The Influence of Various Recovery Modalities on Performance Tasks in Basketball Players

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ABSTRACT:
This study aimed to investigate the effectiveness of three recovery strategies during high-intensity intermittent exercise. Nine male basketball players (age, 23.11 ± 2.8 years; height, 1.83 ± 0.1 m; body mass, 81.87 ± 11.2 kg) completed a series of 3 randomized trials. Each trial consisted of a basketball exercise simulation test (BEST), a series of performance tests, one of three recovery modalities, and a subsequent series of performance tests. The performance tests included the agility test, a maximal vertical jump test, and a line drill test. Furthermore, participants were also asked to rate their perception of fatigue using a 0-10 scale prior to each series of tests. The three recovery conditions lasted 8 minutes each and were active recovery (AR; cycling at 12.8 kg·m/min per kg bodyweight), sitting in a chair (SIT), or standing with minimal movement (STAND). Prior to participation, players’ recovery preferences and habits were recorded to examine possible psychological effects. Results indicated that perceived fatigue was greater following AR compared to SIT and STAND. The agility score was worse following the AR condition, whereas it was unchanged following SIT and STAND. Line drill performance was also worse following the AR condition when compared to SIT and STAND. Psychological variables were not correlated to any performance measures. These findings suggest that active recovery, at the intensity used in this investigation, may limit restoration of performance during intermittent activities such as basketball.

KEY WORDS: sports performance, intermittent exercise, fatigue
INTRODUCTION

Physiologically, basketball is a dynamic sport that requires both aerobic and anaerobic fitness [1]. Thus, adequate recovery is necessary for optimal performance and to minimize fatigue. However, previous investigations have primarily focused on post-game recovery strategies, which aim to maintain or improve performance in a prolonged sense on a game-to-game basis [2,3]. On the other hand, intragame recovery techniques are still largely unexplored. This is important since intermittent high-intensity exercise is a focal point of basketball and many other team sports (e.g., soccer, hockey), and often athletes of these sports experience increased levels of fatigue toward the end of games, which can lead to performance decrements [4–6]. In particular, basketball requires repeated moderate and rapid accelerations, changes of direction, and explosive jumps which may result in muscle damage from eccentric loading [2]. Accordingly, it is not surprising that basketball players’ ability to do repeated sprinting has been shown to decline after just 20 minutes of play, as well as significant decreases in moderate (21%) and high-speed (20%) running, and the number of jumps (12%) during the second half of play [7,8]. What is of arguably more concern is that, in addition to these reductions in physical performance variables, other studies have also revealed skill based impairments due to fatigue such as shooting performance and passing accuracy [9,10]. Therefore, optimizing the rest period may provide a means for athletes to sustain high levels of performance.

Fatigue is essentially the inability to maintain a certain work output, but its exact mechanisms are still not fully understood, making it difficult to explain the aforementioned observed declines in performance. Aside from dehydration-related fatigue, which has been firmly established [11,12], other proposed possible mechanisms focus on fluctuations in glycogen, creatine phosphate (CP), potassium, and blood lactate, but the findings have been conflicting and no single factor has been definitively linked to fatigue [5,13–18]. There has also been increasing support for the role of the CNS and psychological factors such as motivation, experience, routines, self-belief, and perception of exertion/recovery [19–22]. While their true significance remains controversial, successful recovery would seemingly involve restoring some combination of these variables.

Many modalities have emerged as ways to curtail the physiological underpinnings of fatigue, and one of the most popular methods is active recovery in the form of submaximal aerobic exercise. The theoretical benefits of this tactic stem from increased blood flow leading to greater circulation of metabolites; however, a review of the existing literature shows that the results have been equivocal [15,23–27]. Much of the ambiguity stems from variances in the modes of exercise, exercise duration, and rest intervals, with those with longer recovery intervals favoring active rest. On the other end of the spectrum, the effectiveness (or ineffectiveness) of passive rest (i.e. sitting) has not been established either. While it has been suggested that passive recovery allows for resynthesis of substrates like phosphocreatine without incurring the extra metabolic costs that active recovery does [4,28], passive recovery has also been associated with blood flow stagnation and muscle stiffness [25,29].

Evidently, there is a lack of a consensus when it comes to the best way to deal with fatigue as there are different methodologies utilized across sports when players head to the bench for rest. For example, basketball players commonly sit, rugby and hockey players often alternate between standing and sitting, and some football players ride stationary bikes. Therefore, the aim of the present study was to investigate optimum recovery strategies during basketball-specific high-intensity intermittent exercise. Specifically, we sought to examine the influence of three different recovery modalities [active (cycling), standing, and seated rest] on a series of performance measures. It was hypothesized that the active recovery condition would yield the smallest performance decrements. Although it was not a
primary aim, this study also attempted to provide further insight into the role of psychological aspects on fatigue by examining the relationship between recovery preference and best performance condition.

**METHODS**

A repeated measures experimental design was used to test the hypothesis that active recovery would facilitate recovery and minimize declines subsequent performance. Each participant reported to the laboratory for a total of 4 sessions: 1 familiarization session followed by 3 randomized, counterbalanced experimental trials. Trials were separated by at least 48 hours to allow for recovery. During each experimental trial, participants completed a fatiguing bout of high-intensity intermittent exercise which consisted of the Basketball Exercise Simulation Test (BEST). This test was utilized because it aims to encompass all the demands that basketball players face [30]. While it is still correlated to the other interval sprinting based tests such as the Yo-Yo intermittent test and repeated sprint ability test (5, 8), it also incorporates lateral movement, jumping, and speed variation to match time-motion analysis of basketball games [31]. All of the experimental trials were identical with the exception of recovery conditions which are active (AR), standing (STA), and sitting (SIT). Participants utilized theses recovery conditions in-between two series of performance tests. Additionally, to assess the psychological component of recovery, participants’ preferred and predicted best conditions were recorded via questionnaire to test for possible associations with performance.

**Participants**

Ten healthy males were recruited for this study; however, one participant was unable to finish due to an injury unrelated to the study and was excluded (n = 9; age, 23.11 ± 2.8 years; height, 1.83 ± 0.1 m; body mass, 81.87 ± 11.2 kg). To be included in this study, participants must have reported playing basketball at least two days per week for the past 12 months. On average, participants played 8.28 ± 2.6 hours per week. Criteria for exclusion included the presence of an exercise-limiting cardiovascular, neurological, or metabolic disease or condition, the presence of musculoskeletal conditions that could be made worse by physical activity, or currently taking exercise-limiting medications. The participants were instructed to refrain from drinking alcohol and coffee for at least 12 hours prior to exercise. Players were provided with written and verbal information on the objectives of the study and completed an informed consent document. All procedures were approved by the University’s Committee for the Protection of Human Subjects.

**Procedures**

During their first visit, participants were familiarized with the experimental protocol. Participants were required to walk through the performance tests until familiar and then run through the protocols at varied speeds until competent in completing each test. Specifically, these tests were the vertical jump test, agility t-test, and line drill, as defined by the National Strength and Conditioning Association (NSCA) [32,33]. Additionally, participants completed a questionnaire indicating which recovery method they preferred and which method they thought would be most effective out of the three conditions selected. During this time they were also familiarized with the modified Borg RPE scale and were instructed on how to rate their level of perceived fatigue [34]. Prior to the start of each experimental trial (visits 2-4), players performed a 10-minute dynamic warm-up. Participants’ baseline scores on the performance tests were assessed and recorded before commencing an 8 minute version of the BEST as previously described [30]. This simulation is a combination of low intensity activity (42%), high-intensity activity (48%), and shuffling activity (10%), in order to closely replicate percentages observed during current elite male basketball competition[30]. Each BEST circuit consists of approximately 30 seconds of activity at various velocities. The activities performed were: walking, jogging (~50% of the maximal velocity), running
Influence of Recovery Modalities on Performance Tasks

Vol. 6 (1)

International Journal of Applied Exercise Physiology  www.ijaep.com

Influence of Recovery Modalities on Performance Tasks

~75% of maximal velocity), sprinting (maximal velocity), low shuffling (lateral sliding in defensive stance position, performed without urgency), high shuffling (lateral sliding in defensive stance position, performed at maximal effort), and jumping (maximal effort jump initiated with both legs) [30].

BEST circuits were performed continuously for 8 minutes to simulate plausible playing time prior to substitution, with approximately 16 circuits being completed (15.4 ± 0.9). Immediately after the conclusion of the BEST, the participants’ pre-recovery (PRE) performance test scores were assessed. The time between performance tests was standardized at 10 seconds. Participants then recovered in their randomly assigned condition for that visit for 8 minutes. In the sitting condition (SIT), participants sat in a chair. In the standing condition (STAND) they stood, were instructed to minimize activity as much as possible, and were not permitted to take more than 5 consecutive steps in any 30 second period. In the active recovery condition (AR), participants pedaled on a cycle ergometer (Monark 839E, Monark, Sweden) at 12.78 kgm/min per kg bodyweight at 60RM. This intensity was chosen based on previous exercise recovery research [23,35]. Following the recovery period, post-recovery (POST) performance variables were reassessed. All testing sessions were performed on collegiate-sized indoor hardwood basketball courts.

Statistical Analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS for Windows version 20; Chicago, IL, USA). A 2x3 (time x condition) repeated measures analysis of variance was performed on each dependent variable (fatigue rating, agility, vertical jump, and line drill) to compare the effect of the recovery modalities (SIT, STAND, and AR). Significant main effects or interactions were followed up using pairwise comparisons using the EMMEANS syntax within SPSS. Additionally, Pearson product-moment correlations were calculated to determine relationships between parametric variables and a Chi Square Test of Independence was used to detect if there was a significant relationship between participants’ predicted best condition and actual best condition. All tests were considered significant at a level of 0.05.

RESULTS

Although the purpose of this investigation was to examine the influence of recovery modalities on the measured variables, we also recorded the variables before the exhaustive BEST task. This data was pooled across the testing days and is reported in Table 1. Regarding the PRE and POST data, there was a significant time-by-condition interaction on fatigue (F = 20.8; P = 0.001; ES = 0.85). Namely, POST fatigue was significantly lower than PRE in the SIT and STAND conditions, whereas POST fatigue in the AR condition was not statistically different from the PRE value (Figure 1). Furthermore, the POST fatigue score in the AR condition was significantly greater than the POST values in SIT and STAND.

No significant time-by-condition interactions were found on vertical jump height (F = 1.3; P = 0.33). There was, however, a main effect of time on jump height such that it was lower in the POST period (F = 8.7; P = 0.019) (Figure 2). There was a significant time-by-condition interaction on agility (F = 6.8; P = 0.023) and subsequent pairwise comparisons revealed that the agility score was significantly higher during POST compared to PRE in the AR condition (Figure 3). On the other hand,

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<th>TABLE 1. Mean ± SD of baseline scores.</th>
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there was no significant difference in agility score between pre and post-recovery in the sitting and standing conditions. There was also a significant time-by-condition interaction on the line drill score (F = 8.5; P = 0.013). Comparisons found that POST line drill scores were significantly greater in the AR condition compared to the SIT and STAND conditions (Figure 4). Although follow-up comparisons did not reveal any PRE-to-POST differences in any of the conditions, the decrease in line drill score approached significance (P = 0.08) in the sitting condition.

Fatigue level post-recovery was significantly correlated to subsequent agility and line drill performance (r = 0.46 and 0.47, respectively), but was not significantly related to vertical jump performance (r = -0.14). Chi Square cross-tabulations indicated that there were no significant relationships between participants’ predicted best condition or most used recovery mode and the conditions that they achieved the biggest improvement from PRE to POST for each of the variables.

**DISCUSSION**

The main finding of this study was that AR at the intensity used was largely an ineffective strategy for maintaining performance. Agility performance was significantly worse following the AR period, whereas it was not significantly hindered by the SIT and STAND conditions. Furthermore, line drill performance was significantly worse following AR when compared to that following SIT and STAND. In addition, perceived fatigue was greater following AR when compared to that following SIT and STAND. These findings contradict several past studies that showed that AR can be beneficial for recovery. For example, Bogdanis et al [17] found that interspersing two maximal 30-second bouts of cycle ergometry with 4...
minutes of low intensity cycling led to higher mean power outputs in the second bout compared to passive recovery. Similarly, Brown and Glaister [25] further teased out the relationship showing that AR was superior to passive recovery during intermittent cycle sprints in terms of mean power output when the recovery was 180 seconds, but the inverse was true when only 45 seconds of recovery was allowed. Furthermore, AR has even been shown to be effective when the recovery period is extended to 20 minutes [23].

Clearly, the present study is different from previous investigations that have seen beneficial effects of AR in that the main measures were basketball-specific rather than strictly pertaining to cycle ergometry metrics; however, since both activities are intermittent and high-intensity in nature some of the same theoretical principles should apply. Specifically, blood flow is believed to be a key component modified by AR since it regulates CP resynthesis and pH recovery [17]. Proper blood flow is critical as it allows for adequate O2 delivery and subsequently enhances CP resynthesis, simultaneously increasing lactate removal due to the greater gradients between muscle and blood [23]. Therefore, AR is reasoned to increase blood lactate uptake and oxidation by the previously active muscle groups [24]. Additionally, AR often leads to an elevated heart rate in comparison to passive recovery, which can also augment blood flow and prevent blood from pooling in the dilated vasculature of previously active muscles [25]. Thus, central venous pressure can be more easily maintained and declines in cardiac preload and stroke volume that are often observed during passive recovery can be minimized [23]. Moreover, skeletal muscle blood flow has been argued to regulate lactate and hydrogen ion concentrations [25].

Many of the studies that found AR to be inferior to passive recovery used recovery periods less than 30 seconds [4,26,36]. Comparable to the present study, Castagna et al. [4] and Graham et al. [36] utilized basketball players to examine the effectiveness of AR on repeated sprint ability; however, since those protocols only allowed 30 seconds of recovery it is unclear whether AR was ineffective due more so to the length of recovery or the modality of exercise. As some authors have pointed out previously, one drawback of AR is that it may impede ATP and CP resynthesis [25, 29]. Timing is an important consideration because exercise causes a substantial reduction in intramuscular PO2, so an active recovery strategy likely inhibits CP resynthesis during the initial rapid phase. Instead, it is probably during the secondary slower phase of CP resynthesis that AR may be valuable since this phase is primarily limited by intramuscular [H+] [37].

Another crucial factor is the intensity at which the AR is performed. There is an elevated metabolic cost associated with AR, which has been shown to depress muscle tissue oxygenation [26]. Furthermore, AR at 40%-50% of VO2max further depleted glycogen stores [38], whereas AR at 30% did not [39]. In the present study, AR was performed at ~30% VO2max in order to emulate other studies that had seen benefits [17, 23, 24]; however, it has been suggested that if lactate, not glycogen, is the energy source, intensities less than 30% may be more favorable [29]. Thus, the intensity used in this protocol may still have been too high to elicit benefits. Anecdotally, participants reported that their cardiorespiratory system did not feel significantly more fatigued in the AR condition than the other conditions; rather they indicated experiencing substantial lower body muscular fatigue.

Previously, passive recovery has been studied using either a sitting condition or a standing condition, but, to the authors’ knowledge, this is the first study to compare the two simultaneously. SIT had more favorable marks than STAND in 3 out of the 4 measures (fatigue, vertical jump, and agility), but the relationship was not statistically significant. Physiologically, passive recovery has been proposed to be detrimental to performance since it may allow the muscle to remain acidic and inhibit recovery processes such enzymes involved with glycogen synthesis [29]. Consequently, these lingering metabolites may
increase the osmotic gradient leading to a fluid shift from plasma to muscle. If this is the case, substances would have to perfuse over greater distances, thus these results are somewhat unexpected. On the other hand, the fact that participants are not incurring as many energetic costs may have outweighed these possible disadvantages.

Ultimately, a combination of active and passive recovery may be the best approach. Mohr, Krustrup, Nybo, Nielsen, and Bangsbo [40] explored the use of a “re-warmup” at halftime during a soccer game versus passive recovery and found the re-warmup led to increased muscle temperatures and no change in sprint performance, whereas sprint speed and muscle temperature declined in the passive condition. Thus, the authors suggested that during the first 7 minutes of halftime players could recover passively while receiving tactical advice and the second 7 minutes could be used for a re-warmup. Future research should further investigate the effectiveness of mixed recovery strategies (i.e. SIT followed by AR) to provide further insight on this subject.

Secondarily, this study aimed to uncover possible psychological influences associated with participants’ recovery preferences. It was conjectured that if a participant was unaccustomed to a certain condition or did not believe in its usefulness that it may have a negative effect on performance. Past studies have shown that what participants do prior to performance, in addition to their perceptions of recovery, can exert an effect on performance [19,21,22]. Some of the mechanisms that may modulate these effects include reduction of anxiety and increased self-belief [20]. In this study, no significant relationships were determined other than fatigue being moderately correlated to agility and line drill performance. The lack of correlations between psychological variables and performance may be due to only open skills being examined since pre-performance routines have previously been shown to positively affect closed skill ability [19]. Perhaps if shooting ability was also tested participants would have shot better after performing their preferred condition. More studies are needed to better understand this relationship.

It is important to note that the present protocol utilized an 8 minute bout of exercise to simulate a probable stint of playing time for a basketball player before being subbed out, but the results and physiological and psychological interactions may have unfolded differently had the recovery taken place after simulating multiple quarters of play. For example, Mohr et al. [40] found that elevated muscle and core temp due to a re-warmup was beneficial for sprint speed at the start of the 2nd half; however, even though temperatures remained higher than the controls’ at the end of the game, there was no difference in sprint performance.

In summary, AR had a deleterious impact on perceived fatigue, agility, and line drill performance, whereas passive conditions (SIT and STAND) did not. Past recovery behaviors and preferences did not have a predictive influence on performance. Future research should continue to explore the possible effects of manipulating recovery periods, conditions, and intensities.

CONCLUSIONS
This study demonstrates that passive recovery may be more a favorable recovery option than AR during high intensity intermittent exercise, especially relating to basketball activity. Accordingly, coaches and fitness professionals should instruct athletes and players to avoid unnecessary activity when recovering in order to prevent interference with optimal restoration of performance. On the other hand, the potential effectiveness of active recovery done at a lower intensity cannot be ruled out, and thus forthcoming studies should evaluate this facet.
REFERENCES


