Reactive Strength Endurance: Part 2 Is maximal reactive strength associated with reactive strength endurance?

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Reactive Strength index | Fast SSC | Fatigue

Headline

In part 1, *The response of reactive strength to fast stretch-shortening cycle fatigue* (1) we demonstrated that reactive strength progressively decreased, with a large effect, across a 60-second repeat jump test (RSE_{60}). Previously, it has been demonstrated that reactive strength is associated with some athletic capacities critical to sport performance (2,3,4,5,6). However, it has not been definitively established if maximal reactive strength is a limiting factor to performance in sports with greater endurance demands. In the case of sports requiring pacing, an ability to preserve reactive strength or reactive strength endurance may be of importance.

Aim. The aim of the present study was to examine 1) the relationship between maximal reactive strength and relative RSE_{60} 2) the relationship between maximal reactive strength and absolute RSE_{60}. Furthermore, we propose two methods to describe RSE_{60} qualities: Relative RSE_{60} and Absolute RSE_{60}.

Methods

The methods have previously been described in part 1. It should be emphasised here that this paper draws on the same dataset which was presented in part 1.

Athletes. Sixteen recreationally trained sports and exercise science students (age: 23.1 ± 4.4 years, body mass: 84.9 ± 11.5 kg, height: 179.4 ± 3.9 cm) participated in the study. Ethical clearance was granted by the University's ethics committee and all participating participants provided informed consent. The study conformed to the recommendations of the Declaration of Helsinki.

Design. Single group, cross sectional study. Participants attended the laboratory on 2 occasions. On both occasions they performed a standardised dynamic warm-up routine (7) followed by the 10-to-5 repeated jump test and the 60-second repeated jump test.

Methodology. The first testing session was considered a habituation session and only data from the second session was considered for analysis. Both jump tests were performed in an Optojump photocell system (Microgate, Bolzano, Italy) with flight time and contact time recorded for each jump. Jump height was calculated from flight time and the reactive strength index was calculated as the jump height divided by contact time. The 10-to-5 repeated jump test was performed in the manner described by Harper (8). In the 60-second repeated jump test, participants were asked to perform continuous vertical rebound jumps with hands akimbo, and they were instructed to jump as high as possible with minimal ground contact times (≤250ms) for the entire duration.

Analysis

Reactive Strength Index in the 10-to-5 repeated jump test was calculated as the average RSI across the 5 highest reps with a contact time of less than 250ms (8). This metric is abbreviated as RSI_{MAX}.

In the 60-second repeat jump test, a post-hoc threshold of 80% of RSI_{MAX} for the 5-10s time period was applied as an exclusion criterion. Participants who did not achieve this were deemed to be exhibiting a "pacing" strategy and were excluded from analysis. Five of the 16 participants were excluded from the study on this basis (n=11). Reactive Strength Endurance in the 60-second repeat jump test was assessed in relative and absolute terms. Relative RSE_{60} was calculated as the average RSI in the 55-60s time interval as a percentage of RSI_{MAX}. Absolute RSE_{60} was calculated as the average RSI achieved during the 55-60s time interval. The relationship between RSI_{MAX} and relative and absolute RSE_{60} was examined us-

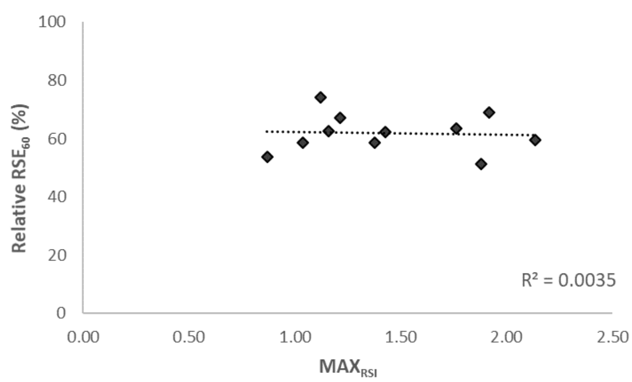

Fig. 1. Relationship between relative reactive strength endurance (Relative RSE_{60}) and maximal reactive strength (RSI_{MAX}).

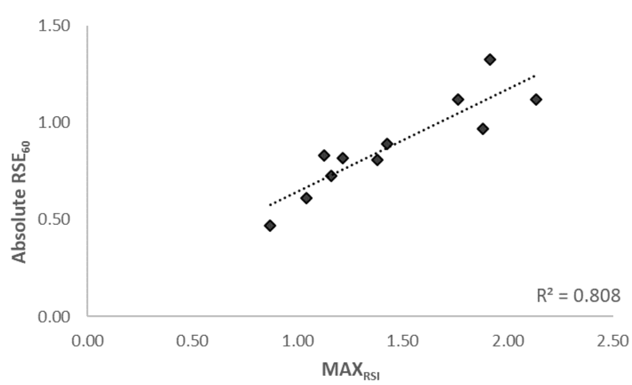

Fig. 2. Relationship between absolute reactive strength endurance (Absolute RSE_{60}) and maximal reactive strength (RSI_{MAX}).

ing the Pearson product correlation (r). The magnitude of the correlation was described using Hopkins' scale of magnitudes for linear trends (9). Threshold values for magnitude of correlation were: <0.1 (trivial, practically zero), 0.1 – 0.3 (small, minor), 0.3-0.5 (moderate, medium), 0.5-0.7 (large, major), 0.7-0.9 (very large, huge) and 0.9-1.0 (nearly, practically or almost perfect). Confidence intervals for r were calculated using the Fisher z-transformation using a freely available, validated spreadsheeet (10). The strength of the relationship between RSI_{MAX} and relative and absolute RSE_{60} was expressed using the variance explained statistic (r^2).

Results

A trivial or "practically zero" relationship was established between RSI_{MAX} and relative RSE_{60} (r = 0.06; 90% CL = -0.57 – 0.48). The variance explained between RSI_{MAX} and relative RSE_{60} was 0.00 which indicates that none of the variance in relative RSE_{60} was explained by RSI_{MAX}. Absolute RSE_{60} demonstrated a very large relationship with RSI_{MAX} (r = 0.90; 90% CL = 0.71 – 0.97). The variance explained between RSI_{MAX} and absolute RSE_{60} was 0.81 which indicates that 81% of the variance in absolute RSE_{60} was explained by RSI_{MAX}.

Discussion

In part 1, we identified that reactive strength progressively decreased, with a large effect, across a 60-second repeat jump test1. This follow-up study examined the relationship between maximal reactive strength and reactive strength endurance in a 60s repeat jump test. The primary finding was that RSI_{MAX} demonstrated a very large relationship with absolute RSE_{60} but had no relationship with relative RSE_{60}. These data indicate that high levels of maximal reactive strength do not have an effect on the relative decrease of reactive strength throughout the process of fast-stretch shortening cycle fatigue. This suggests that the physical qualities underpinning maximal reactive strength and those that attenuate reactive strength during the fast stretch shortening cycle fatigue process are not related.

However, a very large positive relationship was observed between maximal reactive strength and absolute RSE_{60}. This is an important finding which demonstrates that high levels of reactive strength offer a protective effect against decreases in performance when under fatigue. While high reactive strength is not associated with the relative response to fatiguing exercise, it does provide a reactive strength reserve which ensures higher levels of reactive strength can be exhibited when under fatigue. This "buffering" effect might be of particular importance in cyclical sports requiring repeated, sub-maximal reactive strength expression of the lower limbs, such as middle distance running or boxing.

Although maximal reactive strength might not initially appear to be a limitation to performance in these events, high levels may allow for more effective sub-maximal expression of reactive strength in the latter stages of exercise bouts or when under fatigue. Previous studies have suggested that training interventions which improve maximal reactive strength may contribute to enhanced endurance performance (5,6). The current research study suggests that one mechanism which may facilitate this effect is an improved, absolute expression of reactive strength while under fatigue. Reactive strength is associated with leg-spring stiffness (11) therefore a greater absolute level of reactive strength while under fatigue is likely to reduce the energy demand of the active musculature and improve economy.

Practical Applications

The results of this study provide some weight that plyometric training aimed at increasing reactive strength may have positive effects on performance under fatigue.

- Higher levels of reactive strength is associated with greater absolute expression of RSI during a fatigue protocol. Essentially RSI_{MAX} offers a protective effect on performance.
- Practitioners can apply Relative RSE_{60} and/or Absolute RSE_{60} to describe the reactive endurance capabilities of their athletes/sports.
- A note of cation should be applied, as intensive stretch shortening exercise often results in reversible muscle damage (12). However, a shortened assessment could be used such as a 0 – 20 second protocol where a moderate decrease in reactive strength was observed in part 1 (1).
- In the present study, over 80% of the variance in absolute RSE_{60} was explained by RSI_{MAX}. Considering this, one may deem that solely assessing RSI_{MAX} in the 10-to-5 repeated jump test may offer enough insight into absolute RSE abilities. Only assessing RSI_{MAX} however, will not offer any insight into relative reactive strength endurance qualities.

Limitations

The methodological limitations of this research study have been outlined in part 1 (1).

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