4-30-2020

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Nathan Iskowitz

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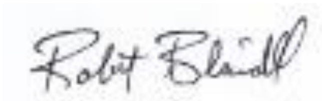
April 30, 2020

Faculty Advisor: Dr. Robert Blaisdell

This thesis has been read and approved by:

Committee Members:

Dr. Robert Blaisdell (Longwood University) 

Dr. Jo Morrison (Longwood University) 

Dr. Laura Jimenez (Longwood University) 

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Study Authors: Iskowitz, Nathan O.[1]; Morrison, Jo[1]; Blaisdell, Robert B. [1]

Affiliations: [1]Department of Health, Athletic Training, Recreation and Kinesiology- Longwood University- Farmville, VA

Abstract

Successful pitching in baseball may be due to several factors including the mechanics of the motion, the strength, power, flexibility of the athlete, as well as their intent and fatigue levels. The pitching motion is a very powerful, violent, complex and abnormal range of motion of the body. In recent studies, it has been widely evidenced that the ability to produce instantaneous high peak force outputs is related to success in sport. Therefore, the ability to produce higher peak force may be related to the ability to pitching in baseball. Mouthguards have been shown to significantly increase power production in several dynamic exercise movements. The purpose of this study was to determine if maximal and average pitching velocity could be increased when wearing a mouthguard. Twenty-two male collegiate baseball pitchers participated in this study (age: 19.9 years old ± 1.4 years, body mass: 87.1 Kg ± 11.6 Kg, body height: 182.5 cm ± 6.1 cm). All study participants were competitive athletes at the NCAA Division 1, Division 3, or University Varsity Club level. Pitching velocity changes resulted in a mean increase of 0.732 km/h for all groups. Velocity change for each level tested resulted in mean increases of 1.652, 0.402, and 0.370 km/h for the university club, Division 3 and Division 1 levels, respectively. The results of a paired samples t-test analysis showed that there was a statistically significant improvement when using a mouthguard in pitching velocity across all groups combined; $t(109) = 2.958$, $p = 0.004$. Further, university club level pitchers experienced a statistically significant improvement; $t(29) = 5.972$, $p = 0.000$; while Division 3; $t(39) = 0.772$, $p = 0.445$; and Division 1; $t(39) = 1.014$, $p = 0.317$; players did not show a statistically significant improvement with the mouthguard. The authors found that a mouthguard may improve throwing velocity in male collegiate baseball athletes. These findings could be useful to both coaches and sport

performance specialists that are working with pitchers to bring about increases in power output and subsequent increases in pitching velocity, simply by implementing the use of a mouthguard.

Introduction

This study investigated the effect a mouthguard could have on pitch velocity in NCAA Division 1, NCAA Division 3, and University club baseball pitchers. The study looked at overhand baseball pitchers who are throwing for maximum velocity with and without the usage of a mouthguard. Data was collected and recorded from velocities after every pitch to compare the data with the usage of a mouthguard and compare to their control numbers where pitchers have no mouthguard inserted. The importance of the data collected may stand to be used by all levels of competitive baseball to offer an ergogenic aid in the process of gaining velocity.

The goal of the present study was to determine if the maximum and average throwing velocity is increased when wearing a mouthguard. It was hypothesized that mouthguard use will increase average and maximal throwing velocity with the same mechanics, intent, strength, flexibility, and fatigue levels in the athlete and that this increase in end-velocity at ball release will be due to an increase in power production. The rationale behind the project is that the mouthguard would act as a buffer between the maxilla and mandible allowing for a greater contraction of the maxilla and mandible muscles during the throwing motion. In theory, this would allow a greater overall force production during the process of throwing allowing for a greater exit velocity of the ball from the hand because of concurrent activation potentiation (CAP).

CAP occurs when muscles that are not directly involved in the activity movement are contracted during the movement, which aids in the overall force production within or during the movement (Ebben, 2006).

In baseball, pitchers are going through constant movement and acceleration during their pitching motion that requires a high level of skill and ability to find success in. The pitching process requires constant practice and repetition to repeat the same display of mechanics throughout the motion. The definition of this process is to deliver the ball to home plate in order to start the play. The most advanced goal of this process is to get every opposing batter to miss the ball that was pitched in motion. Many things go into finding success at the most advanced goal of the pitching process. During the process of the throwing motion, many things can affect the outcome velocity, such as the mechanics of the motion, the strength, and flexibility of the athlete, power, intent, and fatigue (Boggs, 2016). A combination of all these factors results in end velocity after the ball is thrown. The throwing motion is very powerful, violent, complex and abnormal to the normal range of motion of the body. All these factors and more make up the variables in the pitching motion that must be managed and maintained for the pitcher to find success pitching the baseball. After the ball is delivered out of the hand of the pitcher, the outcome of the play is out of their control and any number of results could come from this. Execution of good mechanics is critical in the pitcher's delivery because it gives the best possible outcome to start the play. The biomechanics of the pitching motion include six different phases starting with the wind-up, which is from the initial movement of the pitcher until they reach maximum knee lift. During this phase, weight is transferred from an even distribution to all on the rear leg of the pitcher who is ready to stride down the mound (Escamilla, 2009). The next phase of delivery is the stride, which is when the pitcher drives off his back-foot propelling himself down the mound until just before the front foot strikes at the bottom of the mound (Glenn, 1996). This phase works in conjunction with the arm cocking phase, because in this phase as the pitcher is gliding down the mound the arm travels from the set position under the chin in a near 360-degree motion where the humerus rotates down and in a circular motion to bring the arm back up with the ball in a cocked position for the pitcher to then fire the ball to the plate. There is both an early cocking and late cocking where the arm is cocked before foot strike which is a result of poor mechanics as well as late cocking where the arm is not cocked at foot strike (Escamilla, 2009). Both undesirable scenarios result in the pitcher having less control and velocity of the baseball. The next phase is the arm acceleration phase which begins at maximal shoulder extension and ends at the release of the baseball. This phase consists of shoulder abduction rapidly moving into internal rotation to generate maximum velocity (Escamilla, 2009). Following is the arm deceleration phase which takes place from ball release until maximum shoulder internal rotation is reached. This is the point in the throwing motion where the arm is under the greatest amount of stress and there must be significant work done by the muscles of the shoulder girdle to decelerate the arm (Escamilla, 2009). Finally, the last phase of throwing is the follow-through phase when the body continues to move forward until you are no longer moving and wind up facing the hitter (Seroyer, 2010).

In conjunction with the biomechanics of pitching, the bioenergetics of the action are equally as important. Pitching is a very powerful and fast motion that requires quick movements and acceleration. Pitchers primarily use their anaerobic systems when throwing pitches because it is a very fast and powerful movement with time in between pitches to recover.

The use of mouthguards in sport over the past 100 years has been primarily for protection with the first mouthguard being made to be worn by boxers to prevent them from getting lip lacerations. Since then there have been many improvements to the mouthguard we know today. Mouthguards are now regulated by the American dental association and are also recommended/

required in 29 different sports. Mouthguards are regularly used for protection in contact sports such as football and basketball but are starting to be used more and more in sports where maximum power output has a direct effect on performance such as weightlifting. In recent studies, mouthguards have shown to improve power output in different lifting exercises as well as power movements such as jumping. These recent lights about the effects of mouthguards prompted this study by taking the mouthguard into consideration for increased power production rather than just protection. This is believed to be possible by researchers because of the concurrent activation potentiation (CAP) that happens when an athlete uses a mouthguard and creates a buffer between the maxilla and mandible. CAP is a theory where your performance is increased because of simultaneous activation of muscles primarily involved and not involved in an activity. The activation of all secondary muscles in unison known as remote voluntary contraction can help the prime movers of the action operate more effectively and with more force (Allen, 2020). This study was designed to test this CAP theory and investigate if using a mouthguard in a pitcher will increase maximum velocity by using CAP.

Mouthguards have been shown to significantly increase power production during a countermovement vertical jump with and without arms in college-aged males (Busca, 2017). There are also data showing significant power production differences between the mouthguard wearing subject vs the non-mouthguard wearing subject in power in both men and women (Dunn-Lewis, 2012). Other studies have also shown that clenching down on a customized mouthguard results in a bigger boost in plyometric press power and force production than an over the counter mouthguard (Arnet, 2010). Mouthguard use has also been associated with changes in minute ventilation and VO2peak during maximal exercise in addition to a significant increase in power production in the mouthguard wearing group (Martins, 2018). Further work has shown reductions in post-exercise lactate levels between groups of participants wearing mouthguards when running (Garner et al. 2009).

Mouthguard use has also been associated with increases in strength during the same exercise bout. Handgrip strength was measured in a group of participants when wearing, and not wearing a mouthguard. A significant increase was found in handgrip peak force in the mouthguard wearing group versus the non-mouthguard group. In this same study, there was also a significant increase in scores for back row isometric force in the mouthguard group vs the non-mouthguard group as well as s significant increase in vertical countermovement jump in the group with a mouthguard in place (Busca, 2016). Recent research has shown that mouthguard use is expanding from protection use to use as an ergogenic aid in sports that require power production and strength.

Methods

Introduction

The participants were split randomly into two groups, a group where a mouthguard was used in the first velocity testing period and a group where the mouthguard was velocity tested in the second period. During the first day of interaction with the participants, they went through the informed consent process as well as the mouthguard fitting and familiarization process. These participants were given the opportunity after their mouthguard had been boiled and fitted to use the mouthguard while throwing to become familiar with the piece. In this first session, athletes were also asked to not take part in strenuous activity for at least 24 hours before their testing day. Athletes participating in this study were fitted with a Cramer Custom-Fit mouthguard (Cramer

Products, Inc., Gardner. Kansas) according to the manufacturer's instructions. Throwing velocity was measured using a Stalker 2 Pro radar gun (Stalker Radar, Richardson, Texas) which was provided by each team. Each velocity was recorded in a spreadsheet and was categorized by each person as well as the two testing groups. Baseballs used for this study were a college-approved Rawlings flat seam NCAA baseball that was provided by each team. The maximum velocity tested on the same field mound that the participating team had their regular games and practices on and met all codes for regulation of play.

Participants

Twenty-two male collegiate baseball pitchers (age: 19.9 years old ± 1.4 years, body mass: 87.1 Kg ± 11.6 Kg, body height: 182.5 cm ± 6.1 cm) participated in this study. At the time of the study, all participants were competitively playing at the NCAA Division 1, NCAA Division 3, or University Varsity Club level at an NCAA Division 1 institution. All participants were informed of consent, signed informed consent documents and voluntarily participated in this study.

Procedures

Participants were randomly selected for the variable or control group for their first testing session using a coin flip. Participants completed their respective team warm-up plan that consisted of an aerobic warm-up, resistance band, plyometric ball, multiple dynamic stretches, and their specific throwing warm-up program. These programs consisted of throwing submaximally at a short distance while gradually increasing distance and intent until at the desired length corresponding to their respective warm-up, then decreasing the distance keeping the same intent when throwing. The participants threw until completely warm and were ready to participate in maximum velocity testing. Each participant was given the opportunity to practice throwing while wearing their mouthguard during their warm-up. Participants were randomly assigned which condition they began their maximum velocity throws with; “mouthguard” or “no mouthguard”. During the athlete's first testing period they were given 3-5 throws at maximal intent following the ladder protocol after warming up fully and becoming familiar with the mouthguard. The ladder protocol follows the velocity trend of the athlete, after their first three throws if they drop in velocity on their fourth their trial is over and if they gain velocity they can keep throwing until they either stop gaining velocity or reach 5 throws. The participants completed their throws at maximal intent only being instructed to bite down firmly on the mouthguard and try and achieve peak velocity. No feedback was given on their individual mechanics or form. Feedback of velocity was provided after every pitch to the athlete. Participants were given a 2-3-minute rest period, as customary with the team’s normal training program before completing their final 5 trials. After this rest period was taken by the participants the process was repeated and the participants completed any further warm-up needed after their cool downtime which consisted of a few throws. After rewarming up post-break session the participants completed their next 3-5 throws following the ladder protocol in the opposite group of their first trial. After the testing concluded, the participants completed into a team-issued cool down program. These cool down programs consisted of various intensities of running from sprinting to long-distance cooldowns, foam rolling, stretching, plyometric ball throws, resistance band exercises, mobility drills, etc.

Statistics

Data analysis was performed using SPSS statistical software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Descriptive values have been expressed as mean and SD. A paired samples t-test analysis was completed on pitching velocity with relation to the condition thrown in.

Results

Pitching velocity changes resulted in a mean increase of 0.732 km/h for all groups. Velocity change for each level tested resulted in mean increases of 1.652, 0.402, and 0.370 km/h for the university club, Division 3 and Division 1 levels, respectively. The results of the paired samples t-test analysis showed that there was a statistically significant improvement when using a mouthguard in pitching velocity across all groups combined; $t\ (109) = 2.958$, $p = 0.004$. Further, university club level pitchers experienced a statistically significant improvement; $t(29) = 5.972$, $p = 0.000$; while Division 3; $t(39) = 0.772$, $p = 0.445$; and Division 1; $t(39) = 1.014$, $p = 0.317$; participants did not show a statistically significant improvement with the use of mouthguard. The results are displayed in figure 1. Table 1 below shows the results of the paired sample t-test with a p value of $< .05$ showing significance.

Figure 1. Average velocities between groups

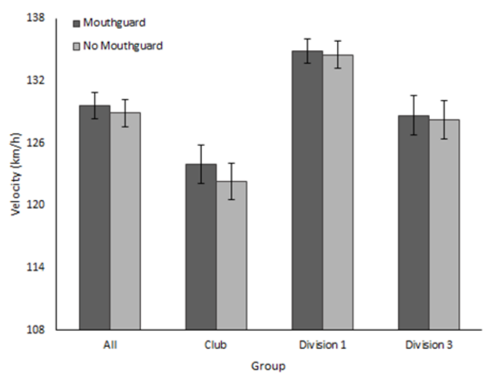

Table 1. Paired sample t-test for all participants together and split into competitive sections

Paired T-test	**NCAA Division 1**	**NCAA Division 3**	**University club**
0.003793547	**0.317020046**	**0.444636233**	**1.7236E-06**

Discussion

The main findings show that with decreased competition level between the players tested, the larger the difference in average kilometers per hour (Km/h) for the mouthguard group. The participants who were members of the university club team had the largest increase in Km/h aided by the mouthguard, followed by the participants that played at the Division 3 level and then the Division 1 players. These findings may be due to a skill gap between the groups and could possibly be a result that the higher competition levels of baseball require experience perfecting variables in their pitching delivery to repeat the same process. This skill differential is possibly related to a higher level of motor development between these players, likely because these competition gaps require much time and effort to jump up levels. These advanced-level players who regularly compete at higher levels may be exposed to more intense training regimes and higher levels of skilled coaching.

The observed increase in velocity when the mouthguard was being used could be attributed to the theory of concurrent activation potentiation. In this theory, the mouthguard acts as a buffer between the maxilla and mandible bones (the jaw), which absorbs force; allowing for greater force production during the bite movement (Lingenfelser, 2014). This has been shown to affect other muscles that are not essential to those responsible for the primary movement but allowing them to contract at a greater force (Lingenfelser, 2014). When simultaneous, additional muscle contractions occur, it may allow for the prime agonist muscles of the movement to experience greater force production. This may be due to previously tensed muscles priming the nervous system and/or due to the higher level of muscle activation (Lingenfelser, 2014).

Practical Application

The authors found that a mouthguard may improve throwing velocity in male collegiate baseball athletes. Specifically, the results showed that as the level of competitive play decreased, the performance boost provided through the mouthguards increased. In this case, the group of pitchers that is most likely the least developed or skilled on the University club team showed the largest increase in velocity from the mouthguard implementation. The NCAA Division 3 team showed less improvement than the University Club team but more improvement than the NCAA Division 1 baseball teams' pitchers. This could be attributed to the differences in the motor skill of these athletes. The higher the level of competition, the higher the skill required to compete and succeed which can be attained by specific practice and training measurements. The higher-level players may have had a higher level of training to improve their movements compared to the lower level athletes. The NCAA Division 1 athletes are allotted 20 hours per week of specific training during their regular season which consists of strength and conditioning, practice, individual workouts, and mechanical rotations. With this amount of training, these athletes may show an improvement in the mechanical aspect of their pitching windup and may show more positive results from their output. NCAA Division 3 employs the same rule and that is why there may be such a small difference between the Division 1 and Division 3 teams in terms of change in velocity. The University club team practiced once or twice depending on their season schedule and had much less time by all accounts for the practice and repetition of their movements. The change in velocity differences showed to be inversely related to the average velocity between the teams showing the NCAA Division 1 team with the highest average followed by the Division 3 and then the University Club team. These findings could be useful to both coaches and sport performance specialists that are working with pitchers to bring about increases in power output and subsequent increases in pitching velocity, simply by implementing the use of a mouthguard.

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