ACUTE EFFECTS OF VARIOUS WEIGHTED BAT WARM-UP PROTOCOLS ON BAT VELOCITY

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ABSTRACT
Reyes, GF and Dolny, D. Acute effects of various weighted bat warm-up protocols on bat velocity. J Strength Cond Res 23(7): 2114–2118, 2009—Although research has provided evidence of increased muscular performance following a facilitation set of resistance exercise, this has not been established for use prior to measuring baseball bat velocity. The purpose of this study was to determine the effectiveness of selected weighted bat warm-up protocols to enhance bat velocity in collegiate baseball players. Nineteen collegiate baseball players (age = 20.15 ± 1.46 years) were tested for upper-body strength by a 3-repetition maximum (RM) bench press (mean = 97.98 ± 14.54 kg) and mean bat velocity. Nine weighted bat warm-up protocols, utilizing 3 weighted bats (light = 794 g; standard = 850 g; heavy = 1,531 g) were swung in 3 sets of 6 repetitions in different orders. A control trial involved the warm-up protocol utilizing only the standard bat. Pearson product correlation revealed a significant relationship between 3RM strength and pretest bat velocity (r = 0.51, p = 0.01). Repeated measures analysis of variance (ANOVA) revealed no significant treatment effects of warm-up protocol on bat velocity. However, the order of standard, light, heavy bat sequence resulted in the greatest increase in bat velocity (+6.03%). These results suggest that upper-body muscle strength influences bat velocity. It appears that the standard, light, heavy warm-up order may provide the greatest benefit to increase subsequent bat velocity and may warrant use in game situations.

KEY WORDS baseball, bat velocity, power, strength

INTRODUCTION
A hitter in baseball has approximately 0.4 seconds to decide whether to swing at a pitch. Hitters who are able to delay the initiation of the swing may increase their chances of success by only swinging at strikes; however, that requires significant bat velocity. Current theory suggests bat velocity is one of the most important aspects in successful hitting; Adair (1) demonstrated a positive relationship between bat velocity and the distance the ball travels after impact. The power necessary to generate bat velocity originates in the lower body, especially the hips (1,20,23,26). Additionally, poor bat velocity typically is attributed to deficiencies in muscular strength (20,23).

However, no published research has examined relationships between muscular strength and bat velocity. One study reported no significant bat velocity increases following a forearm and hand-grip strength training program (17). In recent years resistance training has become an essential component of a baseball hitter’s conditioning regimen. With increased attention on the home run, power training has become a staple in a baseball player’s training.

One example of current resistance training programs is complex training. Complex training utilizes alternating sets of heavy and light resistances to increase power output (4). Typically, explosive, plyometric-type exercises, such as jump squats or bench press throws, are preceded by a heavy set such as free-weight squats or bench press. Several research studies report that alternating heavy and light resistance sets improves muscle power for both upper- and lower-body exercises (4,13,15,29).

The simplest method of applying complex training in baseball is the use of weighted bats, created by placing a “donut” weight on the barrel of the bat. These devices create a heavier bat and may help strengthen the muscles of the forearms and wrist. Two training studies have demonstrated increased bat velocity following several weeks of weighted bat training (8,22). Also, by swinging heavier bats in warm-ups, this contrast in load may enhance subsequent bat velocity when using a standard weighted bat. However, acute studies report that warming up with heavier bats actually decreased linear bat velocity about –1.8 to –0.1 meters per second (9,21,24). Researchers claim the use of heavy bats creates an
inefficient swing motor pattern, resulting in decreased bat velocity (24). The popularity of using weighted bats before a standard bat is a “kinesthetic illusion” because hitters perceive they are swinging faster when, in actuality, they are not (21). To date, little research has studied the acute effects of varying the amount of the weighted bat on bat velocity in baseball players. Further research may provide recommendations for the type and order of various weighted bats to use to maximize bat velocity immediately prior to the game at-bat. The purposes of this study are to (a) determine the optimal order of various weighted bat warm-ups on subsequent bat velocity and (b) establish the relationship between upper-body strength and bat velocity. Based on the results of this study, baseball coaches and players may be able to select a warm-up protocol that enhances bat velocity.

**METHODS**

**Experimental Approach to the Problem**

This study was designed to compare the effect of varying the order of 3 weighted bats used during warm-up exercises on subsequent baseball bat velocity. All subjects participated in 9 separate testing sessions where each session utilized a unique order of weighted bats representing a “light,” “standard” (normal), and “heavy” bat. The bat weights were selected to represent a standard baseball bat weight, one slightly lighter than the standard weight, and a bat with an added weight typically used in baseball that was significantly heavier than the standard bat alone. Each session consisted of 3 sets of 6 bat swings. Prior to and following each warm-up protocol, baseball bat velocity was measured to determine the acute effect of bat warm-up sequence.

**Subjects**

Nineteen subjects (age = 20.15 ± 1.46 years) were recruited from a National Collegiate Athletic Association Division III collegiate baseball team located in the Pacific Northwest. The sample population was limited to players whose primary duties involve hitting (i.e., position players). All subjects were injury-free at the time of testing. All subjects had participated in competitive baseball for at least 5 years. Each athlete was tested toward the beginning of the competitive season (beginning of February) following 4 weeks of preseason baseball practices. The team practiced 6 days a week for 3 hours a day. Preseason practices in January were preceded by an 8-week off-season strength training program, in which all subjects participated. All subjects completed informed consent forms and all procedures involving human subjects conformed to the recommendations established by the American College of Sports Medicine. The Human Assurance Committee of the University of Idaho reviewed and approved this study.

**Instrumentation**

Two aluminum baseball bats and a Pow’r Wrap bat weight (Grand Enterprises West, Bloomington, Minnesota, USA) was used for this study. One aluminum bat, defined as the “standard” bat, measured 83.3 cm long and weighed 850 g. The second aluminum bat, defined as the “light” bat, weighed 794 g and measured 83.3 cm in length. The “heavy” bat was the combination of the “standard” bat and the Pow’r Wrap batting weight, weighing 680 g, creating an 83.3-cm, 1,531-g bat. Bat velocity was measured using 2 infrared photocell control boxes (Model #63504) attached to a multifunction timer/counter to record time (Model #54035A, Lafayette Instrument, Lafayette, Indiana).

**Procedures**

3RM Bench Press. Upper-body strength was measured by performing 3 repetitions maximum (RM) on the standard free weight bench press. Following a light warm-up consisting of jogging and dynamic stretching, an incremental increase in barbell load was added following each successful lift until the

<table>
<thead>
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<th>Protocol</th>
<th>Mean ± standard deviation</th>
<th>% Change vs. control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28.61 ± 4.4</td>
<td>+ 0.39 %</td>
</tr>
<tr>
<td>2</td>
<td>28.87 ± 3.5</td>
<td>+ 1.29 %</td>
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<tr>
<td>3</td>
<td>29.10 ± 4.8</td>
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<td>4</td>
<td>29.14 ± 3.9</td>
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<td>5</td>
<td>29.31 ± 3.6</td>
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</tr>
<tr>
<td>6</td>
<td>29.39 ± 3.6</td>
<td>+ 3.12 %</td>
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<td>7</td>
<td>29.95 ± 5.5</td>
<td>+ 5.08 %</td>
</tr>
<tr>
<td>8</td>
<td>30.22 ± 3.4</td>
<td>+ 6.03 %</td>
</tr>
<tr>
<td>Control</td>
<td>28.50 ± 4.4</td>
<td>—</td>
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</table>

Values are meters/second. 

\(N = 19.\)
subject failed to successfully complete the 3RM lift, per the recommendations of the National Strength and Conditioning Association (2).

Bat Warm-Up Protocols. There were 9 different warm-up protocols for the subjects (Table 1), with the control trial consisting of warm-up swings with only the standard bat. The testing session occurred either before, during, or after each subject participated in a portion of their baseball practice, which involved running, stretching, hitting, and throwing. The weighted bat warm-up protocol was randomized for each visit for each athlete. The test administrator specifically explained the warm-up protocol with the 3 differently weighted bats. It was composed of 6 maximal-effort swings with each weighted bat for a total of 18 warm-up swings. Approximately 3 to 5 seconds of rest was allowed between each swing. The subjects performed this specific warm-up with each of the 3 weighted bats. No stretching or other warm-up activities were allowed immediately prior to and during these protocols.

Bat Velocity Tests. Thirty seconds following their last warm-up swing, the subjects stood under the photocell control boxes and swung 5 times at a soft-toss pitch with 30 seconds of rest in between swings. The rest interval of 30 seconds was used because of the estimated average time between the batter’s final on-deck preparation and the first pitch of their game at-bat. Also, it was an estimated average of 30 seconds in between pitches of an at-bat. The infrared photocell control boxes emit beams directed toward reflectors, creating a pathway of light between them. By recording the distance between the 2 infrared photocell control boxes (30.48 cm) and the recorded time the bat crossed the 2 control boxes, velocity was calculated. The 2 infrared photocell control boxes were attached to an apparatus located above the hitter’s head. The 2 reflectors were placed on the ground near the hitter’s feet. This device did not impede the subject’s baseball swing. The mean of the 5 swings was averaged for each protocol and used for data analysis.

Statistical Analyses

Descriptive statistics were calculated for 3RM bench press and bat velocity. A 1-by-6 repeated measure ANOVA using the GLM model of SAS (SAS Institute, Inc., Cary, North Carolina, USA) was used to determine significant differences between trial means. A Pearson product moment correlation was used to analyze the relationship between average pretest bat velocity and the subject’s 3RM bench press score. The level of significance was set at $p < 0.05$.

RESULTS

The test–retest reliability (intraclass correlation coefficient [ICC]) between swing trials (trial 1 vs. 2, 2 vs. 3, 3 vs. 4, 4 vs. 5, 2 vs. 3, 2 vs. 4, 2 vs. 5, 3 vs. 4, 3 vs. 5, 4 vs. 5) averaged 0.504 for the control protocol condition. Table 2 and Figure 1 present mean bat velocity for all protocols. All weighted bat warm-up protocols improved bat velocity compared to control; however, the improvements did not reach statistical significance. Power computations revealed a 0.99 score, with a relatively large effect size of 0.803. A significant relationship existed between upper-body strength and bat velocity ($r = 0.51, p = 0.01$) (Figure 2).

DISCUSSION

The results did not identify any 1 weighted bat warm-up protocol that significantly increased bat velocity, although all protocols enhanced bat velocity compared to the control trial. However, the relatively large effect size (0.803) suggests that these results may be meaningful. These increases could have
useful effects when applied to practical, competitive situations. For example, a 3 to 6% increase in bat speed could make a difference in the distance a ball travels when contacted in competition leading to enhanced performance.

The use of weighted bats is based on the theory of complex training, where sets of heavier and lighter resistances are alternated to elicit a potential increase in muscle performance (4). The principle behind the heavy facilitation set in complex training is that skeletal muscle tends to be more explosive after being subjected to near-maximal contractions (4). This postactivation potentiation (PAP) as a result of the heavy facilitation set has demonstrated increased power in subsequent movements such as bench press throw distance, broad jump lengths, vertical jump heights, and medicine ball throw distance (4,13,15,29). PAP enhances motor-neuron pool excitability and increased recruitment of motor units, which leads to greater power (4,10,11). The weighted bat is the hitter’s equivalent of a complex “warm-up” as they prepare to maximize bat velocity when hitting.

Previous research reported that approximately 3 to 4 minutes is the optimal amount of recovery to increase power in the light set following the heavy warm-up in complex training (18,29). If power output is evaluated too soon after the facilitation exercise, muscle performance may suffer because of acute fatigue (10,12,16,18). In this study, 30 seconds of recovery was chosen because of the estimated time between final on-deck preparations and the first pitch of the at-bat in a baseball game. This time interval may have been too short for complete recovery. An examination of the optimal rest interval between using the weighted and standard bat should be investigated.

Several suggestions relative to resistance load order have been proposed. Baker (3) reported that when attempting to increase power with a lighter weight, it is best to warm up in a descending order of resistance, with the final weight being the one you intend to use for the test or sport. The heavy warm-up load stimulates the neural system, allowing for greater muscle activation during the light bat swings (3). Therefore, we suspected the protocols ending with the standard bat would have elicited greater bat velocity (protocols 2, 6), especially protocol 2, where the order of the weighted bats was in descending order. Although protocol 2 ranked third in highest bat velocity and percent increase, none of the protocols resulted in significantly different velocities. Perhaps the differences in bat weights were not great enough to elicit a true contrast load effect.

Based on the specificity principle, one may have expected the use of only the standard bat to be beneficial because previous research has demonstrated that the use of heavy bats acutely decreases bat velocity (21,24). This may be from changing the bat’s moment of inertia, which may alter the motor pattern of the actual swing. This did not occur in the present study. In fact, the warm-up consisting of all heavy bat swings (protocol 7) resulted in the second highest bat velocity percentage improvement. Finally, the popularity of weighted bats has been attributed to the “kinesthetic illusion” where hitters believe bat velocity has increased when in fact it has not (21).

Although the 3RM bench press was related to bat speed, a significant portion of the variance was not accounted for (~75%). While the lower body initiates power development (1,20,23,26), the upper body must generate power to transfer the momentum to the bat. If upper-body strength is inadequate, angular accelerations will be less and bat velocity will be lower (26). The relationship between leg strength and bat speed still remains unknown. Perhaps the squat test would have identified a stronger relationship to bat velocity. With the exception of an unpublished Master’s thesis, little is known about this relationship. Based on the importance of the leg swing (1,20,23,26), an upper-body plus a lower-body strength test may provide more insight relating strength to bat velocity. Leg strength may in fact have a greater impact on baseball performance compared to upper-body strength.

In conclusion, the use of a weighted bat combined with underweighted and standard bat weight did not have a significant effect on acutely increasing bat velocity. These results agree with previous research stating the insignificant effects of weighted bat warm-ups to increase bat velocity. The numbers may show insignificance, but several external factors must be considered, all of which could have a practical impact for players and coaches.

**Practical Applications**

All of the listed protocols enhanced acute bat velocity to some degree compared to control, although none were statistically significant. The specific order of standard, light, heavy enhanced bat velocity by 6%, which could make a difference in the distance a batted ball travels. Higher bat swing velocities translate to further distances of the batted ball. Hitters who possess a greater ability to generate high bat velocities also are able to wait a fraction of a second longer before deciding to swing. The extra recognition time enables the hitter to more accurately recognize the type, speed, and location of the pitch, leading to increased performance. Therefore, we recommend the specific weighted bat warm-up order of standard, light, heavy. An upper-body strength/bat swing velocity relationship was found. The greater upper-body strength baseball players possess, the greater their bat speed. Upper-body strength levels of athletes could play a role in the amount of improvement in the power set of complex training—in this case, bat velocity. Therefore, these data could assist coaches and conditioners in designing proper programs for baseball players to enhance bat velocity, which may lead to improved performance.

**References**

Various Weighted Bat Warm-Up Protocols


