RSI REVISITED PART 2

A Comprehensive Manual By:

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THE REACTIVE STRENGTH INDEX REVISITED

PART 2

by Eamonn Flanagan, PhD.

We closed part 1 having outlined a simple, incremental method for assessing reactive strength ability in an incremental drop jump test (DJ-RSI test). While this is a useful tool to optimize the efficacy and safety of drop jump training, it is by no means the only method to assess an athlete's reactive strength ability.

While drop jumps represent a single, maximal effort, which is highly dependent on reactive strength abilities, the RSI can also be measured in repeat hopping and jumping tasks. For coaches who want to get a quick and easy marker of reactive strength ability, the "rebound jump test" can negate the need to use multiple jump repetitions. It also removes the need to use a variety of boxes and allows the coach and athlete to record an RSI score with a single jump.

THE REBOUND JUMP TEST

The rebound jump offers a quick and simple alternative to the incremental DJ-RSI test. We are assessing the same reactive strength quality although possibly at a lower intensity of eccentric loading. In the rebound jump, the athlete performs a single countermovement jump, but upon landing immediately jumps again. In this second jump, the rebound jump (RBJ), the athlete's aim is to minimize ground contact time, jump high and use a "stiff" ankle-dominant jumping action to recruit the fast stretch shortening cycle. This was the type of reactive strength test I used in the research study with cross country skiers that we discussed in part 1. The RBJ proved to be quick, easy and reliable[1].

The rebound jump is worth considering as it allows the athlete, consciously or sub-consciously, the opportunity to "self-select" their own drop height for the rebound jump. Essentially, the athlete is in control of the jump height in the preliminary CMJ which dictates the intensity and loading of the following RBJ. I explored the difference between the RBJ and the incremental DJ-RSI test with elite academy rugby players (19-21 years old). We had players perform the DJ-RSI test across three drop heights and also had them perform a rebound jump. The graph below compares the data. The rebound jump produced very similar RSI scores compared with drop jumps, however it did not produce as high an RSI as the "optimal" drop height identified by the incremental DJ-RSI process.

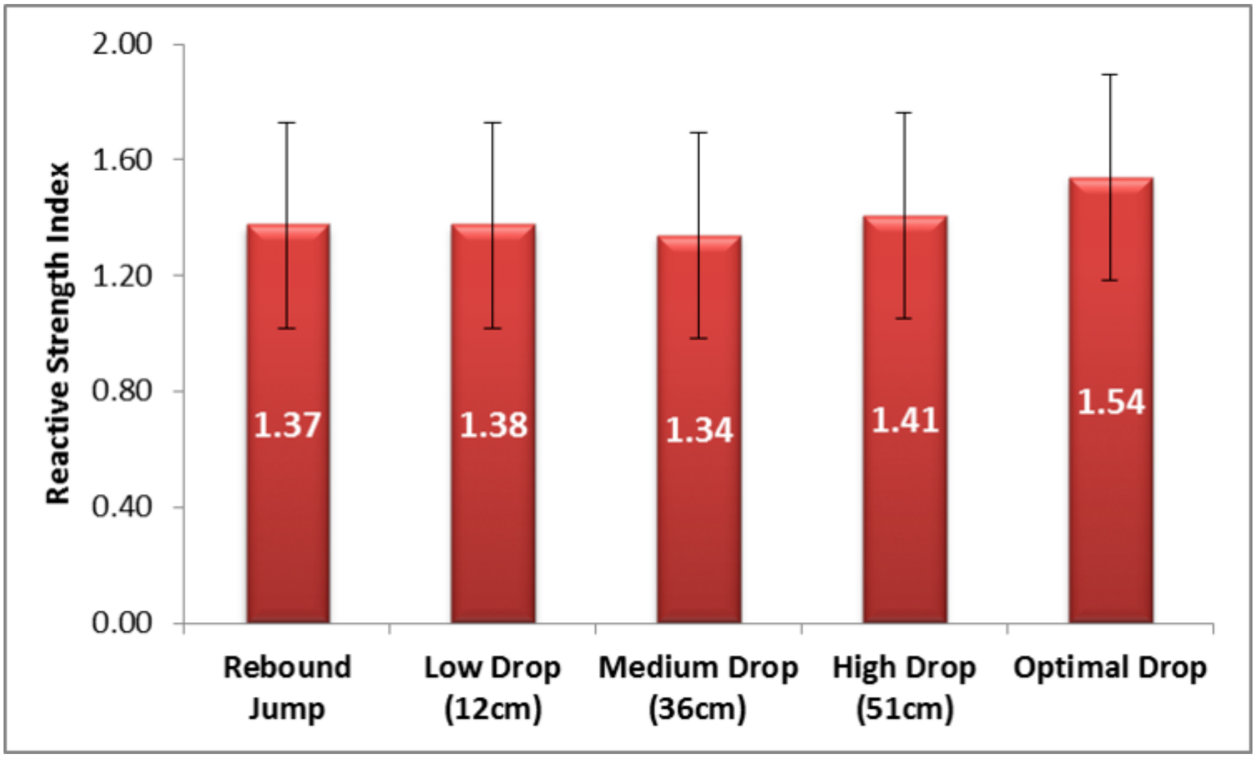

Figure 1: Reactive strength index in the rebound jump vs the incremental DJ-RSI method. Data is from academy rugby players (n = 12; unpublished data)

I should stress at this point that I remain a big fan of the incremental DJ-RSI test. It adds a level of detail and customization to drop jumps which may be a key plyometric exercise in terms of training adaptation (we'll discuss this exercise in more detail in part 3). However, the rebound jump test offers a nice alternative, which saves on time and still allows coaches to collect RSI data on their athletes at key checkpoints in their program. If I was working within a program with very large athlete numbers and I had limited time, the rebound jump would be my choice of test to get a quick benchmark on the athletes' reactive strength levels.

THE 10/5 REACTIVE STRENGTH INDEX TEST

Another option for testing reactive strength is in repeated bilateral hopping tasks. Ultimately there are few athletic endeavours in which success is dependent on a one-off, fast stretch shortening cycle effort. The majority of running based sports are heavily dependent on an athlete's ability to repeatedly produce efficient fast SSC actions. Considering this, testing reactive strength in a repeat effort task seems logical. One option is the 10/5 RSI test. To my knowledge, this test and the method of analysis was originated by Damien Harper of York St. John University in the UK. In this test, like the rebound jump test, the athlete performs a single countermovement jump but upon landing immediately transitions into a series of 10 repeated, bilateral hops. The 5 jumps with the highest reactive strength indices are averaged together for a total score. Harper demonstrated the validity and reliability of this test at the British Associated of Sports and Exercise Science conference in 2011[2].

Having used this test across a number of sports and a range of athletes, it is fast becoming my preferred reactive strength test – especially for those who are not commonly performing drop jumps in their training programs. Athletes pick up the technique of the test quickly – they just seem to "get it". The repeated nature of the hopping is relevant to running based sports in which repeated fast SSC production is key and the test produces very similar reactive strength scores to drop jump testing. The repeated nature of the task possibly allows athletes the opportunity to self-organize and modulate the "stiffness" relationship between the athlete and the ground surface and often you'll observe athletes getting better and better from rep 1 to 10. I have also found that simply taking the last 5 jumps of the test for analysis gives a statistically similar RSI score to selecting the best 5 scores. This makes analysis a little quicker and easier and I believe this is the method that the PUSH device uses in its embedded reactive strength index test. A nice approach when running this test is to give athletes a practice trial in which they are instructed to perform the test with a strong focus on short ground contact times but without worrying about jump height. The results of this practice trial can be reviewed and if the athletes are under the 250ms threshold they then instructed to "maintain those contact times while you now jump as high as possible" following a 3-4 minute rest period. This approach works well to strike the balance between short contact times and maximum effort jump height. As an aside, from my experience athletes are typically well below the 250ms threshold in this test with contact times typically being between 150-200ms.

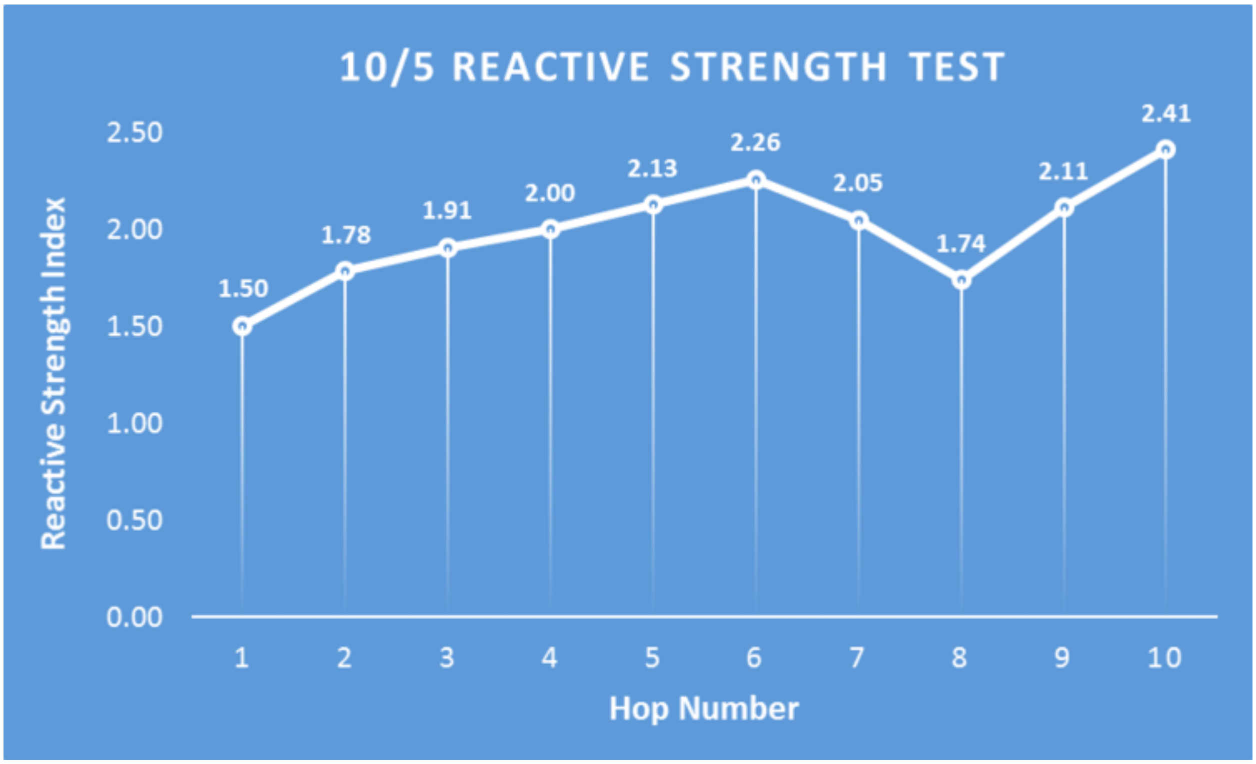

Figure 2: Example data from the 10/5 Reactive Strength Index Test from a winter sport athlete

Hopefully I haven't muddied the water too much by outlining these additional reactive strength testing options. The reassurance for coaches is that each test is valid and reliable and each offers a testing solution depending on the needs of the coach and the athlete. The incremental DJ-RSI test is a more involved test with the highest exercise intensity but it allows for true optimization of a key plyometric training exercise. It's an ideal test for strength and power athletes who want to optimize their high intensity plyometric training. The rebound jump test is a good "snapshot" tool. For coaches working with large groups, who want a quick and easy assessment of athletes' reactive strength abilities, it's a good fit. The "self-selection" of exercise intensity also makes it a good option for novice athletes who may not tolerate the demands of the incremental DJ-RSI test. The 10/5 RSI test offers an alternative to assess reactive strength ability across repeat efforts. It could be a good fit for athletes from running based sports.

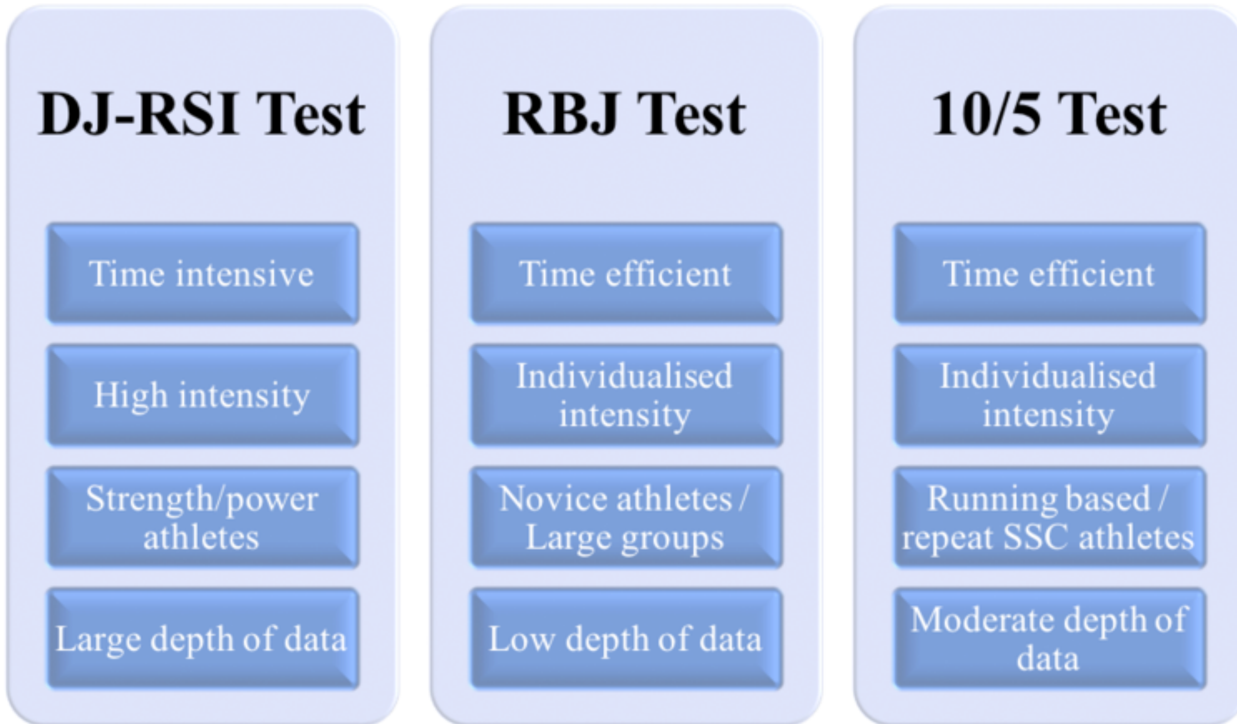

Figure 3: Reactive Strength Index testing options

Surprisingly, despite the increase in use of reactive strength testing, there is limited published RSI normative data. The table below outlines some basic thresholds to help guide coaches' interpretation of RSI results. This is based on my own experience testing RSI across a variety of sports and also based on the limited normative data which has been published in the scientific literature. There are some caveats to this this data. It is based on the assumption that testing is performed without arm contribution (hands on hips) – a higher score is achieved when arm swing contributes to the jumping action. It is based on the RSI being calculated as the jump height (in metres) divided by the contact time (in seconds) as outlined in part 1 of this article series. This is a key point. In some research studies, RSI is reported as flight time (total time spent in the air during the jump) divided by contact time. This give a much larger RSI score than the jump height / contact time method. Both methods are perfectly valid, but result in different absolute values. My preference is the jump height method. I think athletes and coaches alike understand the concept of jump height much more intuitively than a metric like flight time.

Also, coaches should be aware that the ground surface used in testing influences results. More compliant surfaces (rubber matting) produce lower RSI scores in comparison to stiffer surfaces (sprung flooring). These are general thresholds and are based on testing athletes across a spectrum of sports with varying degrees of importance of reactive strength within these sports.

Coaches must think critically about "how strong is strong enough" when it comes to their athletes' pursuit of improving reactive strength. As discussed in part 1, reactive strength testing of this nature is highly ankle-dominant, specifically challenging the calf-achilles muscle-tendon system. A key contribution of reactive strength is to allow impulse generated at the hip and knee to be effectively transmitted into the ground. For many athletes, it doesn't matter how strong or powerful they are at the hip/knee, if they have poor ankle joint integrity and they "leak" force on ground contact. However, the reverse can also be true. Continually targeting reactive strength development in athletes with poor hip/knee strength and power may result in diminishing transfer of training.

Coaches must look critically at the demands of their athletes' sports. For example, sprinters, have a high importance of maximal reactive strength in their event. They transmit huge forces into the ground with every foot strike. Boxers on the other hand may only require a "minimum threshold" of reactive strength and an ability to maintain that reactive strength threshold (or reactive strength endurance) may be of more importance. Coaches must also look critically at their athlete's individual needs. Where are their strengths and weaknesses? Is reactive strength the key area of development or are there other physical characteristics which need to be prioritized? Take the normative data below with a pinch of salt… over time coaches should build up their own reference data relevant to their athletes and the demands of their sport as part of a wider physical capacity assessment.

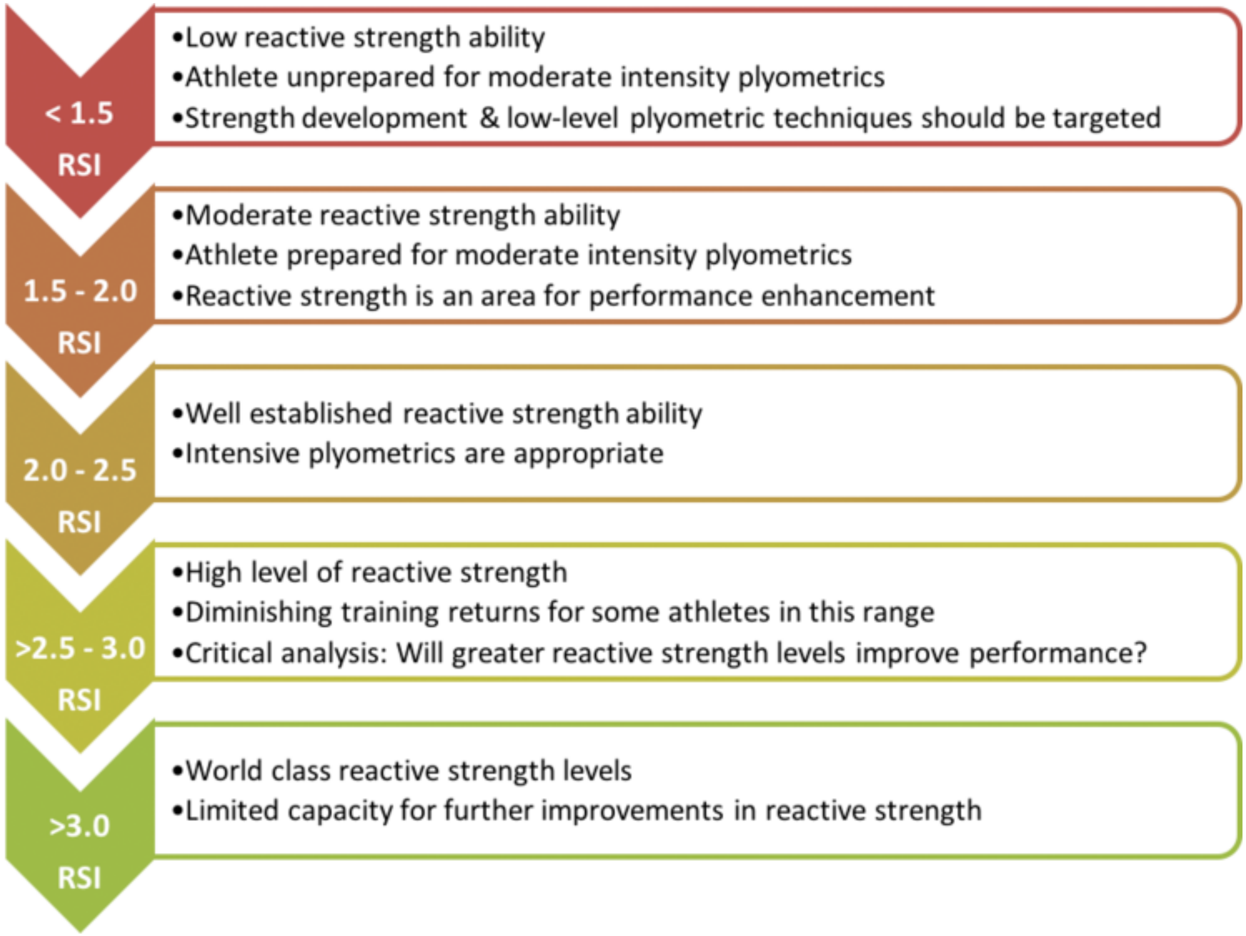

Figure 4: Reactive Strength Index thresholds for the Drop Jump

REACTIVE STRENGTH TESTING AS AN ATHLETE MONITORING TOOL

Increasingly, reactive strength testing has gained popularity as an athlete monitoring tool to assess neuromuscular fatigue. Neuromuscular fatigue is characterized by a reduction in athletes' force and power output capabilities. Reactive strength tests can assist coaches in assessing athletes' fatigue levels, their readiness to train and acute and chronic adaptation to the training and competition process.

Traditionally, simple tests such as the vertical jump or the countermovement jump have been used to investigate fatigue levels. At a simple level, an “outcome” metric like jump height can be measured weekly and coaches can look for peaks and troughs in performance in order to make more educated decisions around training load management. However, there are limitations in the use of outcome measures like jump height. The human body is incredibly adaptable and in times of fatigue athletes can recruit alternative movement strategies to maintain an outcome measure like jump height. For example, under fatigue an athlete may jump as high as usual but they may do so with a different jump strategy. They may move through a longer eccentric phase or may have a delayed transition from the eccentric to the concentric phase. Essentially, there are an infinite number of jump strategies which can be used to achieve similar jump heights. Assessing jump height alone won’t differentiate these different, compensatory jump strategies.

Australian S&C coach and sport scientist Stuart Cormack investigated this extensively across a full season in Australian Rules Football. He measured countermovement jump height and a modified RSI in the CMJ every week across a 22-game competitive season[3]. The modified RSI was more sensitive to change and more representative of neuromuscular fatigue compared with jump height alone. Dave Hamilton, director of performance science at US Field Hockey, has also spoken in depth of his use of reactive strength as a neuromuscular fatigue monitoring tool. In one published research study[4] he examined the response of RSI (via a drop jump test) during tournament match play in youth soccer players. He found significant reductions in reactive strength across the 4-game tournament in players who had high playing time. His research study also suggested that reactive strength monitoring may be sensitive enough to detect disruptions in neuromuscular function in response to extensive travel demands. The soccer players studied had significantly reduced reactive strength ability following a 14-hour, intercontinental travel bout.

Hamilton also presented on his applied work using RSI as a monitoring tool at the 2012 UKSCA conference. As he presented his work with the GB Hockey team in the 4-year period leading up the 2012 Olympics, he further highlighted the usefulness of RSI as a monitoring marker: it is simple, reliable, repeatable and can be performed anywhere, which is a key consideration for teams spending much time “on the road”. The RSI seems to respond to training loads and can be used to potentially highlight athletes who may be close to overtraining. Hamilton has also outlined how the RSI can be a great way to assess the efficacy of tapering or "peaking" strategies. As we back off on training volume in our taper period, are we seeing the associated improvements in neuromuscular function we would expect?

Because a variable like reactive strength looks at both jump height and the time taken to perform the jump (contact time), fatigue has a compounding effect. Small decrements in jump height combined with small decrements in contact time result in significant changes in RSI. It is a sensitive measure which makes it ideal to examine neuromuscular fatigue on an on-going basis. Depending on the circumstances, the DJ-RSI, the rebound jump or the 10/5 RSI test could all be appropriate monitoring tools.

As part of our work with the Irish international junior rugby team, PhD researcher and S&C coach Kris Beattie measured and analyzed DJ-RSI throughout the 2013 Six Nations tournament[5]. We found the metric to be reliable and sensitive to change in an intensive competition period but this research leads us to highlight a couple of key issues to consider when using RSI to monitor athlete's neuromuscular fatigue status:

1) Using the RSI as a monitoring metric will work best with athletes who are regularly completing fast SSC plyometric work in their training programs and are well practiced in the involved techniques. Unpracticed athletes have very "variable" performance from test to test and it can be difficult to differentiate between fatigue and poor technique.

2) For each athlete being monitored, a period of baseline data should be collected and individual thresholds need to be applied to ensure that coaches and athletes are detecting meaningful change and are not being "fooled by randomness". The figure below illustrates how these baselines and individual thresholds can be applied to an individual athlete's data.

3) Fatigue is complex and multi-factorial. It can consist of metabolic, structural, neuromuscular or psychological components. Reactive strength testing provides insight into athletes' neuromuscular fatigue levels but it's not a magic bullet. It should form part of a comprehensive athlete monitoring system, used in conjunction with other appropriate markers.

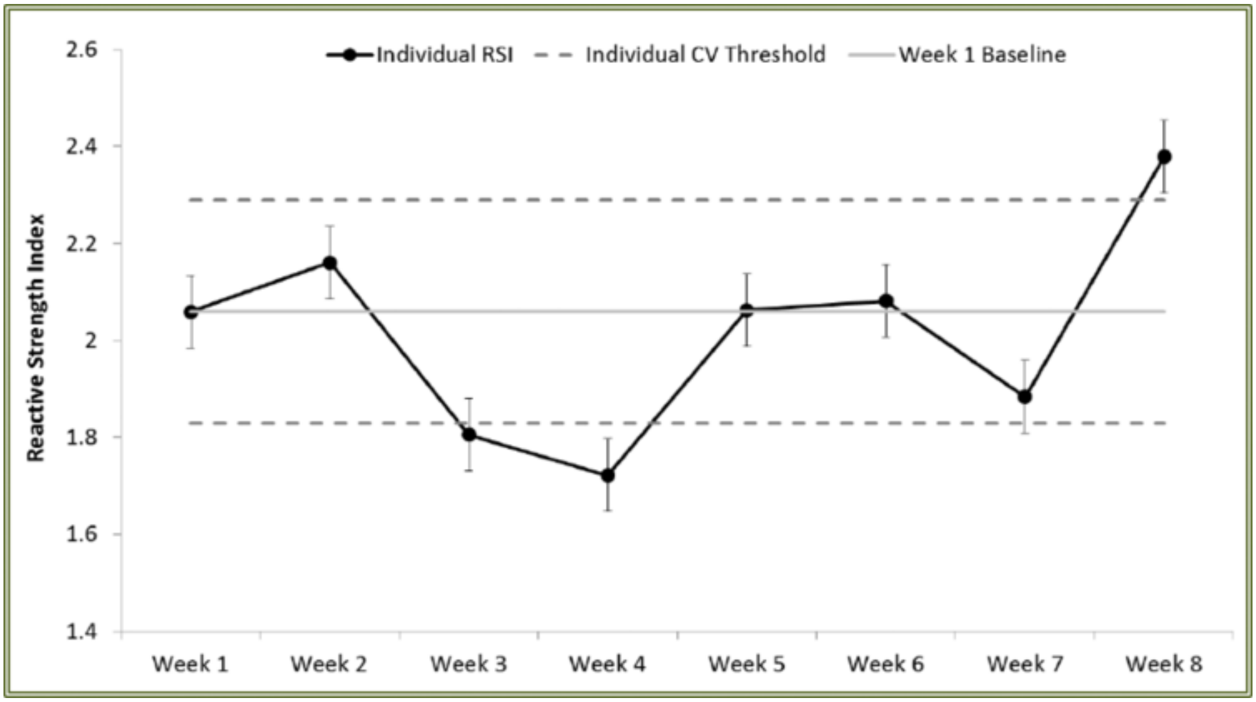

Figure 5: An example of an individual athlete's DJ-RSI and coefficient of variation (CV) thresholds throughout the 8 week competition period. The player shows a meaningful decrease in neuromuscular function in week 4 and a meaningful increase in week 8.

We close part 2 having outlined alternative reactive strength testing techniques to the traditional incremental DJ-RSI test. There are numerous ways to assess reactive strength: coaches and athletes can choose the best fit test for their abilities and circumstances. While reactive strength is a key part of the athlete performance profile, it should be considered a "part of the whole" and coaches must look critically at their athlete's individual needs before aggressively pursuing reactive strength improvements. In part 3 we will look at the relationship between maximal strength and reactive strength and look at how we can progress from low-intensity plyometric training to more specialized, high-intensity reactive strength training techniques. We'll also try to shed some light on the specificity of plyometrics and the transfer of training effect to sporting performance.

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