Repeated-Sprint Ability: Where Are We?

Brian Dawson

Repeated-sprint ability (RSA) is now well accepted as an important fitness component in team-sport performance. It is broadly described as the ability to perform repeated short (~3–4 s, 20–30 m) sprints with only brief (~10–30 s) recovery between bouts. Over the past 25 years a plethora of RSA tests have been trialed and reported in the literature. These range from a single set of ~6–10 short sprints, departing every 20–30 s, to team-sport game simulations involving repeating cycles of walk-jog-stride-sprint movements over 45–90 min. Such a wide range of RSA tests has not assisted the synthesis of research findings in this area, and questions remain regarding the optimal methods of training to best improve RSA. In addition, how RSA test scores relate to player “work rate,” match performance, or both requires further investigation to improve the application of RSA testing and training to elite team-sport athletes.

**Keywords:** team sports, recovery, training, testing

In 1976, the late Tom Reilly and his colleague Vaughan Thomas reported that the ability to perform repeated maximal short-duration sprints during a game is an integral fitness component in team sports. However, back then, no tests of repeated-sprint ability (RSA) had been developed. In 1984, as young and enthusiastic sports scientists, we trialed what we tentatively termed the Phosphate Recovery Test, which was designed to evaluate a player’s ability to repeatedly produce short-duration, high-intensity efforts, interspersed with brief recovery periods. The test involved 20 × 7-second running sprints, on a departure time of 30 seconds. We reasoned that the test would stress the phosphate energy system and the associated recovery mechanisms necessary to allow repeated short-duration, high-intensity efforts, as research into the physiology and metabolism of RSA had not yet been conducted. We continued to tweak the test over the next few years, slowly coming to understand some of its flaws and shortcomings, and by 1991 we had revisited it, presenting evidence of pacing (necessary to survive the test in its initial format!) and high blood lactate accumulation (13–14 mmol/L) as inevitable consequences of the high number of sprints (20) and duration (7 s) involved. Our suggestion was to modify the test back to 8 to 10 sprints of 5 seconds duration (or 30- to 35-m distance) departing every 30 seconds and to include a “% decrement score,” along with a total score for the test, to rate player performance. This type of test format is similar to what is commonplace today in RSA testing, with increased knowledge of sport-specific movement demands from time-motion studies providing good scientific rationale for deciding on sprint times (or distance), length and type (active or passive) of recovery, and total number of sprints to be performed. Time–motion data from many team sports have also been used to develop game-simulation exercise protocols lasting up to 90 minutes, involving repeating cycles of walk-jog-stride-sprint activity and, in some cases, sport-specific skills.

**Repeat-Sprint/Effort Tests**

The eminent 19th-century scientist, Lord Kelvin, has the following quotes attributed to him: “To measure is to know” and “if you cannot measure it, you cannot improve it.”

In the 1980s and 1990s some further research into the physiology and testing of RSA was done, with 5 to 10 × 6-second running (~35–40 m) and cycling sprints departing every 30 to 36 seconds being most popular. These early studies showed that RSA tests of this type required significant energy contributions from the phosphate, anaerobic glycolytic, and aerobic systems and that high muscle (>100 mmol/kg DM) and blood lactate (12–17 mmol/L) levels were recorded. Results also suggested that anaerobic power scores were major determinants of total RSA scores (repeated power or speed) and that aerobic power was more closely associated with % decrement scores (recovery between sprints).

In the 2000s, research into RSA gathered considerable pace and new tests were developed, replicating the specific time–motion data now available on a range of team sports. Spencer et al provided compelling data about the duration and number of sprint efforts typical in international field hockey matches. Mean sprint duration was 1.8 ± 0.45 seconds and the mean number of sprints in a game (71 min duration) was 30 ± 14, which produced a mean recovery time between sprints of ~2 minutes.
However, these “average” time–motion values are of limited value, as team sports have a completely unpredictable nature, with sprinting requirements unevenly distributed throughout a game. Here, repeated sprint “clusters” were defined as a minimum of 3 sprints, with a mean recovery period between sprints of less than 21 s, which were found to occur 17 times during a game. Preparing for the “worst case scenario” likely to occur in a game intuitively makes more sense for testing and training RSA than using average values. In this study, on 4 (of 17) occasions repeated sprint clusters comprised 6 or 7 sprints, mean maximal sprint duration was 4.1 ± 2.1 s, ~25% of the time intervals between sprints were <21 s, and 95% of recovery time between sprints was active in nature.5 These data were used6 as a basis for the development of an RSA test for field hockey, comprising 6 × 30-m (~4 s) running sprints, with an active jog recovery between, departing every 25 s. This test format appears suitable for use with other sport teams, which have similar time–motion data.7,17,18

Notwithstanding the findings of Spencer et al,5 it is evident that there are currently many variations of RSA tests in the literature. Broadly, 3 main formats have been used (sport-specific skills such as passing and shooting accuracy, jumps, and changes of direction are sometimes included, especially in multiple-set/match-simulation tests):

- **Single-set tests (short duration: 3–5 min):** 5–15 repetitions of 3–6 s duration (15–40 m) departing every 20–30 s with active recovery between13,16,19–22
- **Multiple-set (3–5) tests (medium duration: 15–40 min):** 5–10 repetitions of 3–6 s duration (20–40 m) departing every 20–30 s in “hard” sets, sometimes alternated with “easy” sets, departing every 60–120 s, with active recovery between23–26
- **Match simulations/Multiple-set (6–10) tests (long duration: 45–90 min):** Repeated cycles or sets of sprints of 3–6 s duration interspersed with walking–jogging–striding (running) or prescribed power outputs (cycling), departing every 60–120 s, often split into 4 × 15- to 20-min quarters or 2 × 30- to 45-min halves8–10,27–31

Having such a wide range of sprint and recovery times, sprint and set numbers, and overall test durations has no doubt complicated this area, confounding the interpretation of the research findings. In selecting an RSA test for use in experimental work, researchers should carefully consider their questions and aims and decide whether these are best evaluated by a short-, medium-, or long-duration RSA test. If the focus is on a “pure” assessment of RSA, perhaps before or after a training program, it is suggested that a single set test of the type trialed by Spencer et al16 would be preferred. Alternatively, if the focus is on a team-sport match simulation, where the effectiveness of an intervention (eg, precooling/heat acclimation27,32 supplements such as caffeine,10,23,24,33 creatine,28 and bicarbonate34; preexercise stretching25,26; or postexercise recovery procedures19,35) is being evaluated, multiple sets across a medium or long duration may be more appropriate, so that a half- to full-game scenario is replicated. In these types of tests the energetics and metabolism will be different from single-set RSA tests, as multiple set or match simulations often allow longer (~60–120 s) recovery periods between sprints, meaning that less acute challenges to homeostasis are likely with regard to phosphocreatine degradation and resynthesis, anaerobic glycolytic energy contribution, and muscle/blood pH and lactate changes. Performing multiple sets or cycles over medium to long durations, especially when interspersed with lower intensity (aerobic) exercise, will increase the overall aerobic energy contribution, as well as the opportunity (or risk?) of “pacing” in the test. The physiology and metabolism of single-set RSA tests has reasonably well investigated,11,12,15,36–39 but much less is known about multiple-sets or match simulations,8,9 which remain a fertile area for future research.

In parallel with a wide variation of existing RSA test formats, the scoring of these tests has also been somewhat variable. The most common scoring methods are shown in Table 1. An overall test score, where every sprint performed is counted in the final score, is recommended as the primary result. Whether this is calculated as a total sprint or mean sprint score may not matter too much in regard to interpreting the test results. Similarly, a percent decrement score in which every sprint is counted13,16,22,31 is common and preferred to a change (fatigue) score between first and last sprints.41 as these may not necessarily be the best and worst efforts. However, total or mean sprint scores have been shown to have much smaller coefficients of variation and typical error values than percent decrement and fatigue scores,8,31 which may range from 10% to 50%.30 Therefore, the usefulness of these scores

### Table 1 Common Scoring Methods in Repeated-Sprint-Ability Tests

<table>
<thead>
<tr>
<th>Method</th>
<th>Examples</th>
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<tbody>
<tr>
<td><strong>Overall test scores</strong></td>
<td>Total sprint time/work: sum of time/kJ for every sprint done,13,16,19,24,28</td>
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<tr>
<td></td>
<td>Mean sprint time/power: average time/W for all sprints done,10,22,29–31</td>
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<td></td>
<td>Best/first sprint time/work: often used in studies using multiple sets or a nutritional/exercise intervention,22,25,26,40</td>
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<td><strong>Decrement scores</strong></td>
<td>% decrement A: total sprint time/work divided by “ideal” total × 100. Ideal total is best sprint score × number of sprints in a set,13,16,37,38</td>
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<td>% decrement B: mean sprint time/work divided by best sprint × 100 (– 100),22</td>
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<td></td>
<td>% decrement C: % change from first to last sprint in each set,41</td>
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in interpreting RSA test performance and improvement has been rightly questioned. In match simulations the long duration and large number of sprints will likely increase the element of "pacing" for participants, which may promote "first" and "best" sprint scores as useful data for this type of test, although an overall total (or mean) sprint score, based on as many sprints as possible (as not all may be measured), should still be calculated.

**Where Next?**

The popularity and profile of team sports throughout the world ensure that RSA will continue to be an important exercise model for future research. A compelling question is whether RSA (as measured by single set, multiple sets, or match simulations) relates well to team-sport performance (in an overall sense) or only to work rate. Indeed, whether player work rates or movement patterns are strongly related to individual and/or team performance is intriguing, as greater work rates are often not associated with more successful individual or team performance. Incorporating skill and decision-making assessments in RSA tests, as has been done recently, has intuitive appeal and represents a good way forward. The link between single-set RSA performance and medium- and long-duration multiple-set/match-simulation test scores also requires more investigation, as do RSA relationships with actual team-sport competition performance. Data on RSA and Yo-Yo Intermittent Recovery Test (level 2) test scores in elite team-sport populations should also be collected; if a strong relationship is demonstrated, one or the other of these tests may not be necessary in team-sport fitness-testing batteries.

The other compelling question about RSA is what sort of training it will improve most. Previously, 6 weeks of short-sprint (<80 m) training significantly improved 6 × 40-m (departing every 30 s) RSA performance, and 5 weeks of high-intensity interval training (2-min efforts, 1-min recoveries between) improved cycle 5 × 6-second (departing every 30 s) RSA test performance more than moderate-intensity continuous training. In addition, 12 weeks of specific repeated short-sprint (20 m) training, but not high-intensity interval training, improved 6 × 40-m (20-m shuttles, departing every ~25 s) RSA performance. More recently, 4 weeks of sustained (30-s) sprint training did not improve 6 × 30-m (15-m shuttles, departing every ~25 s) RSA performance, whereas short-sprint/ agility (5-s efforts) did improve it. These studies suggest that repeated short-sprint efforts over 4 to 12 weeks can improve single-set RSA performance, but much more research is needed before any definitive conclusions can be made. Future studies should explore training effects in medium- and long-term (as well as single-set) RSA tests, perhaps with skill and decision-making tasks embedded in them, and also examine the physiology and metabolism (especially the aerobic energy contribution) of these multiple-set RSA tests and match simulations.

### References

15. Hamilton AL, Neville ME, Brooks S, Williams C. Physiological responses to maximal intermittent exercise: differences between endurance-trained runners and...


