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The effect of blocked versus random practice on dominant and non-dominant baseball swing

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ABSTRACT

Introduction: Practice schedules have been widely researched in laboratory tasks but remain limited in sport specific skills such as the baseball swing. Therefore, the purpose of this study was to determine the effect of random (RD) versus blocked (BL) practice on the dominant side (well learned) and non-dominant side (novel) baseball swing. **Methods**: 11 male high school baseball players participated in dominant and non-dominant side tee practice. Each participant was randomly assigned to either a RD or BL practice schedule following a pre-test. Sessions consisted of 30 swings on both their dominant and non-dominant sides, twice a week for 4 weeks. Following the 4 weeks of training, participants were given a retention test to determine the effect of their practice schedules on their hitting performance. Hitting performance was determined as the number of solid hits and the batted ball accuracy. Percentage of solid hits and batted ball accuracy were calculated to determine the effect of a RD or BL practice schedule. **Results**: For percentage of solid hits on the dominant side, significant pre- to post-testing differences were demonstrated by the RD condition ($p \leq 0.05$; Pre = 63.4 ± 5.6%, Post = 71.4 ± 2.7%). Batted ball accuracy of the non-dominant side showed significant improvements demonstrated by the RD but not the BL condition (RD: Pre = 54.0 ± 4.9%, Post = 65.7% ± 6.2%; $p<0.01$; BL: Pre = 52.8 ± 5.3%, Post = 56.1 ± 8.6%, $p>0.05$). **Conclusion**: Random practice improved hitting performance on both the dominant and non-dominant sides. A random practice routine can be used as a tool to improve performance on a well learned skill such as dominant side baseball hitting.

Keywords: random practice, contralateral training, contextual interference, motor learning

INTRODUCTION

Fitts and Posner [1] introduced a three stage model related to skill acquisition, where through practice, an individual can progress to an "expert" level. They were known as the cognitive, associative, and autonomous stages, with each stage containing a unique quality for skill acquisition. The cognitive stage, as proposed by Fitts and Posner, involves high conscious effort from an individual to determine how and what to do to execute a skill. During this initial stage of skill acquisition, movement errors are high. Through deliberate practice, individuals progress to the associative stage where movement errors decrease, and cognitive effort diminishes. Once an autonomous stage is reached, skill execution becomes automatic or "second nature" and demands little to no cognitive effort. In the autonomous stage, performance becomes consistent with little variability and is coupled with an ability to detect and resolve movement errors.

Individuals must practice the skill on a regular basis in order to progress from the cognitive stage to the autonomous stage of learning. The role of a coach or trainer is to assist in skill development by organizing and executing an ideal practice routine. One of the challenges that presents itself through skill acquisition is the occurrence of a plateau.

Learning and skill acquisition occur rapidly throughout the cognitive stage, but as one progresses to associative and autonomous stages, cognitive output decreases and learning plateaus. According to Lee's cognitive effort theory, the magnitude of skill acquisition is directly related to cortical output [2].

A concept that has been widely researched for the purpose of enhancing cognitive demands is contextual interference (CI). Magill and Anderson [3] defined CI as the memory and performance disruption that results from performing multiple skills or variations of a skill with the context of practice. Application of CI in practice has been shown to enhance long term learning, skill acquisition, and retention. This is known as the contextual interference effect. Contextual interference ranges from low to high and is seen as a continuum which can be altered regularly in practice.

Although a variety of CI methodologies exists, one implementation that has been previously researched is through varying practice schedules between blocked and random practice. Blocked practice is the repetition of one skill at a time for an entire practice session whereas random practice requires random arrangement of skills within each practice session. For example, Magill and Anderson [3] demonstrated a blocked and random practice schedule which involved the learning of throwing patterns (overarm, underarm, sidearm). Research has shown that blocked practice benefits skill performance within practice in the short term, but random practice enhances learning retention and transfer of skill performance in the long term, as it increases adaptability to performance changes [4]. Blocked practice has been shown to have a low contextual interference effect due to the little memory and performance disruption. However, random practice has a high contextual interference effect due to the practice of multiple skills in random order. This causes a high amount of memory disruption and cognitive effort to execute the various skills. Another method of further increasing cognitive effort and enhancing the learning process, is by training the skill from non-dominant side, also known as contralateral training or cross education. Contralateral training is a methodology that has been widely researched in resistance training [5,6] and medical rehabilitation [7–9] but is limited in its application to sports specific skills training [10].

While CI research has been demonstrated to improve various laboratory skills, only a few studies have been conducted in sport specific skills. Baseball hitting is a skill commonly introduced and practiced at younger age groups. By the time a player reaches adolescence, hitting on their dominant side is a well learned skill that requires little cognitive effort to execute, ultimately leading to a plateau in skill acquisition. With contextual interference studies providing further evidence of enhancing long term learning of novel tasks and neuro-motor skills, there are signs of its increasing adoption by coaches who are now incorporating randomization into their strength and conditioning and sport specific practice programs.

A sport specific skill such as baseball batting usually develops over time from beginning stages to more advanced levels. Introducing non-dominant hitting during the study allowed us to look at the impact of random practice on a less skilled swing as compared to a highly skilled swing (i.e. dominant side). The combination of dominant and non-dominant side practice is referred to as contralateral training. Therefore, the purpose of this study was to determine the effect of blocked versus random practice while batting on dominant (well learned) and non-dominant sides (novel) on baseball hitting in moderately-skilled hitters. It is proposed that randomizing practice with non-dominant side swings and random tee location will enhance batting performance. It should require more cognitive effort and movement planning than the blocked group. According to previous research on variability of practice and CI, we propose two hypotheses: 1) random practice will improve hitting performance on the dominant side more so than blocked practice, 2) Random practice will improve hitting performance more so than the blocked practice on the non-dominant side. Additionally, a further question is posed whether the importance of random practice increases with skill level or does it stay the same?

METHODS

Participants

A total of 11 healthy male high school baseball players participated in the study (Table 1.). All subjects were right hand and right eye dominant and between the ages of 14 to 18 years old. All subjects were free of musculoskeletal injuries and cardiorespiratory conditions (i.e. asthma) that could have impacted their physical capability to complete the study. Prior to the commencement of the study, written informed consent was obtained from the subjects and their parent(s) or legal guardian(s). The procedures carried out in this study were approved by an Institutional Review Board (IntegReview, Austin, TX; Protocol # 0618).

Table 1. Participant Characteristics.

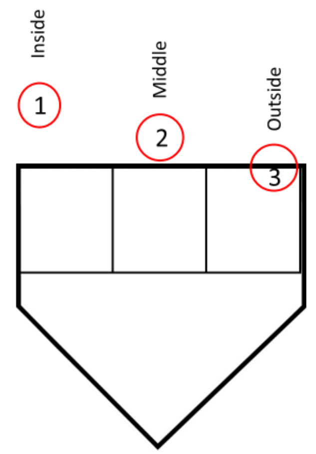
	Random Practice (n=6)	Blocked Practice (n=5)
Age (years)	16.7 ± 2.1	15.6 ± 1.3
Height (cm)	179.1 ± 6.0	177.3 ± 4.9
Weight (kg)	82.0 ± 10.0	80.5 ± 11.0
Baseball Experience (years)	8.7 ± 2.1	7.8 ± 1.3

Characteristic data are mean ± SD.

Familiarization

Prior to pre-testing, subjects underwent one familiarization session to be acquainted to the contralateral tee practice protocol. Subjects took ten swings at each position pictured in Figure 1: the inner-third (1), middle (2), and outer-third (3) of the plate for a total of 30 swings (Figure 1 represents plate positioning for a right-handed hitter). Subjects were instructed to swing the bat as hard as possible (i.e. game like swings) to hit the ball placed on the tee in the corresponding direction it was placed on the tee. For example, right-handed hitters were to hit the ball on the inner third toward left-field, middle to centerfield, and the outer third toward right-field. This protocol was executed on the subject's dominant and non-dominant hitting sides (i.e. 30 swings per side). There was no randomization of tee height in the familiarization session. All subjects were permitted to use a baseball bat of their choice and they were instructed to use the same bat for all subsequent testing sessions until completion of the study. Similarly, subject's placement in the batter's box was self-selected and distance from the back line of the batter's box to the mid-point of the calcaneus of the rear foot was recorded for consistent subject positioning in the batter's box. After completion of familiarization, subjects were randomly assigned to one of two conditions: random tee training (RD) or blocked tee training (BL). Subject's age, height, weight, bat size, tee height, batter's box positioning, and baseball experience was recorded at familiarization.

Figure 1. Schematic of a Right-Handed Hitter's View of Sectional Tee Placement



Retention Test

The retention test was conducted on the dominant and non-dominant hitting sides for all subjects a pre- and post-testing. The retention test was made to mimic the RD tee practice protocol. During the retention test hitting performance and bat swing parameters (described below) were assessed.

Tee Practice

All subjects completed 2 tee practice sessions per week, separated by at least 48 hours, for 4 weeks (8 total sessions). Both protocols (RD and BL) consisted of 30 swings from the non-dominant and dominant hitting sides, completing 10 swings at each position shown in Figure 1. Subjects from both conditions began with the non-dominant hitting side and finished with an equal number of swings on the dominant side. Subjects in the RD condition had a minimum tee height set at the hollow beneath the knee cap and a maximum tee height set at the mid-point between the top of the shoulders and the top of the pant line as these visual descriptors match the strike zone set by Major League Baseball. Tee height of the RD condition randomly variated between the minimum and maximum tee height so that the tee would not be kept at the same height for any two successive swings. Additionally, tee location on was randomly placed across the 3 positions shown in Figure 1 in a pre-determined order known to the investigators but not the subjects. Subjects in the BL condition self-selected their preferred height for tee practice and did not receive any randomization of tee height. The BL condition completed 10 swings in a blocked manner, progressing through inside, middle, and outside locations. All sessions were conducted in an indoor batting cage with dimensions of 54'L x 13.5'W x 10'H.

Hitting Performance

The quality of the batted ball was measured as a solid hit if two criteria were met: 1) exit velocity of the batted ball off the tee was within 10% of the maximum exit velocity achieved at pre-testing and 2) the batted ball was in flight upon contact with batting cage netting. Ground balls were immediately discounted from being a solid hit. The percentage of solid hits was calculated by [(solid hits/total hits) * 100]. Exit velocity was measured by a radar gun (The Stalker Pro II, Stalker Sport; Richardson, TX, USA) positioned on a tripod behind the tee, inside the cage. Additionally, batted ball accuracy was accounted for in which inner tee placement should have an inner segment trajectory, middle placement should have middle trajectory, etc. Accuracy was calculated by [(balls trajected correctly/total number of balls batted) * 100].

Statistical Analysis

Prior to performing inferential statistics, normality of the data was confirmed with Shapiro Wilks test ($p>0.05$) and no significant between group differences was observed for any dependent variables at pre-testing ($p>0.05$). Two-way repeated measures analysis of variance (ANOVA) was performed assuming group and time as fixed factors.

Whenever a significant F-value was obtained, a post-hoc test with Tukey's adjustment was performed for multiple comparison purposes. Whenever p-values for the F-test indicated a trend towards significance, the absolute mean change from pre- to post-testing was calculated for each subject and unpaired t-test were used to compare conditions. Tukey's post-hoc test was used for multiple comparisons when necessary. All statistical analysis was performed using GraphPad Prism (Version 7, San Diego, CA, USA). The alpha level was set a $p \leq 0.05$. Data are reported as mean ± standard error (SE).

RESULTS

Hitting Performance

There were no significant differences between conditions at pre-testing for percentage of solid hits (Dominant: $p=0.73$; Non-Dominant: $p=0.66$) or accuracy of batted ball trajectory (Dominant: $p=0.83$; Non-Dominant: $p=0.87$). For percentage of solid hits on the dominant side, significant pre- to post-testing differences were demonstrated by the RD condition ($p \leq 0.05$; Pre = 63.4 ± 5.6%, Post = 71.4 ± 2.7%; Figure 1A). Both conditions significantly improved percentage of solid hits from the non-dominant side (RD: Pre = 17.1 ± 5.1, Post = 31.4 ± 3.3, $p<0.01$; BL: Pre = 20.3 ± 4.7, Post = 31.3 ± 6.3; $p<0.01$; Figure 2A).

For batted ball accuracy on the dominant side, there were no within or between group differences for (RD: Pre = 72.9 ± 6.5%, Post = 79.6 ± 5.5%; BL: Pre = 74.9 ± 6.1%, Post = 75.1 ± 5.9%); however, significant differences were detected in absolute pre- to post-testing percent change values whereby the RD condition demonstrated a greater increase ($p \leq 0.05$; 11.7 ± 6.9% vs 0.9 ± 5.8%; Figure 1B). In regards to batted ball accuracy of the non-dominant side, significant improvements were demonstrated by the RD but not the BL condition (RD: Pre = 54.0 ± 4.9%, Post = 65.7% ± 6.2%; $p<0.01$; BL: Pre = 52.8 ± 5.3%, Post = 56.1 ± 8.6%, $p>0.05$; Figure 2B).

Figure 1. Dominant Side Results for Percentage of Solid Hits (A) and Batted Ball Accuracy Percent Change (B)

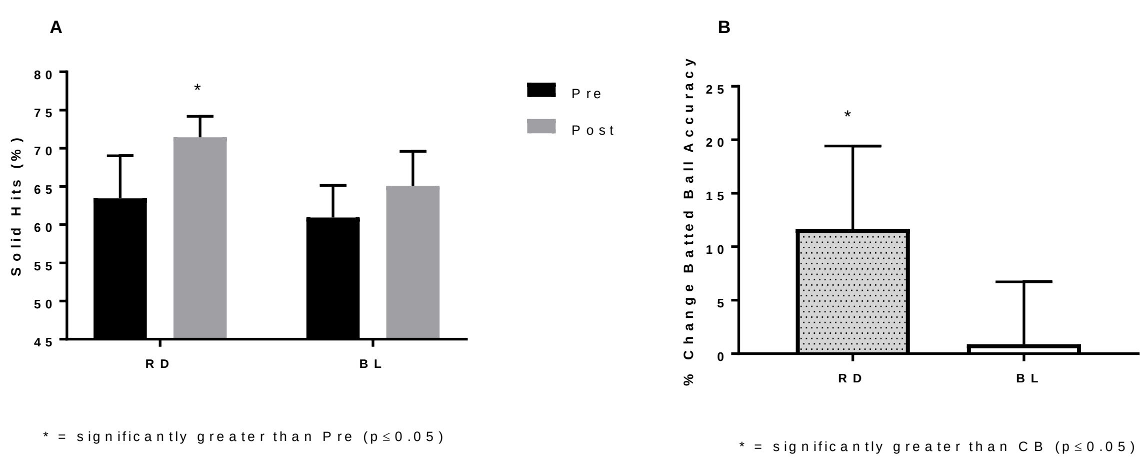
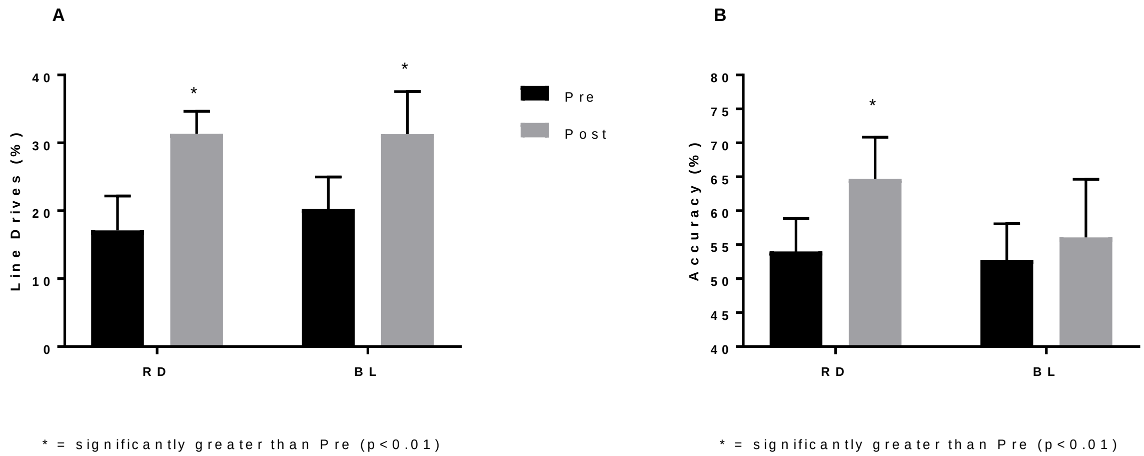


Figure 2. Non-Dominant Side Results for Percentage of Solid Hits (A) and Batted Ball Accuracy (B)



DISCUSSION

The purpose of this study was to determine the effect of random versus blocked tee training on hitting performance as measured by solid hits and batted ball accuracy in moderately skilled baseball players. Our first hypothesis was supported as RD practice did improve all measures of hitting performance more so than blocked practice on the dominant side. For the non-dominant side, both groups improved solid hit performance on the non-dominant side. However, batted ball accuracy only improved in the RD. These results partially support our second hypothesis. Collectively, these results indicate that the necessity of random practice may increase with well learned tasks compared to novel tasks.

Random versus blocked practice schedules have been shown to enhance skill acquisition in various non-sport settings [4,11,12]. This led to the application of random and blocked practice in sport settings and aimed to further enhance skill acquisition in tasks such as basketball free throws, tennis shots, and soccer performance [10,13,14]. Findings from these studies suggested that motor skill acquisition is enhanced by randomized training, which is in-line with the findings from this study. Research investigating the effect of blocked/random practice is limited in baseball. The first, to our knowledge, to investigate the methodology was Hall et al. [15] who investigated random and blocked pitch order on hitting performance. Their results were in line with findings in this study as random practice enhanced skill acquisition over blocked practice through performance in the retention test. There were similar findings when this concept was applied to pitchers as random practice improved throwing accuracy when compared to blocked practice [16]. A random practice schedule has been shown to enhance skill acquisition through retention and transfer tests in various settings as compared to a blocked schedule, and is further supported by the improvement in batted ball accuracy on the non-dominant side. However, once a skill becomes more learned, practice schedules tend to turn to a blocked routine. The findings in the current study suggest that maintaining a random practice routine when a skill is well developed can enhance performance when compared to a blocked routine.

Our rationale for including contralateral training into the practice schedule was to increase CI as this would further increase the "what to do to complete the skill", or cognitive effort required during skill acquisition [10]. Hitting baseballs off a tee is often a well-learned skill and further increasing CI should further enhance skill acquisition. Random practice (high CI) versus blocked practice (low CI) has been investigated in baseball [15,16] but none have looked to further elevate the magnitude of contextual interference. Therefore, including contralateral training increases the level of CI and attempts to create a novel task.

While the results of this study are interesting, the authors recognize its limitations. First the sample size in this study was small. Second while we discuss cognitive effort theory, we did not examine it directly. Therefore, future studies should look to include a cognitive effort scale in order quantify the amount of mental effort required during practice sessions which can be evident of the stages of learning. A cognitive effort scale may provide further evidence as to how CI combined with contralateral training methods can foster neuroplasticity, hence, enhancing neuro-motor muscular communication.

Future investigations should look to use a transfer test to further validate the learning effect as it would require participants to perform the learned skill in a different setting than what was practiced. The test in this study was a retention test as it had no differences to the acquisition period. Future studies should also look to investigate two hypotheses regarding the effect of random practice on skill acquisition. The first was proposed by Shea and Morgan[11] as the elaboration hypothesis, which stated the effect of a high CI requires the learner to elaborate, or relate, any memory of a previous skill that can assist in execution of the current skill. The second, proposed by Lee and Magill [17], was the action plan reconstruction hypothesis stating that high amounts of CI require the learner to reconstruct an action plan for the upcoming skill variation. Both hypotheses appear valid but can rely on what stage of learning the individual may be in.

The findings in this study can be applied to current tee training. Coaches should look to include randomization of tee placement as it has been shown to improve hitting performance in a practice setting in moderately skilled players. Current skill level and task difficulty should be taken into consideration when deciding on the level of CI included during practice. If a coach or trainer determines an athlete is experiencing a performance plateau, application of randomized-contralateral training can induce learning benefits and assist in overcoming plateaus.

Conclusion

As shown in previous studies, random practice improved performance in a novel task. However, random practice also improved peformance with a well learned skill which could signal a need for coaches and players to continue to randomize training even once a skill is well learned in order to continue to improve performance.

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