Effects of Warming up with a Bat Weight on Muscle Activity During the Swing of College Baseball Players

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Effects of Warming up with a Bat Weight on Muscle Activity during the Swing of College Baseball Players

By

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# Table of Contents

**Abstract** .......................................................................................................................... 4  

**Introduction** ....................................................................................................................... 5  
  The Baseball Swing ............................................................................................................... 5  
  Using Electromyography to Measure Muscle Activity ...................................................... 7  
  The Use of a Bat Weight .................................................................................................... 9  

**Methods** .............................................................................................................................. 10  
  Participants and Location .................................................................................................. 10  
  Experimental Design ........................................................................................................ 10  
  Electromyography ............................................................................................................ 13  
  Analysis of Electromyography ......................................................................................... 14  
  Statistical Analysis ........................................................................................................... 15  

**Results** .................................................................................................................................. 15  
  Pre-Trial Survey ............................................................................................................... 15  
  Electromyography Results ................................................................................................ 16  

**Discussion** .......................................................................................................................... 18  

**Conclusion** ........................................................................................................................... 23  

**Appendices** .......................................................................................................................... 24  
  Appendix A ........................................................................................................................ 24  
  Appendix B ........................................................................................................................ 26  

**Reference List** ..................................................................................................................... 28
Abstract:

Hitters in baseball are commonly seen preparing for their next plate appearance swinging with a bat weight to warm up. Intuition tells us that swinging a heavy object immediately before swinging an object of less mass will allow for a quicker and more forceful swing. With the increasing competition in the game of baseball, players are looking for every advantage they can get over the competition. While there have been studies that have examined the effects of a bat weight on certain aspects of the swing, few have examined muscle activity and none to my knowledge have used a pitching machine to simulate a game-like experience. Ten Allegheny College baseball players participated in this study by first completing a survey asking about their opinions and experiences with a bat weight. Surface Electromyography was used to examine the relationship between warming up with a bat weight and warming up without a bat weight. EMG signals were normalized to compare the muscle activity between the two conditions. The athletes participated in six trials of hitting off of a pitching machine in which four muscle groups (lead-arm triceps brachii, trail-arm pectoralis major, trail-leg gastrocnemius and trail-leg biceps femoris), that are considered the prime movers of the baseball swing, were examined. Results yielded no significant difference between the muscle activities of the prime movers after warming up with a weight compared to warming up without one. The majority of participants stated that they believed they would have greater muscle activity after using a bat weight during the survey which means there may be a psychological effect when warming up with a bat weight.
Introduction:

The Baseball Swing

Baseball has been labeled America’s pastime, and competition in the sport is always on the rise (Welch et al., 1995). Hitting is a fundamental aspect of baseball that players will spend hours each day to perfect. Using a round object to hit another round object is arguably one of the most challenging skills to master in all of sports (Escamilla et al., 2009). Batters are always looking for ways to get an edge on the competition whether it is in practice or a game.

The biomechanics of the baseball swing were first analyzed by Race (1961), who used linear and angular displacements and velocities of the bat and certain upper extremity and trunk parameters. The swing has continued to be quantified over time using techniques such as high speed videography and electromyography. High speed videography is used to measure certain linear and angular movements of the swing, and electromyography is used to measure muscle activity during a swing (Herlocker, 2015; Fortenbaugh, 2011; Reyes et al., 2011; Escamilla et al., 2009; Otsuji and Kinoshita, 2002; Welch et al., 1995). The research on hitting has certainly turned the skill into a science (Welch et al., 1995).

Here the biomechanics of hitting is described for a right handed hitter. Directions of movement for left handed hitters are the opposite. The swing begins with a phase called coiling, where the weight shifts to the back leg and the upper body rotates clockwise around the axis of the trunk (Figure 1, C). After coiling, the front leg lifts which increases the force of the back leg in the negative X direction by approximately 102% (Figure 1, A). As the hitter continues his stride, his hips rotate counter clockwise while the shoulders continue in a clockwise motion, increasing the coil around the axis of the trunk. Just prior to the front foot hitting the ground, the
shoulders begin to follow the hips in the counterclockwise direction, but the arms still slightly rotate clockwise (Figure 1, C). After the impact of the front foot on the ground, the arms follow the hips and shoulders as they rotate towards counterclockwise (Figure 1, C). The weight is also shifted at this point while the force from the front leg is approximately 123% of the body weight to the ground and the force of the back leg to the ground is reduced to 53% of the body weight. The front leg then extends pushing the left hip backward while the back leg pushes the right hip forward accelerating the hips around the axis of the trunk. The hip acceleration leads to the acceleration of the upper body, along with the bat, as it approaches contact with the ball. Once the bat reaches contact the ball, the acceleration of the upper body continues through the follow through. The back leg finishes in a flexed position to support the weight of the body (Welch et al. 1995) (Figure 1).

Figure 1. Batter swing movement. A) Global reference frame. B) Stride Parameters. C) Segmental rotation around axis of trunk (Welch et al. 1995).
The swing of a baseball player is a whole body movement, however some muscles are more critical than others while performing the task (Reyes et al. 2011). According to Fortenbaugh (2011) the trail-leg gastrocnemius, the trail-leg biceps femoris, the trail-leg gluteus maximus, the trail-arm pectoralis major, the lead-arm latissimus dorsi, and the lead-arm triceps brachii are considered the most important muscles when swinging a bat. The trail-leg biceps femoris and the trail-leg gluteus maximus are key factors in holding the stability of the base during the stance and also generating power while uncoiling the torso. The upper body muscles are still debated on whether they help generate power, however it is agreed that they are critical for bat positioning during the swing. While other muscles play roles in the swing, these six muscles are considered the prime movers (Garhammer, 1983; Welch et al., 1995).

*Using Electromyography to Measure Muscle Activity*

As humans send a signal from their brain telling a certain muscle to contract, the muscle is stimulated causing myosin and actin to slide past each other to shorten the sarcomere and thus contracting the muscle. When the signal is received the muscle quickly contracts before relaxing. The stimulus is producing what is called a muscle twitch, which is activated by the release of calcium ions which will bind to troponin, allowing myosin to bind to actin. A power stroke then ensues, resulting in the shortening of the sarcomere. A single motor unit can shorten a muscle by one percent, and when combined with all of the motor units, the muscle can be shortened by about sixty percent. Multiple signals occurring at once can lead to the summation of twitches in the muscle. Therefore, higher stimulus voltages have the potential to activate more motor units. More motor units being activated correlates with stronger muscle contractions. This also means that muscle contractions can vary from one another, which leaves potential for outside factors to affect how well a muscle can contract (Fox, 2013).
Surface electromyography (EMG) was first used to quantify dynamic movement in the late 1940s. EMGs began being used in therapy settings to measure patients’ progress and set benchmarks for discharge during the treatment process. Along with being used as a treatment for muscles, surface EMGs can also measure the electrical activity of muscles (Cram and Kasman, 1998).

Surface electromyography provides many advantages. This method involves a safe, easy and noninvasive way of quantifying the energy of muscles. Surface EMGs show the muscle energy at rest and how it changes during a certain motion. This method is able to test whether muscles fire earlier or later during variations of different movements, if certain exercises or movement activate a certain muscles as much as it is supposed to, and if the muscles are activated more or less when comparing exercises (Cram and Kasman, 1998).

Some disadvantages with surface electromyography involve the fact that the same movement can be caused by different muscle groups, causing some practitioners to believe the method is inconsistent (Cram and Kasman, 1998). The other drawback of this method is that “cross-talk” can occur during a movement. “Cross-talk” happens when the energy of a certain muscle groups travels into the recording field of a different muscle group. “Cross-talk” could possibly skew the results. Also, the leads can make the subject feel self-conscious and could potentially change the athlete’s performance (Cram and Kasman, 1998).

Surface electromyography does not measure the strength or force of a muscle. The EMGs only indicate electrical activity that triggers a muscle to perform a dynamic movement. In other words, it is measuring the voltage of the stimulus that is causing the muscle to twitch (Fox, 2013). The EMGs of muscle contractions are often compared by normalizing the signals. The signals can be normalized by taking the root mean square (RMS) of the EMG signals. Taking
Griffin

the RMS will convert the EMG waves into a smooth parabolic curve in which the area under the curve can be measured (Thought Technology, 2008)

**The Use of a Bat Weight**

In the midst of a game, a batter, who is due up to be the next hitter, is allowed to complete practice swings outside of the dugout. It is common practice for these players to take practice swings with a weight on their bat (Otsuji et al., 2002; Montoya et al., 2009). Nowadays in hitting research there is an emphasis on finding an optimal warmup routine while a batter is on deck that will lead to greatest muscle activity and bat speed (Montoya et al., 2009). The ideology of a hitter is that warming up with a heavier object immediately before swinging a lighter object will increase the speed with which that the player can swing the lighter object. The ideology is extended in that swinging a weighted bat will cause greater muscle recruitment which will lead to greater muscle force and bat speed immediately after the removal of the weight (Kauffman and Greenisen, 1973; Reyes et al., 2011). Typically, hitters say that they feel they swing the bat faster after using a weight to warm up (Otsuji et al., 2002). Otsuji et al. (2002) claim that the advantage of warming up with a weighted bat is more psychological than biomechanical due to their observance in a decrease in linear swing velocity when comparing the after effect of using a bat weight and not using one.

This study examined how the effects of warming up with a bat weight compare to warming up with the same bat without the weight. The comparison of muscle activity after both warmup procedures has rarely been studied. Since the muscle activity of a hitter immediately after the use of a bat weight is not often measured, hitters were examined using surface electromyography. I hypothesized that the use of a bat weight before hitting would increase the muscle activity in the important muscles of the swing. As competition is growing in all levels of
baseball, players will be looking for every edge that they can get that will lead them to success when they step into the box.

**Methods:**

*Participants and Location*

The participants in this study included ten Allegheny College baseball players, between the ages of 18 and 22. As college players, they are considered high-level athletes and thus provide consistency from swing to swing.

This study was conducted throughout the 2016 fall semester in the David P. Wise Center (located at Allegheny College, in Meadville, Pennsylvania), which contains a field house with two batting cages. The batting cages are where the experiments took place.

Each participant completed a survey prior to their trials to gather data regarding how often each hitter uses a bat weight and how they felt the use of a bat weight impacted their swing in regards to muscle activity, swing velocity, and overall success (Appendix A). The participants were told that the experiment should be the first time they swing a bat on the day of their trial and that it should also be the first form of physical activity the athlete is participating in that day.

*Experimental Design*

Each hitter went through a dynamic warmup routine and then took a normal round of batting practice, as they would before a game. The warmup round involved 10-20 pitches. The players then had a 10 minute rest. Each day a hitter took two rounds in the batting cage with 15
minutes of rest in between. In these two trials, the different prime mover muscles of the swing (the trail-leg gastrocnemius, the trail-leg biceps femoris, the trail-arm pectoralis major, and the lead-arm triceps brachii) were connected to Vernier EKG sensor electrode leads that had enough slack to let the batters take full swings. For the triceps brachii and pectoralis major, a 3 meter analog extension was needed to provide enough slack to prevent restriction during the swing and detachment of the electrodes. Before the placement of electrodes, the skin was abraded with NuPrep Skin Prep Gel to allow for a clean signal. If there was too much hair on the desired body part, then that particular area was shaved. Three Biopac electrode pads were placed directly on each muscle that was being examined. The electrodes were placed in line with the muscle fibers and surrounded the belly of the muscle, with a firm connection with the skin (Thought Technology, 2008) (Figure 2).

Figure 2. Electrode placement of Biopac electrode patches on lead arm triceps-brachii.

On the first trial day, half of the players took 10 to 12 warmup swings with no bat weight. The other half took the same amount of warmup swings with the Pow’r Wrap 24 Oz. bat weight. The Pow’r Wrap has been trusted by Major League and College baseball players for over twenty five years (Figure 3) (Pow’r Wrap, 2017). The first five hitters to show up were the ones who began without the weight, as the times each participant showed up was random. The
hitters warmed up with the same bat that they hit with and each hitter used the same bat that they used in trial one throughout the rest of the experiment. After the warmup swings, hitters immediately entered the cage and took 5 swings off of a Jugs pitching machine set to throw fastballs at a speed of 35.8 meters per second (80 miles per hour). This speed simulated the velocity of a fastball the hitters may see in a game. The pitching machine was set to throw the ball approximately thigh high, down the center of home plate. It is important to keep variables such as pitch speed, pitch type, and pitch location the same because variations in any of these factors could potentially change the batters’ swings and skew the results. Also, the swings were administered to be game-like swings and if it appeared that a player took a non-game like swing, the EMG for that swing was noted not to be used during analysis.

On a new day, the same experiment was repeated except that the same participants who did not use the bat weight took 10 to 12 warmup swings with a bat weight. The hitters who used the weight in the first trial took the same amount of warmup swings without the bat weight. Each hitter alternated their use of a bat weight and non-use of a bat weight each time they came in for a new trial. Each hitter participated in a total of six trials, in which each trial all four muscle groups were tested. Three of the trials occurred with the use of a bat weight to warmup and the other three occurred without a bat weight. Each trial was run on different days as to prevent fatigue from taking too many swings.

Figure 3. Pow’r Wrap bat weight and positioning on bat (Pow’r Wrap, 2017).
Electromyography

A Vernier EKG sensor interface was used to collect surface EMGs during a player’s swing from the electrodes, which measured muscles activity during the contractions of the muscles. The EMGs were recorded in Logger Lite on a computer (Figure 4). The baseline for the EMG muscle activity was the batter’s static batting stance before the pitch is thrown, at which point the sensors were zeroed. The muscles that were recorded with an EMG included the trail-leg gastrocnemius, the trail-leg biceps femoris, the trail-arm pectoralis major, and the lead-arm triceps brachii. These muscles were selected because they are four of the most heavily recruited muscles during a swing. The triceps brachii and gastrocnemius were measured simultaneously and the pectoralis major and biceps femoris were measured simultaneously. Two muscles were able to be measured at once because of the two channel capabilities of the Vernier EKG sensor interface. By measuring two muscles at once the amount of fatigue experienced by the athletes was reduced since they only needed to take half of the swings.

Figure 4. Examples of raw EMG data of a participant’s lead-arm triceps brachii (blue) and trail-leg gastrocnemius (Red). EMGs were taken simultaneously during five swings.
**Analysis of Electromyography**

The EMGs were analyzed using Logger Lite and Microsoft Excel. Logger Lite calculated the electrical signal with millivolts (mV) on the Y-axis and time in seconds (sec) on the X-axis. The EMG signals from the Logger Lite software were imported into Microsoft Excel where the Root Mean Square (RMS) formula \( \text{RMS} = \left( \frac{\sum x^2}{n} \right)^{\frac{1}{2}} \) was used to translate the data into a curve. In the formula \( x \) represents the voltage of the raw EMG in mV and \( n \) represents the total number of points. The RMS is used to smooth the EMGs and allows for the measurement of the area under the curve (Figure 5) (Thought Technology, 2008). Because each participant is being compared to themselves, the EMGs did not need to be normalized any further and trials between one participant could be compared. To calculate the area under the curve in Microsoft Excel, the trapezoidal rule was used using the data points calculated by the RMS of the EMG as a function of time \( \int_{a}^{b} f(x) \Delta x \approx \frac{b-a}{n} \left[ \frac{f(a)+f(b)}{2} + \sum_{k=1}^{n-1} f\left(a + b \frac{(b-a)}{n} \right) \right] \). The total area for each trial was calculated and an average area under the curve was determined for each trial. Since, the participants alternated the days in which they used the weight and did not, the data was compared between the respected trials. That is, trial one with a weight was compared to trial one without the weight and trial two with a weight was be compared to trial two without the weight.
**Figure 5.** The top graph represents the raw EMG (two contractions) while the bottom graph represents the RMS EMG. The y-axis is measured in mV and the x-axis is measured in sec (Thought Technology, 2008).

**Statistical Analysis**

The area under the curve values were averaged within each trial. To determine the statistical difference between the muscle activity between warming up with a weighted bat and not, a repeated-measures analysis of variance (ANOVA) was run using JMP Pro 12. Significance was set at $P \leq 0.05$. If the ANOVA revealed statistical significance then Tukey’s post hoc analysis was used to refine significance.

**Results:**

**Pre-Trial Survey**

The pre-trial surveys showed that eight of the ten participants have fifteen or more years of baseball experience, while two of the participants have between ten and fourteen years of experience. The surveys also showed that three players always use a bat weight to warm before
an at bat and two participants use it most of the time. One participant said they use the bat weight half the time, while four participants said they rarely use a bat weight. There were no participants who said that they never used a bat weight. Half of the participants said that they believed using a bat weight to warm up would increase success, two of the participants did not believe the use of the weight would increase the chance of success and three participants were not sure. Furthermore, eight of the ten participants believe that their muscle activity would be increased after the use of the bat weight while the other two participants were unsure of its effects. There were no participants who thought the use of the bat weight would not increase muscle activity.

**Electromyography Results**

The muscle activity for each muscle showed no significant differences between the participants warming up with and without the bat weight (P≤0.05) (Figure 6, Table 1). Although some participants showed an increase in certain muscle activity between the use and non-use of the weight, others showed decrease in muscle activity, so there did not seem to be a trend in the data (Figure 6). In the lead-arm triceps brachii trials, four participants saw increases of various degrees in muscle activity after warming up with the bat weight compared to not using it. The other six participants showed decreases in muscle activity from warming up with the weight but the degree to which they differed was high in variability (Figure 6A). For the trail-leg gastrocnemius only three participants showed increases in muscle activity after the use of the weight while the other seven showed varying degrees of decrease in muscle activity (Figure 6B). For both the trail-arm pectoralis and trail-leg biceps femoris, half of the participants showed increases in muscle activity while the other half showed decreases (Figure 6C and D).
Figure 6. Mean muscle activity across trials from Root Mean Squares of EMGs after warming up without the bat weight (blue) and warming up with the bat weight (orange) in the lead-arm triceps brachii (A), the trail-leg gastrocnemius (B), the trail-arm pectoralis major (C), and the trail-leg biceps femoris (D). The Y axis is measuring the total area under the curve of the RMS in millivolts. The X-axis is labeled with individual participants; each blue-orange pair of bars represents one participant. Error bars show standard deviation between trails within treatments for each participant.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>No Weight M±SD (mV)</th>
<th>Weight M±SD (mV)</th>
<th>F</th>
<th>Df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead-Arm Triceps Brachii</td>
<td>0.7870±0.4469</td>
<td>0.6508±0.4013</td>
<td>0.6837</td>
<td>1,35.60</td>
<td>0.4138</td>
</tr>
<tr>
<td>Trail-Leg Gastrocnemius</td>
<td>0.4614±0.3705</td>
<td>0.4174±0.3319</td>
<td>0.8596</td>
<td>1,33.21</td>
<td>0.3605</td>
</tr>
<tr>
<td>Trail-Arm Pectoralis Major</td>
<td>0.7198±0.4759</td>
<td>0.7717±0.4127</td>
<td>0.0223</td>
<td>1,31.84</td>
<td>0.8823</td>
</tr>
<tr>
<td>Trail-Leg Biceps Femoris</td>
<td>0.7360±0.4894</td>
<td>0.7127±0.4127</td>
<td>0.0086</td>
<td>1,33.53</td>
<td>0.9266</td>
</tr>
</tbody>
</table>

Table 1. Means calculated among the means of each participant’s trials and standard deviation calculated from raw muscle activity data. P-values show no significant differences between the two treatments.
Several observations included players showing varying degrees of muscle activity. The varying degrees seemed to have little to do with player height and weight, which were recorded when the participants took the surveys. Also, it was noticeable that some of the participants most solid hits did not come from the highest muscle activity and that when muscle activity was high for a player they did not hit the ball squarely.

Discussion:

My original hypothesis of hitters having increased muscle activity after using a bat weight was not supported by these results. No significant differences in muscle activity were found when it came to warming up with or without a bat weight (Figure 6) (Table 1). Each muscle group tested resulted in a P-value > 0.05 which yielded the difference in muscle activity between the two warm-up methods non-significant. The results suggest that there is not a significant relationship between warming with a weighted bat and a non-weighted bat. Each tested muscle group exhibited both increases and decreases after the use of a bat weight, compared to warming up without one. The amount of increase or decrease in muscle activation was also inconsistent. Furthermore, the participants that exhibited increased of activity in one muscle group were not consistent in having increased muscle activity in the other muscle groups (Figure 6).

The results in my study are consistent with the Ohta et al. (2014) study which found no significant differences in EMG data for movement corrections in the upper limbs after warming up with a weight. Movement corrections refer to a bat weight causing a hitter to have slightly different anatomical positioning in their batting stance as they swing, which causes the muscles
attempt to compensate. Their study examined the lead-arm triceps brachii and trail-arm pectoralis major, among other upper limb muscles, which makes it comparable to my study. They suggest that the use of the bat weight actually diminishes a muscle’s ability to adjust because it decreases the muscle activity. My results show that six of the participants had decreased muscle activity after using a bat weight, however there were four participants who increased their muscle activity after using the weight for the triceps brachii (Figure 6A). Also, seven participants had diminished muscle activity in the pectoralis major after using the bat weight. While more participants decreased in muscle activity following swinging a bat with a heavier mass than the bat they used to actually hit, a larger sample size would be needed to determine if the weight negatively affects muscle activity.

My results are further supported by Kauffman and Greenisen (1973) who used electromyography to find that there was no significant residual effect on muscle activity after using a bat weight to warm up, even though they found that muscles had higher activation while swinging the weighted bat. A baseball player’s ideology may be that after using the weight their muscles will continue to generate the same or an enhanced force when using the unweighted bat. In both my study and Kauffman and Greenisen’s (1973), this ideology seems to be disproved.

The surface electromyography results of Pillmeier et al. (2012) are in agreement with my results in that no significant differences were found in muscle activity between warming up with a heavier compared to warming up with the normal weight. Pillmeier et al. (2012) studied the same muscles that were examined in my study plus many more bilateral muscles. While my study concurs with Pillmeier (2012) in that the four prime movers I examined has no significant differences, Pillmeier presented a more comprehensive list suggesting that even less important muscles to the baseball swing showed no significant differences. It has also been shown that
muscle force between warming up with a weighted bat and warming up with a bat that is much lighter than a normal bat has no significant differences (Pillmeier et al., 2012).

Although bat speed was not used to measure the effects of a bat weight in my study, it is a popular way to examine the consequences of using a weight to warm up. Bat speed and muscle activity can be correlated since it has been shown that increased muscle activity and muscle recruitment can lead to higher muscle force, ultimately resulting in higher swing velocity (Reyes et al., 2011). Bat speed has been shown to be diminished by the use of the bat weight by DeRenne et al. (1992), who found that the as the warm up bat weight deviated the total mass further from the mass of the bat it resulted in slower swing velocities. Otsuji et al. (2002) concurs with these results as hitters hitting suspended balls from the ceiling after sometimes warming up with a bat weight and sometimes not, showed no significant differences in swing velocity. In fact, participants for Otsuji et al., (2002) had a fairly consistent decrease in bat speed after the first swing specifically which was attributed to mechanical changes in bat path. In other words it suggests that the decrease in bat speed may be due to altered hitting mechanics that resulted from warming up with a bat weight. The common trend of bat speed decreasing would also propose the notion that there is some type of fatigue in the muscle activity of the prime mover muscles resulting from swinging the heavier bat. On the contrary, my results showed both decreases and increases in muscle activity which does not support the idea that a decreased bat speed is due to a bat weight causing less muscle activity and recruitment. It has also been shown that the swinging a heavier bat for a short warmup does not produce fatigue (Pillmeier et al., 2012). It could be a result of other aspects such as other a bat weight having a stronger influence on other muscle groups, since the baseball swing is a whole body movement (Reyes et
Future research is needed to examine the relationship between bat speed and muscle activity, along with other factors that may result in diminished bat speed.

My study could have benefited from consistent trial schedules for the participants. Because the participants of this study were college, student-athletes, they were rarely able to come to their trial at the same approximate time of the day. This factor could have led to variations in muscle activity. For example, participants would come between 8:00 AM and 9:00 AM on one day of trials and then not until 10:00 PM on the next day. It is possible that the muscle activity after a person wakes up and close to before a person goes to bed is quite different (Halaki and Ginn, 2012). If participants were able to come at similar times each day they had a trial, the variability of muscle activity throughout the day would not have been a factor. Also, when participants came in later at night it increases their chances of having done activities that resulted in muscle fatigue before their trial, although the participants were notified to avoid this. Unfortunately, on some occasions participants could not avoid mandatory team lifts prior to attending a trial. To compensate they had to wait several hours before participating in their trial and I noted if they had been working out before the trial so that I could identify outliers that may have occurred. Hitting at consistent times of the day throughout the experiment and limiting pre-trial exercise would have reduced intrinsic factors that could have affected muscle activity such as blood flow to the muscle, changes in distance of active muscle fibers, or muscle fiber diameter (Halaki and Ginn, 2012). Future research could examine muscle activity of baseball hitters at different times of the day. Since baseball teams have high variability in the times of the day at which they play their games and muscle activity is known to fluctuate, it may be an interesting study to see if muscle activity is higher at either games during midday or games at night.
There is little evidence that warming up with a bat weight immediately before hitting has any biomechanical benefits in terms of muscle activity, swing velocity and swing path (DeRennes et al., 1992; Otsuji et al., 2002; Reyes et al., 2011; Ohta, 2014). The lack of biomechanical evidence and data that shows hitters believe the bat weight will lead to greater muscle activity and success suggests that the perceived benefit from the use of a bat weight may be psychological. Otsuji et al. (2002) concur with the theory of the bat weight having a predominantly psychological effect due to their post-weighted condition survey results. Participants in the Otsuji et al. (2002) study were asked if they thought the bat felt light and if they thought they were swinging the bat faster after using the bat weight. The participants all said they felt like the bat was lighter and that they felt greater bat speed after warming up with the weight. Otsuji et al.’s (2002) post-experiment survey results are consistent with the Allegheny baseball players’ pre-experiments survey in that most of the players believed the use of the bat weight would have positive effects, either in muscle activity or bat speed. Eighty percent of the participants in my study said they believed that the use of a bat weight would promote increased muscle activity after its use. The studies also concur in that the participants in each study were incorrect in their intuition about the biomechanical effects of a bat weight.

Since the majority of participants in my study believed that the bat weight would produce greater muscle activity after swinging a weighted bat and the results yielded no significant difference between the two warmup routines, it may suggest that the use of the bat weight creates the subjective illusion of swinging an unweighted bat with more force and velocity. My study is in agreement with Ohta et al. (2014) because the participants stated throughout the study that they felt like they were swinging the bat faster and harder in post-bat weight conditions, even though the study found no significant differences the participants muscle activity.
Future research could test to see if players who have a strong psychological belief that they will have greater bat speed or higher muscle activation after swinging a bat weight actually produce an increase in that variable. Since it was evident that some participants increased in muscle activity and some decreased, it could be possible that those that believe they are swinging faster and harder actually are and the ones who do not will swing with less muscle activity and bat speed. This type of experiment should use several surveys, one before the trials, one during the trials, and one after the trials to judge the participants belief that the bat weight actually is helping. Then the experiment should test a variable of the swing much like this study did or it could take a look at bat speed.

Conclusion:

Surface electromyography was used to measure the muscle activity during the contractions of four of the prime movers of the baseball swing. Baseball players use a weight to warm up before they hit because they believe it will increase their chance of success by increasing muscle activity or bat speed. This ideology was supported by the pre-trial survey the ten participants took. However, results yielded a non-significant relationship between the muscle activities after the participants warmed up with a bat weight and without a bat weight. Overall, the results of this study suggest that there is no biomechanical advantage to the baseball swing after warming up with the bat weight with regard to muscle activity. The results are consistent with studies that examined EMG data for differences in weighted warmup swings (Kauffman and Greenisen, 1973; Pillmeier at al., 2012; Ohta et al., 2014). However, because my results showed a non-significant relationship in regards to muscle activity, it does not account for the historical pattern of bat speed decreasing due to a bat weight (DeRennes et al., 1992; Otsuji et al., 2002). More research is needed to identify a relationship between bat speed and muscle
activity. The perceived advantageous effect of the bat weight that the players claimed they felt during the surveys is likely an illusion. Therefore, the use of the bat weight may have a more prominent psychological effect than a biomechanical effect. Future research is needed to see if a player’s belief in how the bat weight effects the swing will actually translate into the player’s expectation.
Appendix A

Participant Survey

The first letter of your mother’s first name (e.g., “Sue” – write down “S”):

Number of older brothers:

Number of older sisters:

The number in your home address (e.g., for 520 N Main St you would put down “520”):

Age:

Class:

Phone Number:

Height (Feet’ Inches”):

Weight (lbs):

How many years have you played baseball?

4 or less | 5-9 | 10-14 | 15+

How frequently do you use a bat weight to warm up before an at bat?

Never | Rarely | Half of the Time | Most of the time | Always

Do you believe that warming up with a weight will improve your chances of success when hitting?

Yes | No | Not Sure
Do you believe that warming up with a weight increases your bat speed immediately after its use?

Yes  No  Not Sure

Do you believe that warming up with a bat weight will induce greater muscle activity during the at bat?

Yes  No  Not Sure
Appendix B

INFORMED CONSENT STATEMENT – ALLEGHENY STUDENTS

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits, and risks of the study and how it will be conducted. Participation in this research is completely voluntary and therefore there are no consequences for either failure to participate or termination of participation of the assessment process.

Title of Study: Effects of warming up with a bat weight on swing speed and muscle activity in baseball players.

Principle Investigator: Colby Griffin, student, Department of Biology, Allegheny College.

Faculty Supervisors: Lisa B. Whitenack, Ph.D., Professor, Department of Biology, Allegheny College.

Purpose of the Study: This study will be used to study what effects, if any, warming up with a bat weight will have on the speed in which a baseball player can swing a bat and if there is any change in the muscle activation in the prime movers of the baseball swing. The use of the bat weight is universal in all levels of baseball yet scientific evidence is lacking regarding its effects on a swing.

Study Procedure: Participants will be asked to complete a brief survey. Each participant will participate in 6 trials, each on a different day. Each trial will consist of 5 rounds of batting practice where players will receive 5 pitches in each round off of a pitching machine. In one round the hitter will be recorded using high speed video cameras to determine angular velocities of the swing. In the other 4 rounds the hitter will be connected to an EKG sensor that will measure one muscle group per round.

Foreseeable Risks: We do not perceive any foreseeable risks or discomfort to our participants.

Benefits to the Subjects: The benefit of this research to the participants will be to gain information on the effect of a bat weight. Results could potentially have an impact on how some players warm up for their at bats.

Confidentiality of Research Records: Information provided by the participants will be used solely for the purposes of data analysis. Participants will be given a number which is what will be linked to the data collected.

Research Participants’ Rights: This research study has been reviewed and approved by the Allegheny College Institutional Review Board (IRB). You may contact the IRB with any questions regarding the rights of research subjects.
**Identity Protection in Video:** Videos from any of the trials have the potential of being presented. To protect player identities the players will wear clothing that would not identify them. If any video is chosen to be displayed in a presentation, the identity of the player will be protected by placing a censor bar over their face.

If you have any questions regarding this research, please contact:

Dr. Lisa Whitenack  
Professor, Biology  
Allegheny College  
814-332-2888  
lwhitena@allegheny.edu

Participant Name (print): ________________________________

I am over the age of 18: _____

By signing this form, I acknowledge that I have read the foregoing information, or it has been read to me. I have the opportunity to ask questions about it, and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Signature: ____________________________________________
References


Reyes GF, Dickin DC, Crusat NJK and Dolny DG. Whole-body vibration effects on the muscle activity of upper and lower body muscles during the baseball swing in recreational baseball hitters. *Sports Biomechanics*. 2011; 10 (4): 280-293.