Journal of Strength and Conditioning Research, 2004, 18(3), 579–583

THE EFFECTS OF ENFORCED, RAPID DECELERATION ON PERFORMANCE IN A MULTIPLE SPRINT TEST

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ABSTRACT. Lakomy, J., and D.T. Haydon. The effects of enforced, rapid deceleration on performance in a multiple sprint test. *J. Strength Cond. Res. 18(3):579–583. 2004.*—The nature of multiple sprint sports such as soccer, hockey, and rugby is such that deceleration plays an important part in the movement patterns of players during a game and training. The purpose of this study was to investigate the effect of deceleration on fatigue during repeated sprint efforts. A group of 18 elite field hockey players (all men) performed a running repeated sprint ability test (6 × 40 m using maximal effort and departing every 30 seconds). In one condition, there was no deceleration zone, and in the second condition, the test had a deceleration component (rapid deceleration to a stop within 6 m of the end of each sprint). Sprint times under each condition were compared using a repeated-measures analysis of variance. No significant difference was seen between the 2 conditions for mean sprint times ($p > 0.05$) or for the mean fatigue index ($p > 0.05$). However, results showed a divergent trend, and further analysis extrapolating the data for an increased number of sprints showed that a significant difference ($p < 0.05$) would have been seen at the 11th sprint. Although this study found that the deceleration zone had little effect on the 6-sprint protocol, it was clear that the deceleration component would have shown an effect, giving rise to greater fatigue and slower sprint times, if the number of sprints had been increased. The implications are that deceleration training should be introduced into general fitness training programs for those competing in multiple sprint sports.

KEY WORDS. high-intensity exercise, eccentric contraction

INTRODUCTION

Sports such as rugby, soccer, tennis, netball, and hockey, as stated by Fitzsimons et al. (10), require short-duration (5–7 seconds) maximal or near-maximal sprints to be regularly repeated for an extended period (70–120 minutes). For example, during a football match, 100 or more sprints may be necessary (9, 10). Fitzsimons et al. (10) go on to state that, because of the nature of these sports, the intensity and duration of the recovery period between sprints are variable. Therefore, the more skillful individual sports and team games present the researcher with more complex problems, because the physiological demands and the fitness required are not so easily determined. There is also the repetitive need to decelerate quickly or to slow down to change direction slowly during these types of sports.

In these sports, the exercise pattern is characterized by repeated short-duration bouts of high-intensity exercise interspersed with longer periods of lower-intensity exercise and passive recovery (4). These sports have been collectively referred to as multiple sprint sports (15). The physiological demands of multiple sprint sports must be understood if performance and training are to be optimal. However, a realistic measurement of the demands of multiple sprint sports is difficult. Play is composed of repeated accelerations, decelerations, turns, and jumps, and tasks that involve both the upper and lower body. Such complexity is not easily reproduced in the laboratory. Therefore, previous authors have suggested that an important fitness component of these types of sports is what is termed repeated sprint ability (RSA) (8, 10). Fitzsimons et al. (10) specifically state that players who can regularly repeat sprint efforts of the same or very similar intensity and quality will be likely to perform better than players who are unable to maintain the RSA levels that are near their best due to fatigue. Furthermore, they claim that an RSA test will challenge the energy systems in a manner that closely replicates the game situation.

Much of the work on RSA comes from Dawson et al. (8) and Fitzsimons et al. (10), who have looked more specifically at the relationship of RSA to aerobic power and performance and the effects of oral creatine supplementation on single and repeated maximal short sprints. Dawson et al. (4) developed the original RSA test, but it was limited to a forward sprint with a tapering down at the end, with no accounting for the impact of deceleration or changing direction. Even though multiple sprint performance has been shown to decay as fatigue occurs (2, 5, 11, 13, 16), the effects of deceleration on multiple sprint ability are not as well researched. The purpose of this study was to investigate the effect of deceleration on fatigue during repeated sprint efforts, particularly since deceleration is an important aspect in the game of field hockey and has the potential of being greatly damaging to muscles. The effects of the deceleration component not only may cause a decrement in performance, but may also increase the potential for injury, neither outcome of which is desirable. Because of studies that have noted the effects of eccentric contraction (3, 14), the current authors predicted that the huge loading of eccentric contraction during a rapid deceleration will affect the rate of fatigue in the muscles and have a detrimental effect on sprint performance during an extended number of efforts.

METHODS

Experimental Approach to the Problem

The goal of the current study was to investigate whether deceleration has an effect on fatigue during multiple sprint efforts. A previously devised (8, 10) RSA test (6 × 40 m), which, at that time, was used by the Great Britain (GB) Men's and Women's field hockey teams (N. Kelly, personal communication, September 2001), was used as the basis for the experimental protocol. Using this already established test allowed a comparison of data from the current study with that from previously published work and any norms and standards found from testing

GB International players. The procedure has already been shown to be an accurate measure of speed endurance, with particular emphasis on performance detriment due to fatigue (10). The current 6 × 40-m protocol has also been shown to have good test-retest reliability ($r > 0.85$) (10). The 40-m distance was deemed reflective of the sprint nature of the game of field hockey, given that sprinting within the game is of relatively short duration and that players rarely sprint for long distances and so do not tend to achieve top speed. Six sprints were used in the present study because it has previously been found, in tests of the same or a similar nature (e.g., 10 × 6 seconds with a 30-second recovery), that this number of sprint repetitions (or fewer) result in a measurable performance decrement (2, 10, 13).

The deceleration condition was achieved by giving players a 6-m zone immediately at the end of the 40-m sprint within which to stop. Following pilot trials with different stopping distances, 6 m was chosen as the best distance to reflect the nature of the game, which requires quick stops and changes in direction. During piloting, it was also found that shorter stopping distances tended to deter players from sprinting maximally during the sprint itself, so that they could better facilitate the upcoming stop. All other variables were held constant or controlled; for example, subjects participated in no exercise 24–48 hours before each test, tests were run at the same time of day, and carbohydrate loading was undertaken during the 24-hour period before each test. The warm-up was monitored to ensure that the intensity of the activity was low, so that the athletes would avoid high levels of lactic acid before the start of the sprints. The only variable of concern was the weather, which was very changeable. To account for this, the test was conducted on days when the overall weather conditions were very similar, including temperature and wind strength.

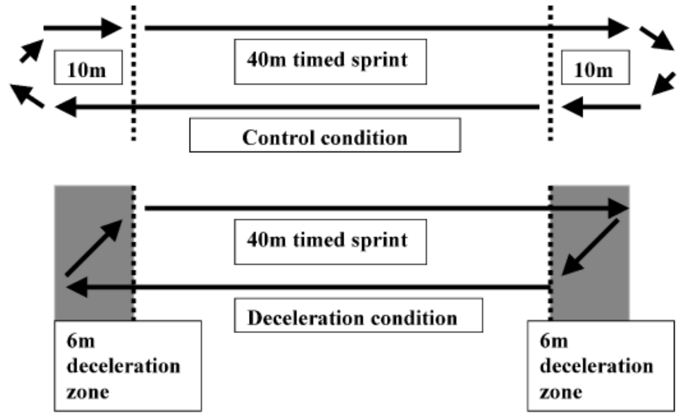

FIGURE 1. Schematic of protocol.

Subjects

Eighteen men (mean ± *SD:* age = 24.4 ± 3.8 years; height = 179 ± 5.3 cm; weight = 76.7 ± 3.9 kg) took part in this study. All of the subjects were members of a Premier National League field hockey team; they therefore trained and competed regularly. The sprint tests were all completed during the first half of the playing season, when players were involved in regular matches and training sessions each week. In addition, all players had completed preseason fitness training.

All subjects gave their informed consent and volunteered to take part in this study, which was approved by the local Research Ethics Committee.

Testing and Procedures

Each subject was labeled with a number and then organized into a randomized test order and allocated randomly to one of two groups of 9 participants. During week 1, the first group of participants completed a standard 6 × 40-m repeated sprint protocol from a standing start, with a 30-second rest between each effort on a sand-based astro turf. After reaching the final gate, the subjects were required to jog around a stationary cone 10 m from the final gate before lining up for the next sprint, as shown in Figure 1. The times for each complete sprint were measured using the Eleiko Sprint Timing System.

During week 1, the second group of participants completed the same sprint protocol with a 6-m "deceleration zone" added to each end of the final timing cells. The subjects were required to complete the sprints with the added dimension of stopping within the confines of the 6-m deceleration zone. Sliding and skidding movements with flat soles were verbally forbidden, and a warning was issued if they occurred, to ensure that the specific act of deceleration was held constant.

The procedure was repeated 1 week later, with all variables held constant. The crossover design meant that the subjects participated in the opposite condition during the second week.

Statistical Analyses

A repeated-measures analysis of variance was used to determine whether deceleration had a significant effect on fatigue and performance during repeated sprints. A fatigue index (FI) was calculated by establishing the % decrement score for the 6 efforts. This standard measure of FI (8) is also used by the English (Field) Hockey Association in its analysis of International players (N. Kelly, personal communication, September 2001).

T-tests were used to determine differences between conditions for any given sprint. Significance was accepted using an a priori level of $p \leq 0.05$. Further analysis was carried out to determine the linear correlation for the sprints in order to extrapolate hypothetical times for an increased number of sprints and to establish at what point (sprint number) a significant difference between the protocols would be found.

RESULTS

The mean ± *SD* sprint times for the 18 participants, for each of the sprint repetitions in both experimental conditions, are shown in Figure 2. The mean FI across participants, in each protocol, is shown in Figure 3.

There was no significant difference ($p > 0.05$) between the mean times for the first sprint for the 2 conditions. This indicates that the subjects started the test with a similar performance and effort and therefore provided a baseline for further analysis. The fastest mean times were achieved during the first sprint (5.82 ± 0.54 seconds), after which there was an increase in sprint times.

For the control condition, the time for sprint 1 was significantly different from that for sprints 4–6 ($p < 0.01$) but was not significantly different from that for sprints 2 and 3 ($p > 0.05$). This indicates that it was not until the fourth sprint during the multiple sprint efforts that a sig-

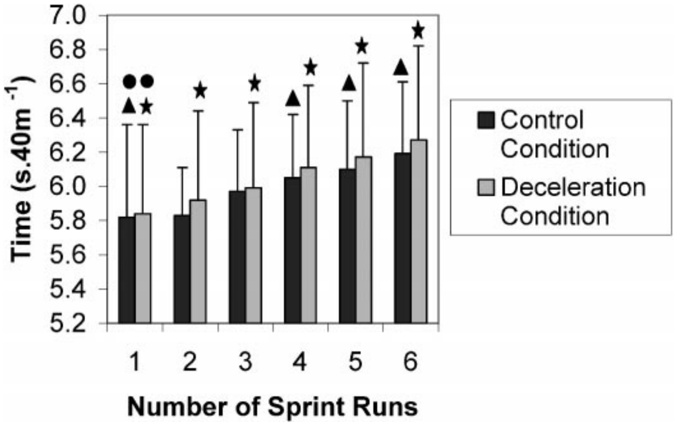

FIGURE 2. Mean repeated sprint times. Values are mean ± *SD*; $n = 18$. (▲) Sprint 1 was significantly different ($p < 0.01$) from sprints 4–6 in the control condition. (★) Sprint 1 was significantly different ($p < 0.05$) from sprints 2–6 in the deceleration condition. (●) There was no significant difference ($p > 0.05$) between the 2 conditions for any of the sprints, e.g., sprint 1 in control vs. sprint 1 in deceleration protocol.

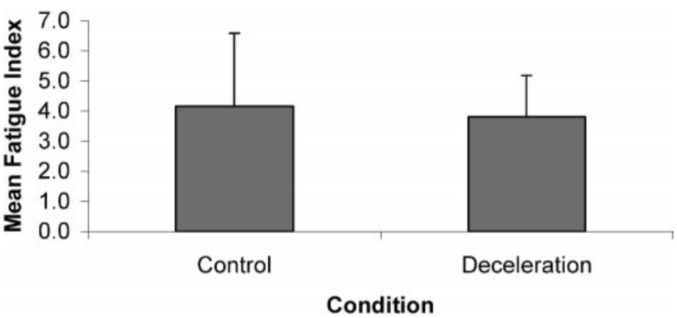

FIGURE 3. Mean fatigue index (%). There was no significant difference ($p > 0.05$) between the 2 protocols.

nificant decrease in performance was shown. The deceleration condition showed that sprint 1 was significantly different from all the other sprints (i.e., sprints 2–6) ($p < 0.001$), with sprint 2 being significantly different from sprint 1 ($p < 0.001$). This appears to indicate an earlier onset of fatigue for this type of effort. A comparison of the times for each condition for any given sprint number (1–6) showed no significant difference ($p > 0.05$).

Each subject's best 40-m sprint time for each protocol was identified (t_{ideal}) and used in the FI calculation. All participants except for one performed their best time during the first sprint. From the individual FIs calculated, a mean FI across all participants was calculated for each condition. The mean FI scores for the control and deceleration protocols of the repeated short sprint test were 4.15 ± 2.44% and 3.80 ± 1.38%, respectively. These composite measures are shown graphically in Figure 3. There was no significant difference between these mean FI scores ($p > 0.05$).

Although the sets of 6 sprints did not show a significant difference in FI between the control protocol and the deceleration protocol ($p > 0.05$), there did appear to be a trend toward significance as the number of sprints increased. Figure 4 shows that there was a high linear correlation ($R^2 = 0.9926$ for the deceleration condition and $R^2 = 0.9703$ for the control) of mean sprint times across

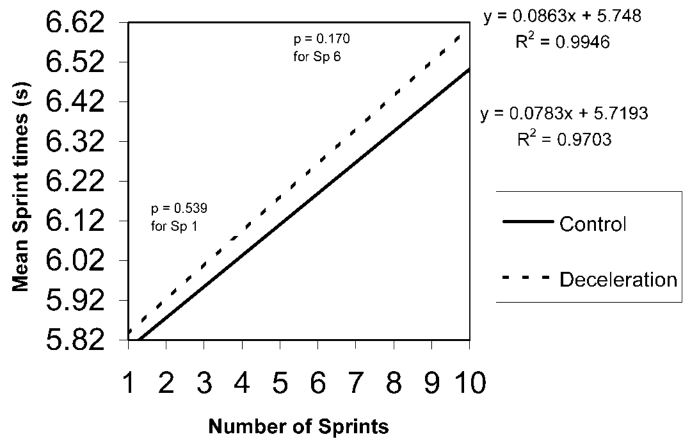

FIGURE 4. Regression lines and projected times for the repeated sprint conditions.

the number of sprints for both conditions and a divergence between the 2 lines. This suggests that if the linear correlation were continued for additional sprints, the difference would become significant. In fact, *t*-tests conducted on hypothetical times using linear extrapolation of player times for each condition showed that significance would have been established ($p < 0.05$) at the 11th sprint.

In summary, the study did not show that the deceleration protocol had a significant effect on fatigue and performance during this 6 × 40-m repeated sprint protocol. However, the results showed a trend toward significance, which was confirmed when a regression analysis was performed. With a greater number of subjects or a greater number of sprints, it appears that the deceleration would have a significant effect.

DISCUSSION

Comparisons with previous studies (6–8, 10) demonstrate the validity of the results obtained in the current study. The control condition in the current study did show predictable fatigue but to a lesser extent than that measured in other studies (8, 10). When mean sprint times are considered, the current study also confirms a general trend toward slower times with each sprint (Figure 2).

The differences between the current study and previous studies (8, 10) are shown as lower mean sprint times and a consistently lower mean FI. This indicates that the subjects in the current study were faster for the sprints individually and that the multiple sprints had less of a fatigue effect. An FI of approximately 5.6% was previously reported (8), whereas in the current study, this figure was lower, being recorded at 4.15% (Figure 3). This could be explained by the nature of the subjects involved in the experiments. Previous studies (8, 10) used amateur-level team sports players as their subjects, whereas the present study used elite players who were training and competing regularly at a national level. The elite players, through their increased involvement in the activity and also through the adaptations they have developed both physiologically and metabolically, could be expected to display less pronounced effects of fatigue than amateur-level sports people when tested using the same protocol designed to induce fatigue.

The FI, according to Fitzsimons et al. (10), is an indirect comparison of every other individual repetition score to the best score; therefore, they state that it is a measure of the subject's ability to repeat sprint efforts at or near their maximum. As such, they claim that it is a measure of the subject's consistency of effort and that it seems to relate more to the ability of the muscle to recover quickly from short maximal efforts. There may be many contributing factors; for example, Fitzsimons et al. state factors such as the rate of adenosine triphosphate (ATP), creatine phosphate, and myoglobin resynthesis; the amount of ATP generated by glycolysis; muscle oxidative and buffer capacity; and muscle fiber type (10). In RSA tests, the athlete not only has to produce high power from anaerobic sources to perform an individual sprint well, but also needs to be able to repeat those efforts again and again in order to produce a consistently high-level performance overall. Such consistency would be measured by a low FI (10). It has been stated, however, that subjects who have good endurance ability, but are less powerful, have a lower FI score, too, but relatively higher sprint times (5, 8, 10). Conversely, Fitzsimons et al. (10) state that many faster sprinters, who possess good anaerobic power, score well on the sprint times but have high FIs. Similar to the trends suggested by Fitzsimons et al., the trends in the current study may reflect the fiber type distribution (i.e., percentage of type I and II fibers) of the subjects in the current study or their training, which has affected the fatiguing nature of their fibers.

The impact of rapid deceleration on fatigue is not well documented, but evidence in muscle physiology, fatigue, and eccentric muscle contraction studies (3) suggests that fatigue should be exacerbated by rapid deceleration. Therefore, it was expected that the deceleration condition would induce significantly higher FIs. Although the impact during the 6 × 40-m protocol has not been demonstrated to be statistically significant in this study, the results do indicate that, with more sprints or more subjects, it might become significant. There are a number of possible explanations for this. The results cannot be attributed to a learning effect, as a crossover design was in place to negate these potential effects.

One of the explanations for the lack of statistical significance is that the subjects involved in the present study were elite field hockey players who are used to training and competing regularly in a multiple sprint sport, which includes many decelerations and changes in direction. It could be argued that the participants of this study were used to the actions of rapid deceleration and stopping through their rigorous training and that they have developed a protection that shows no difference in performance during the course of six 40-m sprints with a short recovery. The subjects involved in the current study were effectively "trained" through their involvement in field hockey and its subsequent decelerations, rapid stops, and changes in direction. Adaptations are likely the result of eccentric exercise (12), and the subjects involved in the current study may have developed an immunity to the fatiguing effects of rapid deceleration during a small number of sprints. This could explain why the 6 × 40-m sprints had no effect but why greater numbers of sprints are projected to have an effect. It may be that fatigue is inevitable, despite the apparent adaptations to eccentric exercise, but the onset of fatigue is seen only in later sprints. This may have implications on the future use of this particular RSA test. It may be beneficial to have more than 6 sprints or even more sprints of a distance shorter than 40 m. It may be that the 6 × 40-m sprints departing every 30 seconds are ideal for amateur-level athletes, but, to facilitate a differentiation between the performances of elite athletes, a more demanding protocol must be introduced.

The results do suggest that the trend for the sprints was toward significance, indicating that a greater number of sprints would make the deceleration component produce significant decrements in performance and increases in fatigue (Figure 4). The extrapolation of the current data beyond the sixth sprint assumed that the performance response to fatigue was linear; however, this assumption must be validated in the future for a field test such as this. A previous study (1) that conducted an 8 × 40-m repeated sprint test to examine the effects of creatine supplementation found, even with the control condition, that sprints 7 and 8 were not substantially increased from sprint 6. This may indicate that there is a plateau after 6 sprints when the decrement in performance is not as pronounced and may raise questions about the linear extrapolation protocol used in the present study. On the other hand, in the deceleration protocol, there could be the opposite effect, with extreme performance deterioration due to fatigue. Therefore, an investigation of a field protocol similar to that in the current study but with an increased number of sprints is still required to substantiate the projections made in this study.

The current study may have limitations in its direct application to sport. For example, although the 6 × 40-m sprint test could be argued to be a sufficient test of RSA, it is not a true depiction of a multiple direction sprint sport such as hockey. It may still, however, provide a useful insight into the effects of an important component of sporting performance on multiple sprint sports (i.e., the effect of deceleration). A further area of study that would be useful to examine would be "acceleration deceleration directional changes," which take into account other elements of a multiple sprint sport such as hockey or soccer. However, the current 6 × 40-m protocol has been shown to have good test-retest reliability ($r > 0.85$) (10), although it does not take into account changes in direction. Although the impact of deceleration studied in the current experiment represents an advancement toward the goal of incorporating changes in direction into this protocol, it is a very early step in understanding the full requirements of multiple sprint sports. The current authors agree with Fitzsimons et al. (10) in their statement that, although the test does not specifically imitate match activities—such as contesting a ball, tackling, running, kicking, sudden changes in direction, or all-out sprinting, all of which are repeated several times with limited recovery between efforts—it is thought to challenge the energy systems in a manner typical of many sports. It would be relatively easy to create specific RSA formats tailored to individual sports—for example, running between the wickets in cricket.

The subjects who are being examined in an RSA test may require different test protocols and parameters, depending on the sport. However, without up-to-date and sufficient knowledge of the exact time-motion requirements for a variety of repeated sprint sports, adapting the RSA test to the various sports is difficult. For instance, it is necessary to analyze the distributions of sprints, decelerations, changes in direction, and rest periods in hockey, as these factors may have implications for the training for such a sport. The work-to-rest ratio could be changed from the current 1:5 and perhaps the incorporation of a different rest interval with a subsequent increase in the number of sprints is necessary.

PRACTICAL APPLICATIONS

The findings of the present study confirm that rapid deceleration between multiple sprints has a detrimental effect on performance. Since deceleration is an important component within multiple sprint sports such as field hockey, there is clearly a need to further investigate whether this deceleration component can be trained or not. Current training programs rarely systematically and explicitly factor in a deceleration component unless it is part of a directional change task or circuit type activity. All too often, an improvement in speed and acceleration is the focus of a training program rather than the ability to effect rapid breaking. If deceleration can indeed be trained for, then this component should be explicitly incorporated into a training program. Investigation into what forms such deceleration training should take was beyond the scope of the current study, although they will most likely require a greater exposure to deceleration activities than those experienced during the 6 × 40-m test used in this study.

A planned preparatory training program, as stated by Green (12), should include periodic and systematic exposure to activities that demand the generation of large forces to stimulate adaptations in the cytoskeletal framework. Green further states that for this type of adaptation to be transferable to a specific task, care must be taken to incorporate high-force activities that fully exploit the muscles and motor units, the range of motion, and the contraction velocity typical of the task. Therefore, players of repeated sprint sports that involve decelerations and changes in directions may need to train specifically for deceleration and changes in direction. Deceleration training should be introduced into general fitness training for multiple sprint sports because of the apparent adaptations that muscles make and the detrimental effect that deceleration has on the rate of fatigue.

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