THE RELATIONSHIP BETWEEN REACTIVE STRENGTH MEASURES AND SPRINTING PERFORMANCE

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This study examined the relationships between reactive strength measures and sprint performance. Ten female sprinters performed bilateral vertical hops and drop jumps (DJs) from 0.3 m and 40 m sprints. Ground contact time, flight time, height jumped and the reactive strength index (RSI) were calculated during hops and drop jumps. Sprint times over 10, 20, 30 and 40 m were also assessed. High positive correlations, calculated using Pearson's r correlations, were found between Hop RSI and DJ RSI ($r = 0.672$) with no other significant correlations found. Although RSI values in hopping and drop jumping are related they should not be used interchangeably as they represent somewhat distinct reactive strength qualities. The results suggest that RSI values, calculated during hopping and drop jumping, were not related to sprint performance.

KEY WORDS: drop jumps, hopping, speed.

INTRODUCTION: Reactive strength has previously been defined as the ability to quickly change between an eccentric (lengthening) contraction and a concentric (shortening) contraction or simply, a measure of an athlete's lower body explosiveness (Newton et al., 2008). The reactive strength index (RSI), calculated as the height jumped divided by the ground contact time in a jump or hop, has been widely used to assess reactive strength ability in athletes (Young 1995). RSI has most commonly been assessed during fast stretch shortening cycle (SSC) tasks (ground contact time < 0.250 s) such as a drop jump, where an athlete drops from a box of a pre-determined height and performs a maximal effort vertical jump upon landing with the intent to jump as high as possible while minimising ground contact time. Bilateral vertical hopping, an alternative fast SSC task, has traditionally been used to assess an athlete's leg stiffness, however recent research has found that RSI measured during hopping was moderately correlated to sprint performance (Nagahara et al. 2014). Research undertaken on drop jumps in female athletes has produced mixed results with RSI found to be significantly related to 30 and 100 m sprint performance in sprint athletes (Hennessy & Kilty, 2001), whereas no relationship was found with 60 m sprint performance in rugby players (Barr & Nolte, 2011). Further research is needed to examine the relationship between RSI measured during hopping and drop jumping. Additionally, it is not currently known which measure of reactive strength is a better indicator of sprinting performance. Therefore, the aim of this study was to assess the relationship between reactive strength measures in hopping and drop jumps and sprint performance in female sprint athletes.

METHODS: Following ethical approval by the local University Research Ethics Committee ten participants ($n = 10$) were recruited for this study. All participants were sprint trained females (mean ± SD: age: 22 ± 4 years; height: 1.72 ± 0.08 m; mass: 65 ± 4.5 kg) and were injury free at the time of testing. Testing took place over two separate days. On the first day, following a standardised warm up, participants performed three bilateral vertical hopping trials in which participants were instructed to hop for ten seconds at a set frequency of 2.2 Hz which was imposed by a digital metronome (Chelly & Denis, 2001). Subjects then completed three bilateral drop jumps with 30 seconds of recovery provided between each jump. All jumps were performed from a box height of 0.3 m. Participants were instructed to keep their hands on their hips at all times, initiate the drop jump by stepping off of the box, avoid any tucking motion in the air, attempt to land in the same position as take-off and to aim to jump for minimum contact while also attempting to maximise subsequent maximal jump height (Young et al., 1995). All hops and drop jumps were performed on AMTI Net force platform (Watertown, MA, USA) operating at 1,000 Hz. The dependent variables calculated were ground contact time (CT), flight time (FT), height jumped (HJ) and reactive strength index (RSI). CT and FT were obtained directly from the force-time data. Height jumped was calculated using the second equation of linear motion i.e. $s = ut + ½at^2$ where $a = 9.81\ m.s^{-2}$ and $t = FT/2$. RSI was calculated as the height jumped divided by CT (Young, 1995). On the second test day, following an individualised race specific warm-up, athletes performed three trials of a 40 m sprint from a block start with full recovery provided (~ 6 minutes) between each sprint. Sprint times over 10, 20, 30 and 40 m were recorded using Racetime 2, dual-beam timing gates (Microgate, Bolzano, Italy). The best trial, defined as the jump or hop yielding the highest RSI and the fastest 40 m sprint time, was retained for each participant and was included in the final analysis. Group means, standard deviations (SD) and 95% confidence interval (CI) were calculated for each measure. Associations between reactive strength measures and sprint times were assessed using Pearson's r correlation test with the alpha level set at 0.05. The strength of the correlations were interpreted according to the scale of magnitudes devised by Hopkins et al. (2009), r > 0.9 is nearly perfect, 0.7-0.89 is very high, 0.5-0.69 is high, 0.3-0.49 is medium, 0.29-0.1 is low and < 0.1 is trivial.

RESULTS: Descriptive statistics for all hopping and jumping measures and sprint times are provided in Table 1 and Table 2 respectively. A scatter plot of the associations between hop RSI and drop jump RSI is shown in Figure 1. A correlation matrix of drop jump, hopping and sprint performance variables is provided in Table 3. A high positive correlation was found between hop RSI and drop jump RSI (r = 0.672). No other correlations were found to be significant ($p < 0.05$).

Table 1
Mean, SD and 95% CI for drop jump and hopping measures.

	Mean	SD	95% CI
Drop Jumps			
CT (s)	0.180	0.031	0.158 – 0.202
FT (s)	0.482	0.044	0.450 – 0.514
HJ (m)	0.287	0.055	0.248 – 0.327
RSI ($m \cdot s^{-1}$)	1.62	0.34	1.39 – 1.87
Hopping			
CT (s)	0.151	0.015	0.140 – 0.162
FT (s)	0.322	0.019	0.308 – 0.336
HJ (m)	0.128	0.015	0.117 – 0.139
RSI ($m \cdot s^{-1}$)	0.86	0.16	0.74 – 0.98

Table 2: Mean, SD and 95% CI for sprint times.

	Mean	SD	95% CI
10 m time (s)	2.04	0.10	1.97 – 2.11
20 m time (s)	3.36	0.15	3.25 – 3.46
30 m time (s)	4.58	0.22	4.43 – 4.74
40 m time (s)	5.79	0.26	5.60 – 5.98
Max Velocity ($m.s^{-1}$)	8.45	0.38	8.17 – 8.72

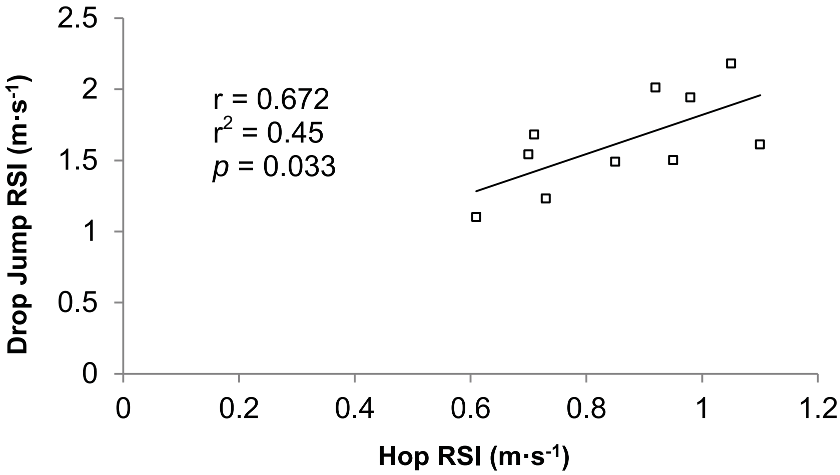

Figure 1: Associations between reactive strength index measured during hopping and drop jumping.

Table 3
Correlation matrix of drop jump, hoppping and sprint performance variables.

	10 m time (s)	20 m time (s)	30 m time (s)	40 m time (s)	Max Velocity ($m.s^{-1}$)
DJ RSI ($m.s^{-1}$)	-0.25 p = 0.480 (Small)	-0.26 p = 0.466 (Small)	-0.37 p = 0.299 (Moderate)	-0.34 p = 0.331 (Moderate)	0.09 p = 0.804 (Trivial)
Hop RSI ($m.s^{-1}$)	-0.47 p = 0.170 (Moderate)	-0.50 p = 0.145 (Large)	-0.62 p = 0.055 (Large)	-0.58 p = 0.079 (Large)	0.48 p = 0.162 (Moderate)

DISCUSSION: The results of this study indicate that RSI assessed during hopping is strongly correlated with RSI assessed during drop jumping however only 45% of variance in DJ RSI was accounted for by Hop RSI. Possible explanations for the shared variance include the fact that both tests have similar instructions i.e. jump / hop for minimum CT and also, that both movements are kinematically comparable i.e. bilateral vertical movements. Differences in kinetics may explain why a stronger correlation wasn't found as the hip joint play a much more prominent role in the drop jump relative to the ankle and knee (Ford et al. 2005) whereas the moments in the knee and ankle joints play a much greater role relative to the hip in hopping (Hobara et al. 2010). Contrary to previous research in sprint athletes by Hennessy and Kilty (2001) and Nagahara et al. (2014), no statistically significant correlations were found between reactive strength measures and sprinting performance. This is possibly due to the relatively small sample size used in this study. Although the correlations between Hop RSI and sprint performance over 20, 30 and 40 m were not statistically significant, they can be interpreted as large with Hop RSI accounting for 25, 38 and 34% of variance respectively. This can potentially be explained by some similarities in the neural mechanisms active during fast SSC activities. With respect to sprint ground contact times, previous research has reported mean CTs of 0.133, 0.119 and 0.112 s for the acceleration (0-10 m), transition (10 – 30 m) and max velocity (40 – 60 m) phases respectively in female sprinters (Debaere et al. 2013). The mean CTs in this study for hopping and drop jumping were 0.151 and 0.180 s respectively. Although sprinting, drop jumping and hopping are all considered fast SSC movements, the relative contribution of each potential mechanism e.g. the stretch reflex, the storage and subsequent utilisation of elastic energy etc., are likely to be dissimilar to a certain extent. This could be due to factors such as CTs and movement differences i.e. sprinting is a horizontal ipsilateral movement whereas hopping and drop jumping are bilateral vertical movements. It is possible therefore, that sprinting should be viewed in a slightly different category as a hop or a drop jump and consequently, reactive strength assessed through these methods may not be appropriate unless contact times are closer to those observed during sprinting. This may explain why larger correlations were found between hopping and sprinting compared to drop jumping. This concept however, requires further investigation.

CONCLUSION: This study found a significant correlation between RSI values measured in hopping and drop jumping. Although these measures are related they should not be used interchangeably as they represent somewhat distinct reactive strength qualities likely due to the differences in jump kinetics. The results suggest that RSI values, calculated during hopping and drop jumping, were not related to sprint performance possibly due to ground contact times that were much larger than those typically observed during sprinting. Coaches are advised to select tests that yield contact times that are consistent with sprinting i.e. $<$ 0.130 s.

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