.

Ground Contact Times

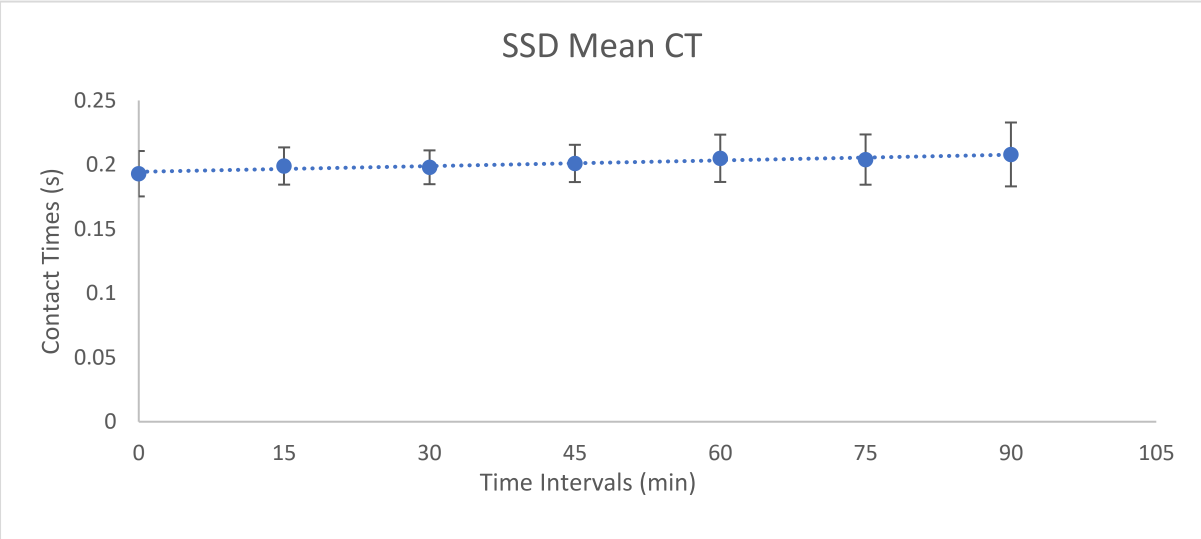

Figure 4 SSD 10 Hop Mean CT

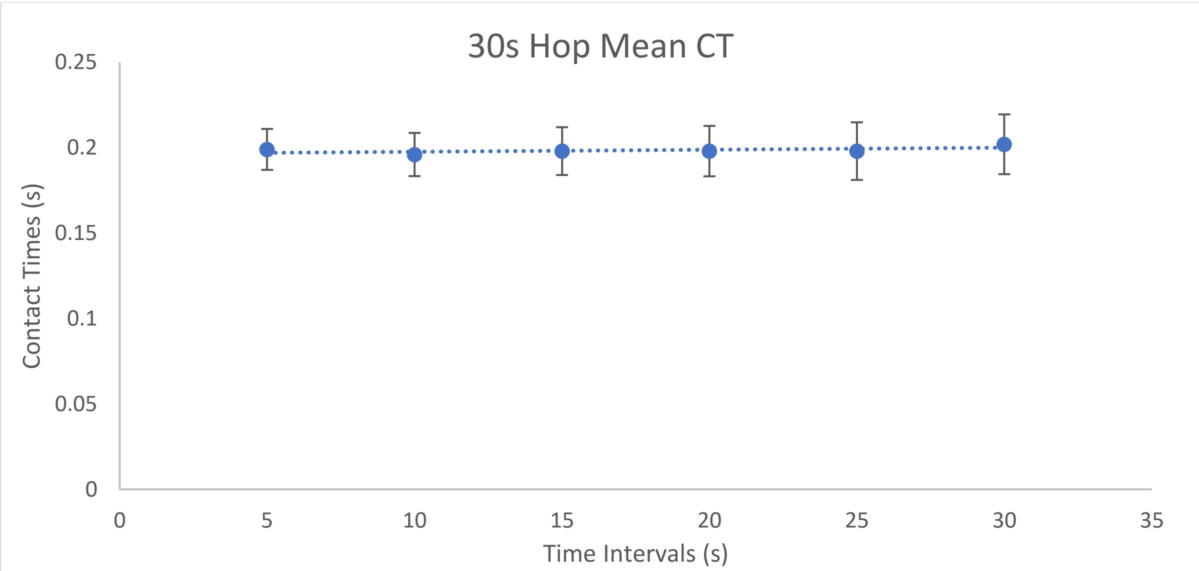

Figure 5 30s Hop Mean CT

Figures 4 and 5 display the mean ground contact times performed by all subjects across each time interval. Figure 4 describes the CT of the 30s Hop test in each 5 second interval. Figure 5 describes the CT of the SSD 10 Hop in each 15-minute interval. Mean Contact Times (CT) increased by 7.77% from pre-trial to post-trial in the SSD 10 Hop, with a moderate effect size d = 0.85. An increase of 1.51% was seen in CT from start to end of the 30s Hop Test, with a small effect size of d = 0.25.

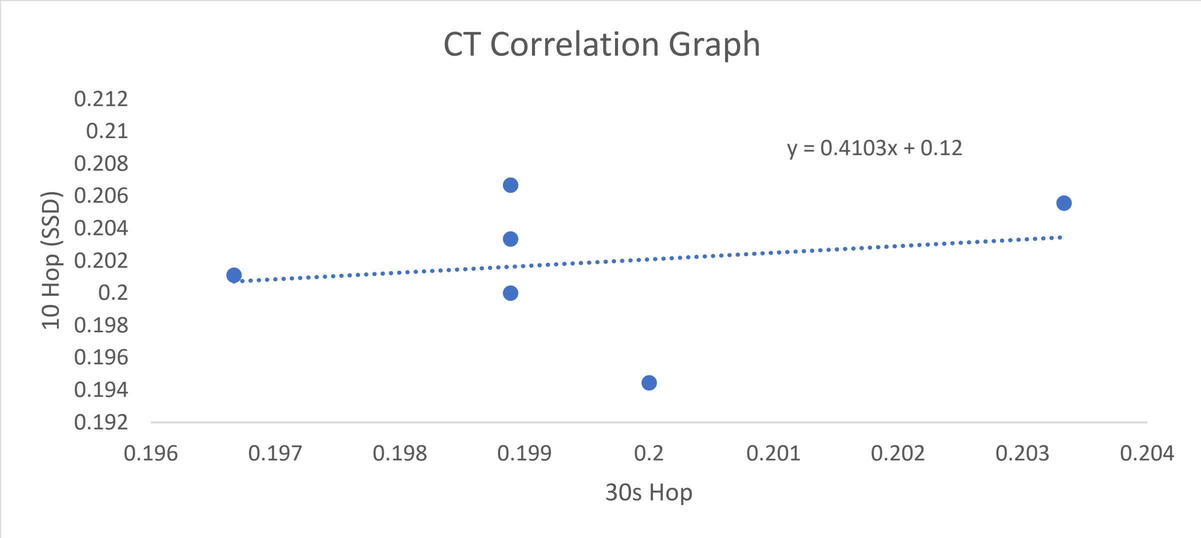

Figure 6 CT Correlation Graph

Figure 6 describes the correlation between SSD 10 Hop and 30s Hop relating to CT. Analysis displayed a score of r = 0.537. There was a moderate positive correlation between both tests in Contact Times. The trendline can be represented by the equation y = 0.4103x + 0.12.

RSI Scores

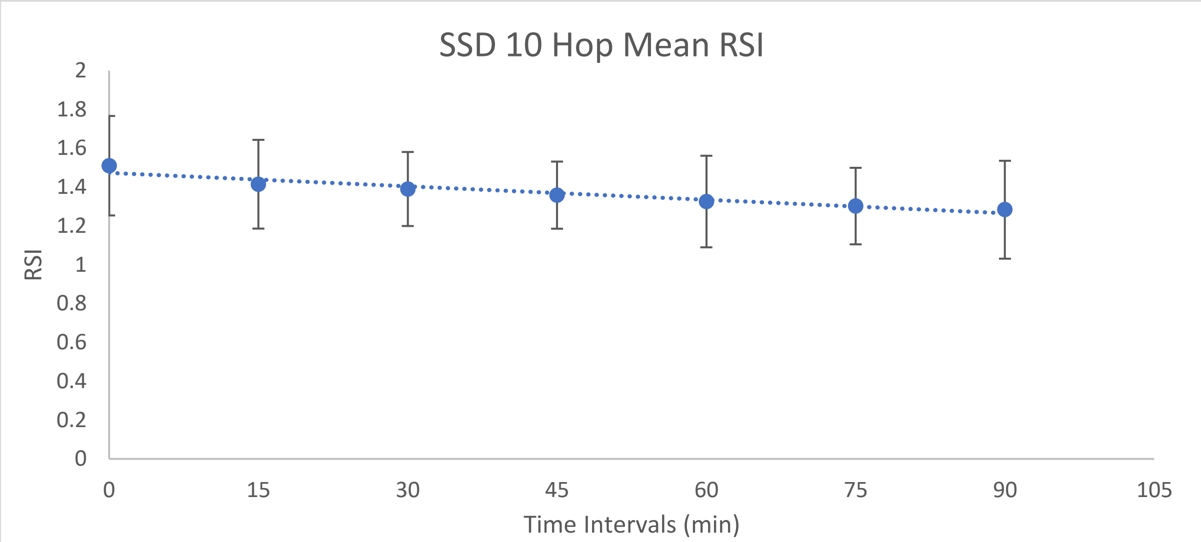

Figure 7 SSD 10 Hop Mean RSI

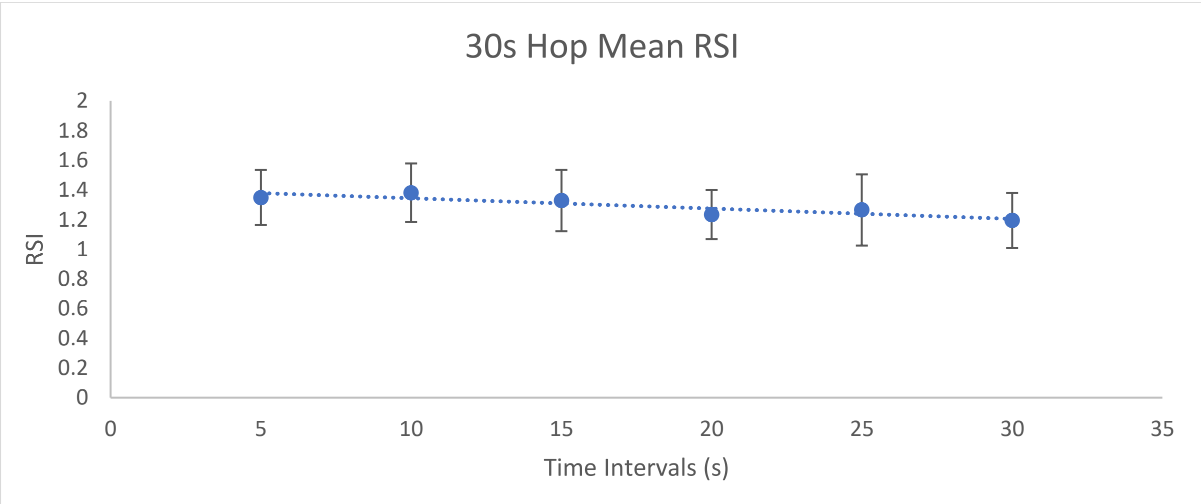

Figure 8 30s Hop Mean RSI

Figures 7 and 8 display the RSI performed by all subjects across each time interval. Figure 6 describes the RSI scores of the 30s Hop test in each 5 second interval. Figure 7 describes the RSI scores of the SSD 10 Hop in each 15-minute interval. Mean RSI scores decreased by 15.01% from pre-trial to post-trial in the SSD 10 Hop, with a moderate effect size of d = 0.89. An average decrease of 11.49% was seen in RSI scores from start to end of the 30s Hop Test, with a moderate effect size of d = 0.84.

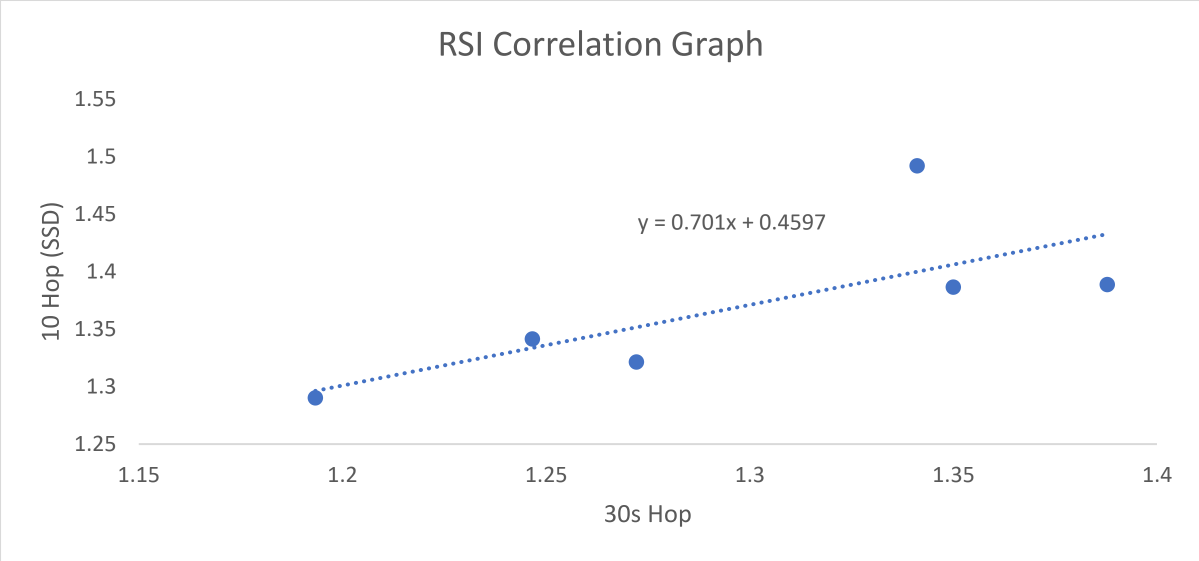

Figure 9 RSI Correlation Graph

Figure 9 describes the correlation between SSD 10 Hop and 30s Hop relating to RSI. Correlation analysis displayed a score of r = 0.727. There was a positive correlation between both tests in RSI. The trendline can be represented by the equation y = 0.701x + 0.4597.

SSD CMJ Jump Heights

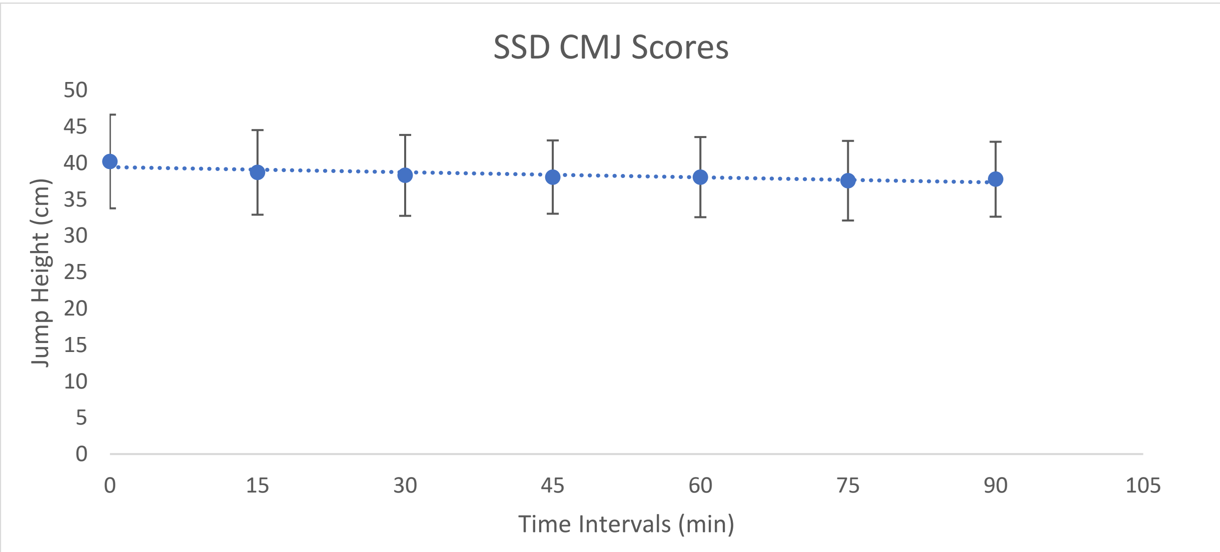

Figure 10 SSD CMJ Mean JH

Figure 10 describes the mean jump heights of the SSD 10 Hop in each 15-minute interval. JH scores in the SSD CMJ tests decreased by 6.07% from pre-trial to post-trial, with a small effect size of d = 0.25.

Discussion

The impetus of this study was to assess the validity of the 30s hopping test as a means of measuring reactive strength fatigue in the lower limbs of competitive soccer players. Validity refers to the degree to which the test measures what it is intended to measure (Matthews & Kostelis, 2011). Explosivity and reactive strength is a major element in the dynamic movements a competitive soccer player makes during a 90-minute match. The measurement of RSI in these athletes can be beneficial for the continual monitoring of reactive strength throughout a season to avoid overtraining, mitigate the risks of injury and improve explosivity in such athletes' lower leg muscles. As a result, content validity can be inferred. As previously stated, this study aimed to answer four questions.

1. Do the athletes' jump data from the SSD 10 Hop and the 30s Hop change significantly?

2. Does this change (if any) demonstrate fatigue levels typically shown in competition?

3. Is there any correlation between the SSD 10 Hop and the 30s Hop in relation to reactive strength fatigue?

4. Is the 30s Hopping Test a valid measure of this reactive strength fatigue displayed in the soccer simulation drill (SSD).

The author's hypothesis states that there would be a significant association between the SSD 10 Hop jump data and the 30s Hop jump data. Null Hypothesis states no association between the SSD 10 Hop and 30s Hop. If there was a significant association calculated from correlation analysis, the null hypothesis of no change can be rejected, and criterion validity of the 30s Hop can be inferred. Validity assesses the correlation of concurrent (SSD) and criterion measurements (30s Hop).

Magnitude of Fatigue

Regarding the first question, whether there was a meaningful change in the magnitude of fatigue induced through the two tests, JH scores in the SSD CMJ, SSD 10 Hop showed small effect sizes (d = 0.25 and 0.5, respectively). This finding in JH differed from the magnitude shown in the 30s Hop, with a moderate effect size shown (d = 0.94). CT scores in the SSD 10 Hop increased through the trial, with a moderate effect size (d = 0.85) which is unlike the small effect size seen in the 30s Hop (d = 0.25). RSI scores were both classed as moderate effect sizes across the two trials (d = 0.89 and 0.84, respectively). The findings can be interpreted to indicate that there was a meaningful change in jump height in the 30s Hop but insignificant in the SSD CMJ and SSD 10 Hop. No significant changes were seen in CT in the 30s Hop unlike the SSD 10 Hop. RSI scores saw meaningful change in both tests.

In relation to the question on whether the fatigue shown in jump scores demonstrates similar figures typically shown from previous studies, the jump scores aligned with a study by Flanagan et al. (2019). This study saw decreases in JH of 15.04% and RSI of 10.82% in the 30s Hop test. This study saw a mean decrease of 10.9% in JH and a mean decrease of 11.49% in RSI. It is worth noting that this study used Intraclass Correlation (ICC) to assess magnitude of difference. Another study by Lehnert (2020), who assessed the effects of simulated soccer match play on neuromuscular performance reported RSI increased from pre- to post- SAFT90 trial, unlike results shown by this present study. It should be noted that age variability may be a factor as these subjects were youth team players.

Briefly noting aerobic capacity, all subjects experienced maximal exertion, as indicated by the Garmin chest-strap monitor. Mean HR was recorded as 179.2 +/-7.98 BPM across the SSD. It can be assumed that lactate threshold was reached as athletes performed near to their HR Max (80-90%) (Hoff, 2005; Williams, 2010).

Validity of the 30s Hopping Test

Results have shown a large correlation between the SSD 10 Hops and 30s Hop tests in both the RSI Scores (r = 0.727) and JH (r = 0.835) scores, and a moderate correlation in CT scores (r = 0.537). The impetus of this study was to assess the validity of the 30s Hop test to measure reactive strength fatigue. Validity coefficients rate the three variables as "Excellent" (JH), "Unacceptable" (CT), and "Good" (RSI). The values in relation to the validity co-efficient scale demonstrate the 30s Hop as a valid measure of Jump Height scores and RSI, but not for CT as the SSD showed a larger mean increase (7.77%) compared to the 30s Hop (1.507%). Regardless of the larger CT scores shown across the 10 Hop and this weak correlation, this RSI scores across the two tests performed in an equivalent manner. In the aim to assess the validity of the 30s Hop to measure reactive strength fatigue, it can be concluded that the 30s Hop is a valid measure of Reactive Strength fatigue in competitive soccer players in relation to match-specific conditions, as it replicate similar levels of JH and RSI. Regarding the weak correlation in CT, which refers to time taken to obtain force to get back off the ground in an explosive manner, the significant increase seen in the SSD can be expected given the intense nature of the trial (90 minutes of intense exercise vs 30 seconds of repeated jumps). RSI and JH scores still showed similar rates of change throughout both trials, regardless of the difference in CT. The present findings fail to reject the null hypothesis. There is significant correlation between the two tests pre- to post- trial.

The findings of this study provide a tool for the measurement of RSI in soccer players when comparing to levels demonstrated in a match-specific environment. The use of the 30s Hopping test for close monitoring of reactive strength in conjunction with plyometric and resistance training may allow for maintenance of performance levels, mitigation of over training and injury, and improve explosivity in the lower limbs of these athletes.

Some limitations of this study include position variability in relation to fatigue levels, intra and inter-individual variability aspects and lack of a baseline fitness test to compare the SSD scores to for reliability. Additionally, the analysis of the sprint speeds could be performed in future research. Improvements in Jump Scores amongst several subjects were seen in the SSD CMJ tests which aligns with previous findings (Lehnert, 2020). Indications of improved scores may be as a result in improvements in technique with more attempts, which indicates familiarisation during the SSD protocol.

Regarding reliability of this study undertaken, all data collection techniques and analytic procedures would produce consistent findings if they were repeated on another occasion or if another researcher replicated them. There lies no threat to reliability through participant error, participant bias, researcher error or researcher bias. Some common errors can, of course, always present in any measurement. Random error like mood, motivation, environment, prior fatigue, and improved familiarity may affect findings. However, no systematic errors were present. Subjects showed maximal aerobic exertion, in line with findings in competitive soccer matches, furthering support for the SAFT90 trial as a reliable and valid tool for inducing match-like fatigue (da Silva & Lovell, 2020; Barrett, 2013).

Conclusions

This study set out to evaluate the validity of the 30-second hopping test as a practical tool for measuring reactive strength fatigue (RSF) in male competitive soccer players, in comparison to fatigue experienced during a soccer-specific match simulation (SAFT90). The results revealed strong positive correlations between the 30s Hop and SSD 10 Hop tests for reactive strength index (RSI) and jump height (JH), suggesting that the 30s Hop can meaningfully reflect changes in RSF that occur in ecologically valid soccer settings. However, the correlation for ground contact time (CT) was weaker, indicating that not all components of reactive strength are captured equally well by the 30s Hop.

Both RSI and JH decreased substantially post-exercise in both test formats, highlighting the sensitivity of these measures to fatigue from simulated match demands. While the 30s Hop test does not precisely replicate the duration or multidimensional fatigue of a full match, the rates of decline in RSI and JH suggest it can serve as a practical field measure for monitoring neuromuscular fatigue over time. Therefore, the 30s Hop can be recommended as a valid measure of RSF in competitive soccer players, particularly for practitioners seeking efficient field-based monitoring tools.

While the findings provide encouraging evidence for the 30s Hop's utility, caution should be applied in generalizing results. The study's participant group was small (n=10) and limited to a homogenous population of young, healthy male soccer players, which restricts extrapolation to larger, more diverse groups including females and older athletes. All subjects were competitive players but from a limited performance spectrum; outcomes may differ in elite or recreational athletes—or between clubs using different training regimes. Additionally, the lack of variation in athletes' position leaves room for more analysis of changes due to position-specificity. Observed increases in SSD CMJ scores for some subjects may reflect improved technique or familiarization rather than true fatigue resistance. The sequential design and possible lack of randomized trial order may have influenced motivation or fatigue independently of protocol. The controlled nature of the SAFT90 and test environments may not fully recreate the tactical, psychological, or contextual stressors experienced in competitive matches. No baseline aerobic fitness or lower-body strength test was conducted, which could influence RSI and fatigue response. Sensor accuracy (e.g., OptoJump) and timing systems may introduce small errors in CT and JH, potentially affecting correlations. Only acute (immediate post-exercise) responses were measured; no assessment of longer-term recovery or repeated test reliability was performed. Sprint data were collected but not analysed, missing an additional metric relevant to soccer-specific fatigue profiles. The study did not examine whether changes in 30s Hop performance reflect improvements after a neuromuscular training program.

In summary, while the 30s Hop provides a valid and efficient means of tracking match-relevant reactive strength fatigue in this sample, future research should address its application across broader populations, settings, and time frames, and should incorporate a wider range of conditioning and contextual variables to confirm and extend these

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Tables

Figures