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University of Montana, Missoula

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EXAMINING THE RELATIONSHIP BETWEEN THROWING INJURIES SUSTAINED IN
ADOLESCENT BASEBALL PLAYERS AND USE OF AN INJURY PREVENTION
SMARTPHONE APPLICATION “THROW LIKE A PRO”

By

DAVID SCOTT GROVE

BS Psychology, Appalachian State University, Boone, NC, 2008

Thesis

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Missoula, MT

May 2016

Approved by:

Scott Whittenburg, Dean of The Graduate School
Graduate School

Valerie J. (Rich) Moody PhD, ATC, LAT, WEMT-B, CSCS, Chair
Health and Human Performance

Matthew W. Bundle PhD
Health and Human Performance

James J. Laskin, PT, PhD
Physical Therapy and Rehabilitation Science

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Chairperson: Valerie J. (Rich) Moody PhD, ATC, LAT, WEMT-B, CSCS

Abstract

Background: Throwing related injuries occur in adolescent athletes, a majority being overuse injuries to the rotator cuff muscles and elbow ligamentous structures. Throwing related injuries as well as surgical interventions has increased dramatically among adolescent baseball players. Adequate injury prevention methods are lacking for this population.

Hypothesis: Adherent use of the smartphone application “Throw Like a Pro” will decrease the incident rate of throwing related injuries in adolescent baseball players.

Study Design: Non-random, Between-subjects Experimental Design

Methods: Approximately seventy-five adolescent baseball players will be included in this study. Participants will be separated in a non-random fashion into a treatment group (TG) and control group (CG). Participants in the TG will be instructed on proper use of the smartphone app “Throw Like a Pro”. Surveys will be conducted at three months and six months of use. Data analysis will assess compliance and number of injuries sustained and descriptive statistics will be analyzed. One-way ANOVA will be run to identify statistical significance between compliance and throwing injuries sustained. T-test analysis will determine significance between the TG and CG and throwing injuries sustained.

Results: Athletes in the high compliance group will show significantly less throwing related injuries after 6 months than athletes in the low compliance group. Further, athletes who received the intervention of “Throw Like a Pro” will show decreased throwing injuries when compared to the control group.

Conclusion: The smartphone app “Throw Like a Pro” is recommended for adolescent baseball players, as relationships exist between adherent use of the application and reduction of throwing related injuries.

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Chapter 1

Introduction

Statement of the Problem

There are currently around 9 million youth baseball players between the ages of 6 to 17, and although baseball is a relatively safe sport, arm pain is a very common finding among players. Injuries to the upper extremity account for nearly 33% of all baseball related injuries.¹ The prevalence of arm pain also increases as age increases.² However, factors differ between the common arm pain due to muscle soreness that many experience and isolated shoulder and elbow pain, suggesting differences in etiology of the injury.² The number of high school and college baseball players that have undergone surgical intervention to correct throwing related injuries (TRI) to the shoulder and elbow has grown dramatically in the past few years.³ Furthermore, players are experiencing pain at a very young age, with nearly half of adolescent baseball players experienced shoulder or elbow pain while pitching.^{4,5} While introduction of stretches, exercises, throwing programs, and pitch count regulations offer relief to the growing number of injuries, a lack of education and implementation of these preventative measures exists.

There exists a growing trend in the healthcare industry to use smartphone apps to reach patients and help implement a plan of care. Smartphone apps have increased in use to monitor mental health conditions⁶, provide a remote-based exercise protocol for cardiac rehabilitation patients⁷, as well as used for rehabilitation of ankle injuries.⁸ As 70% of teens aged 13-17 own smartphones⁹, implementation of a smartphone app is a practical alternative to current techniques. Despite the growing dependence of smartphones and other mobile devices for a variety of tasks, very little research has focused on the use of smartphone apps to integrate exercise prescription programs for the general population. To date, no research exists that utilizes

the efficacy of a smartphone app in prevention of TRI. In 2014, Dr. James R. Andrews and Dr. Kevin Wilk worked in collaboration with Abracadabra Health, LLC to develop a smartphone app designed to reduce the number of TRI. The app “Throw Like a Pro” has a Pre-Season mode and an In-Season mode, and contains stretches, resistance band exercises, throwing progression program, and pitch count tracker. The aim of the application is to improve strength, enhance endurance, increase flexibility, and strengthen core muscles used in throwing. As an increasing amount of adolescents use smartphones⁹, the use of an app to facilitate proven exercise protocols to reduce injury is a viable and superior alternative to past dissemination methods of injury prevention.

Purpose of the Study

The rationale behind my research is to determine two critical criteria; does the application provide a platform that is easy to use and accessible enough for the athletes to be compliant with the recommendations, and whether adherent use of the application illustrates a significant relationship to decreased injuries. After collection and analysis of data, dissemination of the information will be presented through an educational seminar to local baseball teams in the Missoula, Montana community. As baseball continues to see high numbers of youth participants, educating the players and coaches directly about effective ways to decrease injury rate is paramount. Dissemination of helpful information for public knowledge is the main reason for research, though dissemination of health research remains ineffective.¹⁰ One study reveals that although an increasing amount of primary and secondary research in the areas of dissemination and implementation exist, little is known about the effectiveness of current dissemination practices. The reviews examined in the study suggest that popular passive dissemination methods

occurring at conferences, professional journals or in mass mailings of educational materials is generally ineffective, at best resulting in only in small changes in practice.¹⁰

The need for more medically oriented content provided by applications exists, as fifty-three percent of orthopedic surgeons are currently using smartphone apps in practice, and of those 96% said they would like more apps to be available for referencing information and techniques.¹¹ The desire to track personal health on a smartphone among those with mental health conditions is almost 80% among the 30 year-old and younger population.⁶ Currently, the National Institute for Health Innovation and the Department of Sport and Exercise Science at the University of Auckland, New Zealand, are studying the effect of a remote personalized exercise prescription program to increase exercise adherence delivered via smartphone.⁷ Therefore, the purpose of this study is to identify if adherent use of the smartphone app “Throw Like a Pro” shows a significant relationship to decreased injuries.

Research Questions

Three main research questions are addressed in this study:

1. How adherent are adolescent baseball players in following the recommendations set forth by the app “Throw Like a Pro”? This question will be discussed by analyzing self-reported data collected from 3 & 6 Month Follow-Up surveys on:
 - a. Number of days per week the participants use the app “Throw Like a Pro”,
 - b. Compliance of participants in following the recommended pre-season throwing interval program,
 - c. Number of days per week the participants perform the recommended stretches,
 - d. Number of days per week the participants perform the recommended exercises, and

- e. Compliance of participants in following the recommended rest periods as suggested in the Pitch Count tracker.
2. Is there a relationship between adherent use of “Throw Like a Pro” and injury rates adolescent baseball players? This questions will be discussed by analyzing self-reported data collected from 3 & 6 Month Follow-Up surveys on:
 - a. Amount of formal practice or game time missed due to injury in the shoulder or elbow.
3. Does the treatment group exposed to “Throw Like a Pro” show a significant decrease in amount of throwing related injuries compared to the control group? This question will be addressed by analyzing the number of self-reported throwing injuries between groups on the 3 & 6 Month Follow-Up surveys.

Hypothesis

Null Hypothesis: There is no relationship between adherent use of the smartphone app “Throw Like a Pro” and throwing related injuries.

Alternative Hypothesis: Adherent use of the smartphone app “Throw Like a Pro” shows a significant decrease in throwing related injuries.

Significance of the Study

Injury prevention programs that are utilized in the smartphone app “Throw Like a Pro” are well established as beneficial for both preventing TRI as well as rehabilitation from such injuries.^{12,13} Obtaining high compliance rates among exercise prescription and rehabilitation programs is challenging^{14,15}. If our hypothesis is confirmed, and the use of the smartphone app will both reveal adherent use as well as decreased injury rate, the implementation of this as an

alternative method to distribute an established preventative exercise program^{12,13} will benefit millions of youth baseball players. As smartphone use increases annually, the move towards technology based applications for therapeutic exercise will reach more athletes with better results.

Positive outcomes will place more emphasis on research that pairs the use of smartphone apps with preventative and rehabilitative programs, as well as provide additional motive for development of more health-based applications that more effectively distribute information to the public, reaching more of the public than current methods permit. This will lead to more effective dissemination of information, ultimately creating a better alternative to educate athletes on current research.

Definition of Terms

1. Injury: The term “injury” in this research project refer to any physical problem to the shoulder or elbow that resulted in at least one missed game or practice.¹⁶ Injuries documented include but are not limited to: shoulder impingement, little league shoulder, little league elbow, and tendonitis in the elbow or shoulder.
2. Shoulder impingement: The term shoulder impingement is a broad term that encompasses a group of pathologies that essentially describes pain in the shoulder region as a result of mechanical ‘impingement’ of the rotator cuff tendons as they pass under the coracoacromial ligament or between the undersurface of the rotator cuff and the glenoid or labrum. Included pathologies are compression, entrapment, or mechanical irritation of the rotator cuff structures and/or long head of the biceps tendon. If left untreated rotator cuff impingement may proceed to partial or complete rotator cuff tendon rupture.^{17,18}

3. “Throw Like a Pro”: This study focuses on a smartphone application “Throw Like a Pro” smartphone application (Abacadabra Health, Inc. Birmingham, AL <https://itunes.apple.com/us/app/throw-like-pro-dr-james-andrews/id885558423?ls=1&mt=8>) This application was developed in order to educate youth on throwing related injuries, and incorporates stretches, therapeutic exercises, and a throwing progression program with goals of strengthening the throwing arm and preventing injury.
4. Compliance: For the purpose of this study, compliance refers to how adherent the participants are in performing the stretches and exercises presented in “Throw Like a Pro”, as well as following the recommended rest periods as dictated in the throwing progression program and pitch count tracker.
5. Prevalence: The term prevalence in this study refers to the incident rate of throwing related injuries of adolescent baseball players.

Delimitations

The participants for this study will include 12-18 year old baseball players participating in the Babe Ruth League youth baseball organization. Participants will be given two 11-item surveys referred to as the “3 Month Follow-Up Survey” and the “6 Month Follow-Up Survey”. In addition to the surveys, participants will complete demographic questionnaires outlining current and past baseball related activities and history of previous injuries. Researching the overall change in strength of the athletes using EMG or other data is not indicated, as this the focus of this study is purely the relationship between use of the application and injury rate.

Limitations

We acknowledge certain limitations and threats to internal validity within our study. Mortality of participants is likely, as no requirement can be made of the participants to complete

the follow up surveys.¹⁹ It is likely that a decrease in numbers from prospective participants to completed participants will occur. Participants will not be able to fully complete the initial throwing progression program as outlined in the application. Introduction of the app will not be initiated long enough before formal practices and games took place to complete all phases of the throwing progression program pre-season. Though proper form and effort on stretches and band exercises will be instructed and demonstrated to participants, the majority of exercises and stretches are performed without direct supervision of the principle investigator. Improper mechanics may alter the effectiveness of the stretches and exercises. As injury rates will be collected via online survey, potential responder bias exists on self-reported surveys and questionnaires in regards to injury and compliance. Also, It is possible that other confounding factors of existing risk-related activities associated with throwing injuries will be present within the studied population.

Threats to external validity are also present within this study. Treatment diffusion threats are possible, as a participant in the treatment group may expose their use of “Throw Like a Pro” to their peers in the control group, in turn affecting the actions of those in the control group.¹⁹ Steps to minimize this effect will be taken in that the participants in the control group are not in close proximity geographically to those in the treatment group. As the sample population will be taken from Missoula, Montana, environmental conditions may restrict participation in baseball related activities more in the selected sample population than in warmer climates, thus creating an external threat of ecological validity.¹⁹ The injury rate among adolescent baseball players in Montana may differ regionally due to these differing amounts of baseball activities.

Organization of Remaining Chapters

The remaining chapters will present relevant information to the proposed study. A review of the current literature on throwing related injuries and injury prevention is discussed in chapter two. Lastly, methodology of the proposed study is outlined in chapter three.

Chapter 2

Review of Literature

Overview

Millions of adolescent baseball players participate in both recreational and competitive leagues each year.¹ Little League Baseball is the largest operating youth sports program, and reports having more than 2.4 million participants each year in over 80 countries,²⁰ and the Babe Ruth League reports over 1 million participants each year.²¹ Participation in baseball is increasing, as sample weights provided by the National Electronic Injury Surveillance System (NEISS) show more than 15.5 million baseball participants in 2002,²² and in 2008 USA Baseball reported more than 19 million adolescent baseball players.²³ Baseball ranked as the third most popular high school sponsored sport in 2013 among male athletes.²⁴ Although baseball is a relatively safe sport to participate in compared to other sports, injuries are still prevalent and injured athletes are subject to potentially costly long-term disability, especially pitchers.²⁵ The severity of baseball injuries is often more than other sports, and the combination of relatively high severity and the very large number of participants in these sports produces a substantial number of individuals with significant injuries each year.²⁶ One study found that baseball ranks second highest for the percentage of injuries resulting in loss of participation longer than 7 days.²⁷

Baseball Related Injuries: Acute vs. Chronic

Acute Injuries

Baseball injuries are categorized into two common categories: acute injuries resulting from internal forces placed on anatomical structures or external traumatic forces, and insidious or chronic injuries that occur as a result of repetitive micro trauma on soft tissues. A 2009 study

focusing on acute injuries in adolescent baseball players found over 1.5 million emergency department visits due to injury between 1994 and 2006. The majority of acute injuries were to the head and upper extremity accounting for 65.9% of injuries, and overall rate of injury proves highest in adolescents 13 to 17 years old.¹ These findings as well as an increase in epidemiology and injury surveillance research in baseball exposed a need for organized baseball to initiate medical advisory committees to generate policies aimed at reducing the risks of injury in baseball.²⁶

Efforts to reduce acute injuries in baseball have led to better protective equipment such as helmets with face shields, properly fitted mouth guards, safety baseballs, and breakaway bases as well as increased focus on proper techniques and regulations on pitch type and pitch count in certain leagues.^{1,25} Similarly, field conditions and environmental cautions such as lighting strike are taken into account to reduce injuries. While this awareness to limit preventable injuries has spread throughout organized baseball, high participation rates still expose millions of adolescent baseball players to injury, signifying the importance of injury prevention.

Chronic/Overuse Injuries

However, more common baseball injuries, though often harder to identify and quantify, are overuse injuries.²⁸ Throwing related injuries account for a majority of the overuse injuries that occur in baseball, and a vast amount of research is conducted focusing on overuse injuries in the overhead athlete, specifically of musculoskeletal origination in the throwing arm. Among the most common of injuries are ulnar collateral ligament (UCL) tears, rotator cuff tendonitis or muscle damage, “Little League Shoulder”, “Little League Elbow”, and shoulder impingement syndrome.^{3,12,13,18,25,26,29–35} These common injuries to the shoulder and elbow affect adult and adolescent populations alike.

Ulnar collateral ligamentous damage is among the highest reported and fastest growing chronic injuries in adolescent baseball players. In one major center, approximately 8% (7/85) of UCL reconstructions were performed on adolescent athletes between 1988 and 1994, jumping to approximately 13% (77/609) between 1995-2003.³⁶ Further, approximately 28% of adolescent baseball pitchers report experiencing medial elbow pain while pitching.⁴ Increase in injury rate may be attributed to heightened awareness and recognition of the injury, improvements in surgical outcomes, excessive pitch counts, or pitching while fatigued.³⁷

Shoulder injuries, namely shoulder impingement syndrome, are possibly the most common throwing-related injury that overhead athletes will suffer during their playing career.^{18,38} The term shoulder impingement is a broad term that encompasses a group of pathologies that essentially describes pain in the shoulder region as a result of mechanical impingement of the rotator cuff tendons as they either pass under the coracoacromial ligament or between the undersurface of the rotator cuff and the glenoid cavity or labrum.^{13,18,38} Included pathologies are compression, entrapment, or mechanical irritation of the rotator cuff structures and/or long head of the biceps tendon. If left untreated rotator cuff impingement may proceed to partial or complete rotator cuff tendon rupture.^{17,18}

A mass of research is conducted on various pathologies related to shoulder impingement. Ludewig and Reynolds¹⁷ provide evidence that scapular motion abnormalities on the thoracic wall can also contribute to shoulder impingement. Normally, the scapula rotates upward and tilts posteriorly during arm elevation, however poor coordination of these movements may contribute to an impingement rotator cuff injury. Abnormal activation of the deltoid and supraspinatus muscles resulting in an increased critical shoulder angle of the glenohumeral (GH) joint also shows strong associations with rotator cuff pathology.³⁹ Research suggests that limited internal

rotation of the GH joint and posterior capsule tightness may cause superior translation of the humeral head, increasing the risk for subacromial impingement.⁴⁰

The outcomes for shoulder injuries can be unpredictable, and include both fear of re-injury as well as physical re-injury, chronic pain, and disability. Further, research shows that only 50% of shoulder injuries resolve within the first 6 months, with 40% of injuries persisting for more than 12 months.^{41,42}

Adolescent Injuries

As this paper focuses on the adolescent population, it is important to note specific throwing related injuries to the adolescent population. Among the previously mentioned injuries including valgus stress on the medial aspect of the elbow and shoulder impingement, adolescents are subject to elbow dislocations, olecranon “sleeve” fractures, supracondylar, lateral condyle, and radial head or neck fractures.⁴³ Adolescent baseball players are especially prone to two common injuries: “Little League Shoulder” and “Little League Elbow”.

Although the direct cause of “Little League Shoulder” is still uncertain, it is characterized as throwing-related pain localized to the proximal humerus and radiographic findings of widening of the proximal humeral epiphysis.⁴⁴ It is also characterized by progressively worsening upper arm pain with throwing.²⁹ The most common etiology is a result of overload of the proximal humeral epiphysis near the time of end range shoulder external rotation.^{44,45} “Little League Shoulder” is a debilitating injury, and Carson and Gasser found in one case study of 23 adolescents the average duration of symptoms persisted over 7 months.⁴⁴

“Little League Elbow” is attributed to a medial epicondyle avulsion from the humerus.^{2,12,26,32,33,46} Rice and Congeni define “Little League Elbow” as medial elbow pain in skeletally immature athletes as a result from throwing a large number of pitches or maximum-

effort throws, insufficient rest between pitching assignments, or improper throwing mechanics.²⁶ Pitchers are most likely to be affected by this condition, but it can also occur in other players at positions requiring frequent and forceful throwing such as catchers and outfielders. Traction forces on the medial elbow can cause separation or avulsion of the humeral medial epicondyle apophysis and overuse injury to the common flexor tendon, while compression forces laterally can cause osteochondritis dissecans in adolescents and Panner disease in children younger than 10 years.^{12,26}

Risk Factors

Numerous studies have identified activity related risk factors for these injuries, and have examined everything from the biomechanical forces of the throwing motion, pitch type used during competition, overall pitch count, and other risk prone activities associated with TRI.^{1-4,25,26,32,33,35,46,47} Certain risk factors are attributed to TRI in adolescent athletes, and recommendations are made based on these factors. Tyler et al¹⁶ obtained preseason strength and range of motion (ROM) measurements from 101 high school pitchers. Findings suggest that though ROM deficits did not correlate to higher incidence of injury, preseason weakness of the supraspinatus muscle, a main stabilizer of the shoulder,³⁹ resulted in significantly increased risks for major injury (missing more than 3 games) during the season.¹⁶ Similar risk-prone pitching activities are identified by Yang et al³⁵ and include: pitching in back-to-back days, pitching in multiple games in one day, pitching for multiple teams within one season, and throwing curveballs. These activities all had a significant impact either on increased arm tiredness or pain. Yang et al³⁵ further determined overall risk-prone activities to include: pitching competitive baseball for over 8 months per year, pitching in a league without pitch counts or limits, assuming

the catcher position when not pitching, and playing baseball exclusively with no other sport participation.

Prevalence of Injury

While some research shows that serious arm injuries have leveled off in recent years after the introduction of methods to reduce arm injuries such as pitch type and pitch count,^{48,49} there is an apparent rise in elbow injuries based on the increased coverage by the media and television networks. Although there are no national databases that show the total number of elbow surgeries in baseball pitchers, the Andrews Sports Medicine and Orthopaedic Center supports the belief that an increased number of elbow injuries are occurring.⁴⁹ Recent studies have shown supporting evidence that serious shoulder and elbow injuries are occurring in the adolescent population, with many athletes having serious injuries necessitating surgical intervention for treatment.^{3,4,36,37} A 1999 study reveals that out of 500 pitchers aged 9-14 years old, 50% reported experiencing elbow or shoulder pain during the season.³⁷ Shoulder and elbow injuries constitute a majority of overuse injuries in adolescent baseball players, and a significant amount of time is lost from participation due to these injuries, particularly if surgical intervention is required.

Implementation of Injury Prevention Strategies

While overuse or repetitive trauma account for 50% of adolescent injuries⁵, and as nearly half of baseball players between ages 9 to 14 have experienced shoulder or elbow pain while pitching,⁴ the need for better injury prevention programs is imperative. Epidemiological research indicates the incidence of TRI in adolescents is on the rise due to a multitude of factors including immature ossification of the physis plates in the elbow which relates to physical maturity⁴⁹, improper throwing biomechanics, pitch type and pitch count, increasing emphasis on velocity, rotator cuff weakness, and glenohumeral internal rotation deficits (GIRD).^{5,37,49-51}

Implementation of preventative programs to decrease throwing-related injuries need to address these risk factors.

The National Athletic Trainers' Association (NATA) released a position statement in 2011 outlining the key elements of injury prevention in pediatric athletes (6-18 years of age). Outlined in this document are recommendations on injury surveillance, pre-participation examinations, and strength and conditioning exercises for prevention of overuse injuries among adolescent athletes. Trainings on recognition and record keeping of injuries are recommended, along with thorough pre-participation examinations conducted for all adolescent athletes with emphasis placed on implementation of proper strength and conditioning programs.⁵

The NATA recommended approach to injury prevention includes pre-season and in-season training programs focusing on neuromuscular control, balance, coordination, flexibility, and strengthening of the lower extremities starting at least 2 months before the sport season starts. Pediatric athletes are recommended to have at least 1 to 2 days off per week from competitive events, with the progression of training intensity not to increase more than 10% each week to allow for adequate adaptation and to avoid overload. After injury or delayed time without throwing, a gradual return-to-throwing program over several weeks is recommended before resuming full throwing activities. Finally, recommendations are made for adolescent athletes to participate in other sports to enhance overall fitness and coordination.⁵

Preventative/Rehabilitative Exercises

Stretching

Stretching, therapeutic exercise, throwing progression programs, and rest periods in between activity are well documented in the research to help prevent throwing-related injuries. Stretching increases ROM of the shoulder joint, thereby reducing risk of injury due to tight

muscular and ligamentous structures.^{17,46,52} The posterior shoulder soft tissue plays a significant role in the motion of an overhead throw, and research illustrates that tight or sore posterior shoulder soft tissue is attributed with throwing-related injuries. As the humerus internally rotates after the release of the ball, the posterior shoulder muscles and ligaments are placed in a position of primary restraint of the decelerating arm.^{51,53} As accumulative stresses are placed on these tissues, the posterior shoulder capsule and soft tissue are subject to tightness and overuse injuries. Research by Trakis et al⁵⁴ demonstrates that posterior shoulder strengthening is indicated as an important injury prevention exercise, as well as for shoulder rehabilitation in adolescent athletes.

Overhead athletes tend to have increased external rotation and decreased internal rotation of the GH joint. It is theorized that loss of internal rotation and total motion after throwing is a result of eccentric muscle damage as deceleration forces are placed on the posterior muscles.⁵⁵ Increasing internal rotation of the shoulder helps reduce the risk of altered kinematics of the joint, reducing risk of injury.^{46,53} The sleeper stretch is commonly used to help lengthen the soft tissue of the posterior shoulder, and is clinically proven to acutely increase posterior shoulder flexibility and internal rotation of the GH joint, thus decreasing the risk for injury.⁵² To perform the sleeper stretch, athletes are in the sideling position to restrict scapular movement. The shoulder is then internally rotated to isolate the posterior soft tissue restraints.^{46,52,56,57}

The cross-body stretch is also utilized to prevent posterior capsule tightness of the shoulder, and some debate has occurred as to whether the sleeper stretch provides better results of increased internal rotation ROM than the cross-body stretch. McClure et al⁵⁷ included 54 asymptomatic participants in a study using both the cross-body stretch and the sleeper stretch. Results show that the cross-body stretch provided significantly better internal rotation ROM than

the sleeper stretch, while the sleeper stretch failed to provide significant gains in internal rotation ROM than the control group of no stretch.⁵⁷ This is contradicted in research by Laudner et al⁵² that show the efficacy of the sleeper stretch on internal rotation. Other research suggests that the sleeper stretch is aggressive on the shoulder joint and often performed incorrectly by the athlete when performing independently, and preference is given to the cross-body stretch.⁵⁸ As insufficient evidence exists to recommend one stretch over the other, a common approach is to use both stretches to increase internal rotation ROM.^{46,59}

The throwing motion also places increased stress on the soft tissue structures of the medial elbow and forearm, and kinematic data shows that the flexor-pronator mass, specifically the flexor carpi ulnaris, serves as a main dynamic stabilizer of the elbow.⁶⁰ As forces accrue on the flexor-pronator mass, micro trauma accrues in the tissues, placing it at increased risk for injury. It is believed that flexor-pronator mass injuries occur before or concurrently with UCL injury.⁶¹ The forearm and wrist extensor muscle mass contributes to ulnohumeral depression, providing further stabilization to the elbow.⁶⁰ Therefore, stretching of the flexor-pronator mass and common extensor mass is utilized for prevention of elbow injury.

Tightness of the pectoralis minor is associated with altered scapular kinematics, previously discussed in changing the throwing motion and predisposing an athlete to injury. As scapular dyskinesis is a common finding in subjects with shoulder impingement syndrome⁶², stretching of the pectoralis minor is indicated for injury prevention. Borstad and Ludewig⁶² researched three stretches purported to increase pectoralis minor length. The corner stretch is proposed as the most effective stretch for lengthening the pectoralis minor and is used in both preventative and rehabilitative programs, though more research is needed to support the efficacy

of this stretch.^{13,17,59,62} After proper stretching occurs in the necessary tissue, strengthening of the shoulder and elbow muscles in the throwing arm is recommended.^{12,13,59,63}

Therapeutic Exercise

Strengthening of the muscles surrounding the GH joint and elbow joint is key for dynamic stability during the throwing motion. It is well noted that adequate strength of the rotator cuff muscles is imperative for stabilizing the humeral head as well as promoting inferior translation of the humerus in the glenoid fossa.^{13,17,58,64} This action on the humeral head allows for the shoulder to move through the normal throwing motion with adequate space for the soft tissue structures between the acromion of the scapula and the humeral head. When the arthokinematics of the shoulder are affected due to overly tight or weak musculature or inflammation, pressure is placed on these soft tissue structures increasing the risk for shoulder impingement syndrome and labral tears.^{13,17,18,58,65}

A systematic review by Littlewood et al⁶⁶ reveals all 20 studies reviewed show a beneficial response to rotator cuff exercises. Kuhn's systematic review of rotator cuff impingement exercises shows that strengthening exercises should focus on the rotator cuff and scapular stabilizing muscles.⁵⁹ Rotator cuff and scapular stabilizer strengthening should be utilized in all planes of movement, and each exercise is recommended to be performed in 3 sets of 10 repetitions, with increases in elastic resistance as strength and endurance improves.⁵⁹

Many preventative and rehabilitative programs designed for increasing rotator cuff strength and scapular stabilization include a series of proven therapeutic strengthening exercises termed the Throwers Ten Exercise Program (TT).^{12,13,63,67} The Throwers Ten is designed to exercise the major shoulder, elbow, and scapular muscles needed for throwing, and improves strength, power, and endurance of the shoulder and elbow complex. Exercises focus on the GH

movements of flexion, extension, external rotation (0 and 90 degrees abduction), internal rotation (0 and 90 degrees abduction), abduction to 90 degrees, scaption external rotation, side-lying external rotation, prone horizontal abduction (neutral and full external rotation and 100 degrees abduction), prone rowing (into external rotation), press-ups, push-ups, elbow flexion, elbow extension (abduction), wrist flexion and extension, supination, and pronation. The Throwers Ten program shows positive results in rehabilitation of varying shoulder and elbow pathologies.^{12,13,63,67}

Throwing Progression Programs

Adequate strength and endurance of the rotator cuff and stabilizer muscles is needed to withstand the repetitive forces placed on them while throwing. Throwing progression programs are theorized to build strength of these muscles in a progressive manner while avoiding overloading the muscles too soon. Many different throwing progression programs are used in strengthening the arm and are developed based on age and sport specific distances and need.^{32,68,69}

Reinold et al⁷⁰ developed interval sport programs that progress an injured athlete back towards competition. The little league interval throwing program outlined in their study progresses the athlete through two phases of increasing distance and volume of throwing, and takes four weeks to complete.⁷⁰ Although the majority of the interval throwing program is from flat ground, the crow-hop method is instructed in order to maintain proper throwing form and biomechanics. Research supports the crow-hop method, and also suggests that off-the-mound throwing be utilized earlier in throwing interval programs.^{12,13,68,70,71}

Rest Periods and Pitch Counts

Overuse shoulder and elbow injuries in youth baseball result from the repetitive stresses of throwing and lead to muscle fatigue and then to muscle, tendon, and ligament damage.²⁶ A common conservative treatment for overuse injuries to the muscle includes the RICE principles in immediate care: rest, ice, compression, and elevation, though the efficacy of this approach is consistently debated in the literature and has limited experimental evidence.⁷² However, resting is thought to decrease metabolic activity of the injured tissues, allowing for the healing process to take place. An inadequate rest period for pitchers has emerged as a major risk factor in developing shoulder and elbow injuries.^{3,35} Rest periods and pitch counts are currently being implemented in youth baseball leagues in order to limit the amount of pitches, and therefore repetitive stress on the throwing arm.^{2,4,25,26,51} Research on pitch type and count recommend that pitchers between 9 and 14 years old should be limited to 75 pitches in a game and 600 pitches in a season, along with recommendations of limiting number of batters faced to 15 per game and 120 per season.^{2,4} Rest periods are also implemented during the interval-throwing program designed for pre-season strengthening of the throwing arm, as progression to the next phase of the program recommends 24 hours of rest. Current methods for monitoring pitch count is limited to keeping a pitch count log, or tracking total innings pitched.^{2,4,26}

Smartphone Applications

Smartphone use has increased dramatically in recent years, as 70% of adolescents aged 13-17 now own a smartphone.⁹ Smartphone application use has followed the same trend, with an average of 27 apps and 30 hours of use monthly per person.⁷³ Smartphone applications are validated methods for collecting data⁷⁴ on physical activity levels and energy expenditure, and are steadily growing in popularity within the medical community. Smartphone apps have

recently been implemented for use in rehabilitation, exercises prescription, and other medical capacities.^{6-8,11} The National Foundation for the Center for Disease Control and Prevention recently developed a concussion related app “HEADS UP” that is aimed at helping parents and coaches learn how to spot a concussion, and proper care for a concussion or other serious brain injury. The app also instructs on helmet safety and highlights information on selecting an appropriate helmet activity. Surveys among orthopedics have shown that 53% use apps in a clinical setting, and among them 96% reported wanting more apps available to orthopaedic surgeons and are willing to pay an average \$30 for a time-saving application.¹¹

Today, only a few apps are available containing a claim to prevent sports injuries. A recent review found that of 18 iPhone and iPads apps, only four incorporate evidence on effective preventive measures or treatment protocols.⁷⁵ Three applications on shoulder and rotator cuff injuries were included in the 18, however all three were found to be absent of evidence as determined by Mechelen et al⁷⁵ Another Dutch research team, Reijnen et al⁸, developed and implemented an app “Strengthen Your Ankle” for a proprioceptive balance-board training program for prevention of ankle sprains. Analysis of this application by Vriend et al⁷⁶ compared the effectiveness of this application for ankle sprain prevention. Findings show that the dissemination of this app seemed encouraging based on the total number of downloads since its release, however a low percentage of users sustained an ankle sprain over that period. Further, actual app usage did not indicate that users conducted a high enough number of required exercise sessions for the program to be effective.⁷⁶

Throw Like a Pro

To our knowledge, only one current smartphone applications exist purely for prevention of throwing related injuries. “Throw Like a Pro” is an application designed by Abracadabra

Health, LLC in coordination with Dr. James Andrews and Dr. Kevin Wilk of the American Sports Medicine Institute. “Throw Like a Pro” incorporates clinically based techniques into the development of the app, which are proven to produce beneficial results in strengthening the throwing arm and reducing risk for injury.^{12,49,63,70}

“Throw Like a Pro” is separated into four initial sections: Injury Overview, which presents background information regarding TRI to the user, along with statistics on current injury rates as well as goals for the application of improving strength, enhancing endurance, increasing flexibility, and strengthening the core muscles; Pre-Season preparation, which instructs users on proper stretches, the Thrower’s Ten strengthening program, and an interval throwing progression program; In-Season recommendations of proper warm-up, pitch-count tracker for pitching athletes, and general recommendations on avoiding behaviors associated with increased risk for injury; and finally a general overview of the company and chief researchers.

Summary

Baseball continues to be a popular sport for millions of adolescent athletes.^{1,20-23} Although baseball is a relatively safe sport, injuries in baseball can lead to long-term disability and withdrawal from participation.²⁵⁻²⁷ Overuse injuries are among the leading cause for baseball injuries in adolescent athletes, with serious shoulder and elbow injuries increasing in occurrence.^{28,36,41,42,49} Certain risk behaviors are identified with increased injury, including weak rotator cuff muscles, scapular dyskinesis, posterior shoulder capsule tightness, and overloading the muscles and tendons with too large a volume of activity.^{1-4,16,25,26,32,33,35,39,46,47} Implementation of these preventative measures are taking place in adolescent baseball leagues, however injury rates are still high with 50% of players experiencing pain in the shoulder or elbow while participating.^{1,4,5,25,26}

Research and implementation of preventative and rehabilitative stretching and exercise programs have shown beneficial results in decreasing TRI. Stretching of the posterior shoulder capsule increases ROM, therefore reducing risk of injury.^{46,53,55,57-59} Therapeutic exercise programs such as the Thrower's Ten Exercise Program demonstrates increases strength and stability of the GH and elbow joint, both necessary for recovery from injury as well as helping to prevent TRI.^{12,13,63,67} Interval throwing progression programs increase the strength of the throwing arm in a safe and progressive manner without causing undue stress on the throwing arm.^{32,68-70} Implementing rest periods between pitching activities and pitch counts reduce the stress on the throwing arm.^{2,4,25,26,51}

As smartphones become more prevalent in the adolescent population^{9,73}, the use of applications for injury prevention is a viable method for dissemination of information and an easy way to relay preventative therapeutic exercises to decrease injuries. Hootman et al⁵⁰ determined in their report on summary and recommendations for injury prevention initiatives that emphasis on developing, evaluating, and implementing injury prevention interventions over the next decade is of great importance. As no current research on prevention of throwing-related injuries through use of smartphone applications exist, our research focuses on examining the relationship between throwing injuries sustained in adolescent baseball players and use of the injury prevention smartphone application "Throw Like a Pro".

Positive results of this study will have a beneficial impact on reducing TRI, and will offer alternative options for implementation of preventative exercise programs. Furthermore, if the "Throw Like a Pro" app does indeed reduce TRI and show high rates of compliance, this will provide necessary validation to spread the use of this injury prevention application to wide

reaching population of adolescent baseball athletes with the possibility of preventing a substantial number of injuries.

Chapter 3

Methods

As outlined in the first two chapters, the purpose of this study was to examine the relationship between throwing injuries sustained in adolescent baseball players and use of the injury prevention smartphone application “Throw Like a Pro”. Three main research questions were asked in this study: 1. How adherent are adolescent baseball players in following the recommendations set forth by the app “Throw Like a Pro”, 2. Is there a relationship between adherent use of “Throw Like a Pro” and injury rates adolescent baseball players, and lastly, 3. Did the treatment group exposed to “Throw Like a Pro” show a significant decrease in amount of TRI compared to the control group?

A Chi Square for association was utilized to show relationship between adherence to the app, and number of injuries sustained. A non-random, between-subjects experimental design was used to show significant differences in throwing injuries between the two treatment groups. Participants completed a demographic questionnaire assessing past and present baseball activities and history of injury. Follow-up surveys were used to assess compliance in using the app “Throw Like a Pro”, as well as identify injuries sustained during the course of the study. This chapter discusses the design of the research study, as well as a review of the research questions. The population, sample, selection of participants, and instruments used are also addressed in this chapter.

Research Questions

Three main research questions were addressed in this study:

1. How adherent are adolescent baseball players in following the recommendations set forth by the app “Throw Like a Pro”. This question was analyzed using self-reported data collected from online self-reported surveys on:
 - a. Number of days per week the participants used the app “Throw Like a Pro”,
 - b. Compliance of participants in following the recommended pre-season throwing interval program,
 - c. Number of days per week the participants performed the recommended stretches,
 - d. Number of days per week the participants performed the recommended exercises, and
 - e. Compliance of participants in following the recommended rest periods as suggested in the Pitch Count tracker.
2. Is there a relationship between adherent use of “Throw Like a Pro” and injury rates in adolescent baseball players? This questions was analyzed using self-reported data collected from online self-reported surveys on:
 - a. Amount of formal practice or game time missed due to injury in the shoulder or elbow.
3. Does the treatment group exposed to “Throw Like a Pro” show a significant decrease in amount of TRI compared to the control group? This question was not addressed due to the limitation of not presenting a control group.

Participants

The population for this study consisted of adolescent baseball players within the United States. It is estimated that there are just over 2 million baseball players between the ages 13 to 17 in the United States.¹ Participants of this study consisted of youth baseball players varying in age from 12 to 18 years old, participating in a Babe Ruth League youth baseball team in Western Montana.

Selection of Participants

A total of 20 participants were selected from Babe Ruth League youth baseball teams in Western Montana. A non-random, purposive sampling technique was used to obtain participants for this study. This sampling technique is described by Johnson & Christensen in that the researcher “specifies the characteristics of the population of interest and locates individuals with those characteristics”.⁷⁷

Eligibility for inclusion in this study was based on participating in the Babe Ruth youth baseball organization; having personal access or parents with access to a smartphone or other device capable of carrying "Throw Like a Pro"; and completing the follow-up surveys at the culmination of the study. Exclusion criteria for this study included anyone not participating in the Babe Ruth youth baseball organization; not having access to "Throw Like a Pro" app, or currently exhibiting a TRI to the shoulder or elbow.

Ethical Nature of Data Collection

Prior to collecting any information, approval from the University of Montana Institutional Review Board (IRB) was granted. Participants 18 years of age were provided with a Subject Information and Informed Consent Form (Appendix A). Participants under 18 years of age were provided with a Minor Consent Form (Appendix B), along with parental approval obtained via

the Parental Permission form (Appendix C). An Online Survey Consent Form was obtained from all participants, which is included in the informed consent forms. All information collected in this study was kept confidential by use of subject ID numbers, as well as keeping hard documents in a locked file cabinet.

Procedures

The procedures for the quantitative data collection in this study consisted of: an initial in-person meeting with the prospective participants, parents, and coaches, collection of a demographic questionnaire assessing past and present baseball activities and history of injury (Appendix D), the 3 Month Follow-Up Survey (Appendix E), and the 6 Month Follow-Up Survey (Appendix F). Surveys were conducted using the internet-based survey collection software Survey Monkey. Prior to utilizing the surveys in this research, a group consisting of UM faculty, coaches, and former baseball players reviewed the surveys and made suggestions towards accuracy and clarity of the questions, readability of the survey, and an estimate of time to completion of the survey. Corrections were made based on expert opinion and feedback from the review group.

The timeline for this study started with obtaining IRB approval the first week of April 2015. Contact with coaches of prospective participants was made via email and phone following IRB approval. The initial meeting with coaches, parents, and participants took place on April 28th, 2015. The start date for data collection began on the day of the initial meeting. Follow-up contact with participants was made via phone or in person two times per month to answer any questions and encourage use of the smartphone application. Three months after the initial meeting, the 3 Month Follow-Up Survey and 3 Month Injury Report (Appendix G) was sent to the participants (or parents of minors) via email. Six months after the initial meeting, the 6

Month Follow-Up Survey and 6 Month Injury Report (Appendix H) was sent to the participants (or parents of minors) via email. Participants had the option to enter their name for a chance to win sporting good equipment at the end of the study.

Treatment Groups

Selected participants were separated into a control group, and a treatment group. The control group (CG) consisted of two Missoula baseball teams participating in the Babe Ruth League youth baseball organization. A meeting with the coaches, parents, and players occurred where informed consent was obtained. The control group was not notified of the treatment, and was only asked to report sustained shoulder and elbow injuries throughout their baseball season. The 3 and 6 Month Injury Report survey were emailed to the participants (or parents of minors) via email. Six months after the initial meeting, the 6 Month Injury Report was sent to the participants (or parents of minors) via email. Participants had the option to enter their name for a chance to win sporting good equipment at the end of the study. Data collection consisted purely of number of TRI sustained to the shoulder and elbow joint.

The treatment group (TG) contained 3 Missoula area teams participating in the Babe Ruth League youth baseball organization. During the initial meeting, information was given to prospective participants, parents, and coaches regarding the details of the study. Consent from participants and parents were gained, and demographic information from the participants will be collected. Detailed information on the smartphone app “Throw Like a Pro” was given along with instructions proper technique of recommended stretches and therapeutic exercises. Instructions were given on how to download and access the application, and therapeutic exercise bands (Thera-Band® Exercise Tubing – Exercise Tubing 100ft., Red (medium), Hygenic Corporation, Akron, OH https://www.medco-athletics.com/Supply/Product.asp?Leaf_Id=91650) were

distributed. Three months after the initial meeting, the 3 Month Follow-Up Survey was sent to the participants (or parents of minors) via email. Six months after the initial meeting, the 6 Month Follow-Up Survey was sent to the participants (or parents of minors) via email.

Participants had the option to enter their name for a chance to win sporting good equipment at the end of the study.

Variables

The primary variables researched in this study are TRI sustained, and compliance of use of “Throw Like a Pro”. TRI sustained was measured via self-reported data on the follow-up surveys. Measures of TRI were obtained by self-reported questions on pain in the shoulder or elbow joint, and missing one or more formal practices or games due to pain in the shoulder or elbow joint. Measures of compliance were obtained by self-reported responses on use of the app “Throw Like a Pro”. Compliance was determined on a continuous spectrum from 0-10, with 0 being least compliant, and 10 being fully compliant. Scoring of compliance is described in detail in the section *Scoring and Interpretation*. Other demographic information such as age, gender, height, weight, position, years of participation, past and present injuries to the shoulder or elbow, and risk-related baseball activities was collected.

Instruments

For this study, two instruments were used to collect data. The first instrument is an adaptation of the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score (Appendix E). This instrument was used to gather participant demographics and information on previous baseball activity. The 3 and 6 Month Follow-Up Surveys were used to gather participant compliance and incidence of injury.

Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score

The Kerlan-Jobe Orthopaedic Clinic (KJOC) Shoulder and Elbow Score was developed for functional assessment of overhead athletes. The KJOC is shown to provide clinically relevant information when used for overhead athletes, and is proven to be both reliable and valid in assessing shoulder and elbow function.⁷⁸ A modified version of the KJOC was used to acquire demographic information and past baseball activities and injuries.

3 & 6 Month Follow-Up Survey and 3 & 6 Month Injury Report

The quantitative assessment tools used in this study are the 3 Month Follow-Up survey and the 6 Month Follow-Up survey (Appendixes F,G). Online surveys were selected for this study in efforts to maximize financial resources, ease of use for the participants, ability to efficiently analyze results, as well as limiting the amount of in person meetings necessitated for data collection.⁷⁹ The rationale in selecting Survey Monkey for the online survey was to utilize these benefits of data collection while ensuring ease of use for the participants.

Though multiple shoulder and elbow functional assessments exist, incorporating participant use of the app “Throw Like a Pro” requires development of a new survey. The principal investigator conducted development of the surveys. The follow-up surveys serve two objectives, determination of compliance of participant use, and incidence of shoulder and elbow injuries sustained during the study.

Three and 6 Month Follow-Up survey questions consist of 9 multiple-choice questions that determine evidence of shoulder or elbow injuries sustained during the study. One additional question obtains any risk-related behaviors the athlete is currently engaging in, and the final question consists of a request for the athlete to type their name in order to be entered into the drawing. Per IRB conditions, no requirements were made for the survey questions to be

answered, and participants could quit at any time during the survey. The 3 and 6 Month Injury Report (Appendixes F,G) were sent to the participants in the CG to obtain data on TRI during the course of the season.

Administration, Scoring/Tabulating, and Interpretation

Surveys were emailed to participants (or parents of minors) for follow up at 3 and 6 months into the study. The principal investigator scored the surveys to determine participant use (compliance) of the smartphone app, as well as shoulder and elbow injuries sustained during the study.

Adherent use of the application was measured on a continuous spectrum from 0-10, 0 being the lowest possible compliance score and 10 being the highest possible compliance score. Survey questions measuring compliance were designated with 0, 1, or 2 points for compliance respectively. Overall compliance scores from the 3 Month Follow-Up survey and the 6 Month Follow-Up Survey ranged from 0-10 points. A detailed Compliance Scoring Rubric used can be seen in Appendix I.

Data Analysis

The alpha level for this study was set at .05 *a priori*. Data analysis began with collection of 3 & 6 Month Follow-Up surveys. Descriptive statistics were run to analyze compliance among the participants, with mean compliance, standard deviation, and range selected for among others. A Chi Square for association was run to determine a relationship between compliance rate and TRI.⁷⁷ An independent t-test was run to analyze statistical significance in number of throwing injuries between the CG and TG.⁷⁷ Statistics were obtained on the statistical software SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Macintosh, Version 22.0. Armonk, NY: IBM Corp.).

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Appendix A1: Subject Information and Informed Consent Form for TG

SUBJECT INFORMATION AND INFORMED CONSENT

Study Title: Examining the Relationship Between Throwing Injuries Sustained in Adolescent Baseball Players and Use of an Injury Prevention Smartphone Application “Throw Like a Pro”

Sponsor: NATA Foundation

Investigator(s):

PI: David Grove
David.grove@umconnect.umt.edu
University of Montana
32 Campus Dr. McGill Hall 238C
Missoula MT 59812
770-715-2103

Faculty Supervisor: Valerie Moody PhD, ATC, LAT, WEMT-B, CSCS
Valerie.moody@mso.umt.edu
University of Montana
32 Campus Dr. McGill Hall 238C
Missoula MT 59812
406-243-2703 office

Special Instructions:

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

Purpose:

You are being asked to take part in a research study that will compare throwing related injuries to the shoulder or elbow in youth baseball players. A smartphone application “Throw Like a Pro” has been developed with the hope of decreasing the amount of arm injuries in youth baseball.

The purpose of this research study is to find out if proper use of the smartphone application and its instructions is practical, and to see if the application does indeed help to avoid arm injuries.

The results will be used for educational purposes to share the results with other baseball teams in hopes of giving other a better understanding and an easy way to reduce their chance of getting hurt.

Procedures:

A meeting will be held in which all participating coaches, parents, and athletes will be present. If you agree to take part in this research study, you be asked to fill out a brief background questionnaire, you will be given instructions on how to download the “Throw Like a Pro” application, and instructions on how to properly use the application

including proper form on the stretches, exercises, and other features of the app will be discussed in detail.

You will be required to use the application as instructed. Some things like the stretches you will be required to do everyday, and should take about 5 minutes to complete. Other things like the strengthening program you only need to do 2-3 times per week, and should take about 30 min to complete. All resistance bands required for these exercises will be given to you at no cost. Certain features of the application like the pre-season throwing program and the pitch count recommendation should be followed daily.

The study will take place before your season starts, as you will need about 1 month to complete the throwing progression program. It is recommended that the throwing progression program be completed before the season starts, and takes about 24 days, 30-45 minutes per day. The throwing progression is a key part to strengthening your arm before the season starts. The study will end on September 1, 2015

There will be two surveys during your season that you will be asked to complete. The first one will be filled out 3 months into the study, and the second will be filled out 6 months into the study. The survey will only take about 10 minutes to complete. They will be conducted online, and will be emailed to your parents.

Payment for Participation:

As an incentive for participating in this study, you will not only be given \$10 to cover the cost of the application, but you will also receive the exercise bands for free, as well as receive entry into a drawing for a gift card to a local sporting goods shop upon completion of the surveys for up to \$200.

Risks/Discomforts:

There is no anticipated discomfort for those contributing to this study, so risk to participants is minimal. If at any time you feel pain while performing the stretches or exercises, including throwing a baseball, you should stop immediately and seek medical attention.

Mild discomfort may result from the required stretches, but this is a normal part of stretching, and is a different sensation than sharp pain.

Muscle soreness may occur as a result of performing the strengthening exercises or throwing the baseball, however this again is different than sharp pain, and you should not continue to do anything past the point of comfort.

Answering the survey questions may cause you to think about feelings that make you sad or upset.

You will be informed of any new findings that may affect your decision to remain in the study.

Benefits:

There is no promise that you will receive any benefit from taking part in this study, or guarantee that if you follow the advice on the application you will not hurt your arm; however your participation in this study may help future baseball players become more educated in ways to reduce their risk of throwing related injuries. You will receive knowledge on stretches and exercises that have been clinically evaluated to help decrease arm injuries and help in recovery from an existing throwing related injury.

Confidentiality:

Your records will be kept confidential and will not be released without your consent except as required by law.

If the results of this study are written in a scientific journal or presented at a scientific meeting, your name will not be used.

The data will be stored in a locked file cabinet. Your signed consent form will be stored in a cabinet separate from the data.

Voluntary Participation/Withdrawal:

Your decision to take part in this research study is entirely voluntary, and you may refuse to take part in or you may withdraw from the study at any time without penalty or loss of benefits to which you are normally entitled.

You may be asked to leave the study for any of the following reasons:

1. Failure to follow the Project Director's instructions;
2. The Project Director thinks it is in the best interest of your health and welfare; or
3. The study is terminated.

Questions:

If you have any questions about the research now or during the study contact: David Grove at 770-715-2103 or david.grove@umconnect.umt.edu; Valerie Moody at 406-243-2703 or valerie.moody@umontana.edu

If you have any questions regarding your rights as a research subject, you may contact the UM Institutional Review Board (IRB) at (406) 243-6672.

Statement of Your Consent:

I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be

answered by a member of the research team. I voluntarily agree to take part in this study. I understand I will receive a copy of this consent form.

Printed Name of Subject

Subject's Signature

Date

Email Address to be contacted for survey

ONLINE SURVEY CONSENT FORM

You are invited to participate in a research project about “Examining the Relationship Between Throwing Injuries Sustained in Adolescent Baseball Players and Use of an Injury Prevention Smartphone Application “Throw Like a Pro””. This online survey should take about 10 minutes to complete. Participation is voluntary, and responses will be kept confidential to the degree permitted by the technology being used.

You have the option to not respond to any questions that you choose. Participation or nonparticipation will not impact your relationship with The University of Montana. Submission of the survey will be interpreted as your informed consent to participate and that you affirm that you are at least 18 years of age.

If you have any questions about the research, please contact the Principal Investigator, David Grove at 770-715-2103 or david.grove@umconnect.umt.edu or Valerie Moody at 406-243-2703 or valerie.moody@umontana.edu. If you have any questions regarding your rights as a research subject, contact the UM Institutional Review Board (IRB) at (406) 243-6672.

Please print or save a copy of this page for your records.

** I have read the above information and agree to participate in this research project.*

_____ Enter survey

Appendix A2: Subject Information and Informed Consent Form for CG
SUBJECT INFORMATION AND INFORMED CONSENT

Investigator(s):

PI: David Grove
David.grove@umconnect.umt.edu
University of Montana
32 Campus Dr. McGill Hall 238C
Missoula MT 59812
770-715-2103

Faculty Supervisor: Valerie Moody PhD, ATC, LAT, WEMT-B, CSCS
Valerie.moody@mso.umt.edu
University of Montana
32 Campus Dr. McGill Hall 238C
Missoula MT 59812
406-243-2703 office

Special Instructions:

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

Purpose:

You are being asked to take part in a research study that will obtain the rate of throwing related injuries to the shoulder or elbow in youth baseball players.

The results will be used for educational purposes in hopes of giving others a better understanding of injuries in youth baseball.

Procedures:

If you agree, a meeting will be held in which all participating coaches, parents, and athletes will be present. If you agree to take part in this research study, we will ask you to answer some background questions, and you will be asked to fill out a survey to let us know if you hurt their shoulder or elbow during this baseball season.

There will be two surveys during your season that you will be asked to complete. The first one will be filled out 3 months into the study, and the second will be filled out 6 months into the study. The survey will only take about 5 minutes to complete. They will be conducted online, and will be emailed to your email address. The surveys are very important to our research, so completion is highly encouraged.

Payment for Participation:

As an incentive for participating in this study, you have the option to enter your name into a drawing for a gift card to a local sporting goods shop upon completion of the surveys for up to \$200.

Risks/Discomforts:

There is no anticipated discomfort for those participating in this study, so risk to participants is minimal. The only physical task asked of you will be to complete the online surveys.

Benefits:

There is no promise that you will receive any benefit from taking part in this study, however your participation in this study will help us identify injury rates for youth baseball players. After completion, you will get the results of the study and any recommendations that may appear.

Confidentiality:

Your records will be kept confidential and will not be released without your consent except as required by law.

If the results of this study are written in a scientific journal or presented at a scientific meeting, your name will not be used.

The data will be stored in a locked file cabinet. Your signed consent form will be stored in a cabinet separate from the data.

Voluntary Participation/Withdrawal:

Your decision to take part in this research study is entirely voluntary, and you may refuse to take part in or you may withdraw from the study at any time without penalty or loss of benefits to which you are normally entitled.

You may be asked to leave the study for any of the following reasons:

1. Failure to follow the Project Director's instructions;
2. The Project Director thinks it is in the best interest of your health and welfare; or
3. The study is terminated.

Questions:

If you have any questions about the research now or during the study contact: David Grove at 770-715-2103 or david.grove@umconnect.umt.edu; Valerie Moody at 406-243-2703 or valerie.moody@umontana.edu

If you have any questions regarding your rights as a research subject, you may contact the UM Institutional Review Board (IRB) at (406) 243-6672.

Statement of Your Consent:

I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be answered by a member of the research team. I voluntarily agree to take part in this study. I understand I will receive a copy of this consent form.

Printed Name of Subject

Subject's Signature

Date

Email Address to be contacted for survey

ONLINE SURVEY CONSENT FORM

You are invited to participate in a research project about “Examining the Relationship Between Throwing Injuries Sustained in Adolescent Baseball Players and Use of an Injury Prevention Smartphone Application “Throw Like a Pro””. This online survey should take about 10 minutes to complete. Participation is voluntary, and responses will be kept confidential to the degree permitted by the technology being used.

You have the option to not respond to any questions that you choose. Participation or nonparticipation will not impact your relationship with The University of Montana. Submission of the survey will be interpreted as your informed consent to participate and that you affirm that you are at least 18 years of age.

If you have any questions about the research, please contact the Principal Investigator, David Grove at 770-715-2103 or david.grove@umconnect.umt.edu or Valerie Moody at 406-243-2703 or valerie.moody@umontana.edu. If you have any questions regarding your rights as a research subject, contact the UM Institutional Review Board (IRB) at (406) 243-6672.

Please print or save a copy of this page for your records.

** I have read the above information and agree to participate in this research project.*

_____ Enter survey

Appendix B1: Minor Assent Form for TG

Minor's Assent for Being in a Research Study University of Montana

Title: Examining the Relationship Between Throwing Injuries Sustained in Adolescent Baseball Players and Use of an Injury Prevention Smartphone Application “Throw Like a Pro”

Sponsor: NATA Foundation

Why am I here?

We are asking you to take part in a research study because we are trying to learn more about how using a smartphone app “Throw Like a Pro” can help prevent shoulder and elbow injuries in adolescent baseball players. We are inviting you to be in the study because you are a baseball player who is at risk for shoulder and elbow injuries.

Why are you doing this study?

The study will help us determine if there are better ways to help prevent shoulder and elbow injuries caused by throwing too much. We want to see if using a smartphone app and following the recommendations given will be helpful in strengthening your arm in order to prevent throwing injuries.

What will happen to me?

You will be shown how to perform the recommended stretches, exercises, and throwing plans that the app contains. You will then be asked to follow the recommendations for the duration of the study, which will be 6 months long. Some things you will need to do everyday, like stretch. Other things you will only need to do a few times a week.

Will the study hurt?

The stretches and exercises are meant to make you stronger and should not cause any pain. If for any reason you feel pain during the recommended exercises, you can stop immediately.

Will the study help me?

The application contains stretches, exercises, and a throwing plan that is designed to make you stronger and decrease your risk of getting a shoulder or elbow injury. There are no guarantees however, so there is still a chance that you might get injured during your season whether you follow the instructions or not. As a bonus for participating in this study you will receive the exercise bands for free, as well as receive entry into a drawing for up to \$200 of sporting good merchandise upon completion of the surveys.

What if I have any questions?

You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me (Dave) at 770-715-2103 or ask me next time. You can also contact Valerie Moody at 406-243-2703.

Do my parents [guardians] know about this?

This study was explained to your parents/guardians and they said that you could be in it. You can talk this over with them before you decide.

Do I have to be in the study?

You do not have to be in the study. No one will be upset if you don't want to do this. If you don't want to be in this study, you just have to tell me. You can say yes now and change your mind later. It's up to you.

Writing your name on this page means that that you agree to be in the study, and know what will happen to you. If you decide to quit the study all you have to do is tell me or the person in charge.

Name of Minor (printed)

Signature of Minor

Date

Signature of Researcher

Date

Appendix B2: Minor Ascent Form for CG

Minor's Assent for Being in a Research Study

University of Montana

Purpose of the study: We are examining the occurrence of throwing injuries in youth baseball.

Why am I here?

We are asking you to take part in a research study because we are trying to learn more about injury rates in youth baseball. We are inviting you to be in the study because you are a baseball player who is at risk for shoulder and elbow injuries.

Why are you doing this study?

The study will help us determine injury rates in youth baseball, and if there is a need for development of injury prevention programs.

What will happen to me?

The only information that will be asked of you if you participate will be some background questions about you, and you will be asked to fill out a 5 minute survey to let us know if you hurt your shoulder or elbow during this baseball season.

Will the study help me?

This study will help determine throwing injuries in youth baseball, and after we get the results, we may be able to look at ways to prevent throwing injuries. As a bonus for participating in this study you can enter your name into a drawing for up to \$200 of sporting good merchandise upon completion of the surveys.

What if I have any questions?

You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me (Dave) at 770-715-2103 or ask me next time. You can also contact Valerie Moody at 406-243-2703.

Do my parents [guardians] know about this?

This study was explained to your parents/guardians and they said that you could be in it. You can talk this over with them before you decide.

Do I have to be in the study?

You do not have to be in the study. No one will be upset if you don't want to do this. If you don't want to be in this study, you just have to tell me. You can say yes now and change your mind later. It's up to you.

Writing your name on this page means that that you agree to be in the study, and know what will happen to you. If you decide to quit the study all you have to do is tell me or the person in charge.

Name of Minor (printed)

Signature of Minor

Date

Signature of Researcher

Date

Appendix C1: Parental Permission Form for TG

PARENTAL PERMISSION FORM

Research Title: Examining the Relationship Between Throwing Injuries Sustained in Adolescent Baseball Players and Use of an Injury Prevention Smartphone Application “Throw Like a Pro”

Sponsor: NATA Foundation

Investigator(s):

PI: David Grove
David.grove@umconnect.umt.edu
University of Montana
32 Campus Dr. McGill Hall 238C
Missoula MT 59812
770-715-2103

Faculty Supervisor: Valerie Moody PhD, ATC, LAT, WEMT-B, CSCS
Valerie.moody@mso.umt.edu
University of Montana
32 Campus Dr. McGill Hall 238C
Missoula MT 59812
406-243-2703 office

Purpose:

You are being asked to give permission for your child to take part in a research study utilizing a smartphone application “Throw Like a Pro” in an effort to decrease risk for throwing related injuries to the shoulder and elbow.

Your child has been chosen because he/she is a member of the Missoula Prospects baseball organization, and as a youth baseball player is at risk of shoulder or elbow injuries.

The purpose of this research study is to figure out if the use of a smartphone application designed to better condition youth baseball players is effective in decreasing injuries.

Procedures:

If you agree, a meeting will be held in which all participating coaches, parents, and athletes will be present. If you agree to take part in this research study, and your child will be given instructions on how to download the “Throw Like a Pro” application, and instructions on how to properly use the application including proper form on the stretches, exercises, and other features of the app will be discussed in detail.

Your child will be required to use the application as instructed. Some things like the stretches your child will be required to do everyday, and should take about 5 minutes to

complete. Other things like the strengthening program your child only needs to do 2-3 times per week, and should take about 30 min to complete. Certain features of the application like the pre-season throwing program and the pitch count recommendation should be followed as instructed.

The study will begin before your child's season starts, as they will need about 1 month to complete the throwing progression program. It is recommended that the throwing progression program be completed before the season starts, and takes about 24 days, 30-45 minutes per day. The throwing progression is a key part to strengthening your child's arm before the season starts. The study will end on September 1, 2015

There will be two surveys during your child's season that they will be asked to complete. The first one will be filled out 3 months into the study, and the second will be filled out 6 months into the study. The survey will only take about 10 minutes to complete. They will be conducted online, and will be emailed to your email address. The surveys are very important to our research, so completion is highly encouraged.

Payment for Participation:

As an incentive for participating in this study, your child will receive the exercise bands for free, as well as receive entry into a drawing for up to \$200 of sporting good merchandise upon completion of the surveys.

Risks/Discomforts:

There is no anticipated discomfort for those participating in this study, so risk to participants is minimal. If at any time your child feels pain while performing the stretches or exercises, including throwing a baseball, they should stop immediately and seek medical attention if appropriate.

Mild discomfort may result from the required stretches, but this is a normal part of stretching, and is a different sensation than sharp pain.

Muscle soreness may occur as a result of performing the strengthening exercises or throwing the baseball, however this again is different than sharp pain, and your child should not continue to do anything past the point of comfort.

You will be informed of any new findings that may affect your decision to have your child remain in the study.

Benefits:

There is no promise that your child will receive any benefit from taking part in this study, or guarantee that if they follow the advice on the application they will not hurt

their arm; however your child's participation in this study may help future baseball players become more educated in ways to reduce their risk of throwing related injuries. Your child will receive knowledge on stretches and exercises that have been clinically evaluated to help decrease arm injuries and help in recovery from an existing throwing related injury.

Confidentiality:

All records will be kept confidential and will not be released without your consent except as required by law.

If the results of this study are written in a scientific journal or presented at a scientific meeting, neither you nor your child's name will be used.

The data will be stored in a locked file cabinet.

Your signed consent form will be stored in a cabinet separate from the data.

Voluntary Participation/Withdrawal:

Your decision for your child to take part in this research study is entirely voluntary, and you may refuse your child to take part in or withdraw from the study at any time without penalty or loss of benefits to which your child is normally entitled.

Your child may be asked to leave the study for any of the following reasons:

1. Failure to follow the Project Director's instructions;
2. The Project Director thinks it is in the best interest of your child's health and welfare; or
3. The study is terminated.

Questions:

If you have any questions about the research now or during the study contact: David Grove at 770-715-2103 or david.grove@umconnect.umt.edu; Valerie Moody at 406-243-2703 or valerie.moody@umontana.edu

If you have any questions regarding your rights as a research subject, you may contact the UM Institutional Review Board (IRB) at (406) 243-6672.

Parent's Statement of Permission:

I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be

answered by a member of the research team. I voluntarily agree to have my child take part in this study. I understand that I will receive a copy of this permission form.

Printed Name of Subject (Minor)

Signature of Parent or Legally Authorized Representative

Date

Email Address to be contacted for survey

Appendix C2: Parental Permission Form for CG

PARENTAL PERMISSION FORM

Investigator(s):

PI: David Grove
David.grove@umconnect.umt.edu
University of Montana
32 Campus Dr. McGill Hall 238C
Missoula MT 59812
770-715-2103

Faculty Supervisor: Valerie Moody PhD, ATC, LAT, WEMT-B, CSCS
Valerie.moody@mso.umt.edu
University of Montana
32 Campus Dr. McGill Hall 238C
Missoula MT 59812
406-243-2703 office

Purpose:

You are being asked to give permission for your child to take part in a research study examining the occurrence of throwing injuries in youth baseball.

Your child has been chosen because he/she is a member of the Babe Ruth League organization, and as a youth baseball player is at risk of shoulder or elbow injuries.

Procedures:

If you agree, a meeting will be held in which all participating coaches, parents, and athletes will be present. If you agree to let your child take part in this research study, we will ask your child to answer some background questions, and they will be asked to fill out a survey to let us know if they hurt their shoulder or elbow during this baseball season.

There will be two surveys during your child's season that they will be asked to complete. The first one will be filled out 3 months into the study, and the second will be filled out 6 months into the study. The survey will only take about 5 minutes to complete. They will be conducted online, and will be emailed to your email address. The surveys are very important to our research, so completion is highly encouraged.

Payment for Participation:

As an incentive for participating in this study, your child may enter their name into a drawing for up to \$200 of sporting good merchandise upon completion of the surveys.

Risks/Discomforts:

There is no anticipated discomfort for those participating in this study, so risk to participants is minimal. The only physical task asked of your child will be to complete the online surveys.

Benefits:

There is no promise that your child will receive any benefit from taking part in this study, however your child's participation in this study will help us identify injury rates for youth baseball players. After completion, you and your child will get the results of the study and any recommendations that may appear.

Confidentiality:

All records will be kept confidential and will not be released without your consent except as required by law.

If the results of this study are written in a scientific journal or presented at a scientific meeting, neither you nor your child's name will be used.

The data will be stored in a locked file cabinet.

Your signed consent form will be stored in a cabinet separate from the data.

Voluntary Participation/Withdrawal:

Your decision for your child to take part in this research study is entirely voluntary, and you may refuse your child to take part in or withdraw from the study at any time without penalty or loss of benefits to which your child is normally entitled.

Your child may be asked to leave the study for any of the following reasons:

1. Failure to follow the Project Director's instructions;
2. The Project Director thinks it is in the best interest of your child's health and welfare; or
3. The study is terminated.

Questions:

If you have any questions about the research now or during the study contact: David Grove at 770-715-2103 or david.grove@umconnect.umt.edu; Valerie Moody at 406-243-2703 or valerie.moody@umontana.edu

If you have any questions regarding your rights as a research subject, you may contact the UM Institutional Review Board (IRB) at (406) 243-6672.

Parent’s Statement of Permission:

I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be answered by a member of the research team. I voluntarily agree to have my child take part in this study. I understand that I will receive a copy of this permission form.

Printed Name of Subject (Minor)

Signature of Parent or Legally Authorized Representative

Date

Email Address to be contacted for survey

Appendix D: Modified KJOC Demographic Questionnaire



Background Questionnaire

Name _____ Age _____ Sex _____ Height _____ Weight _____

Dominant Hand (R) _____ (L) _____ (Ambidextrous) _____

Position _____ Years Played _____

Please answer the following questions related to your history of injuries to **YOUR ARM ONLY**:

YES **NO**

- | | | |
|---|--------------------------|--------------------------|
| 1. Is your arm currently injured? | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Are you currently active in your sport? | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Have you missed game or practice time in the last year due to an injury to your shoulder or elbow? | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Have you been diagnosed with an injury to your shoulder or elbow other than a strain or sprain?
If yes, what was the diagnosis? _____ | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Have you received treatment for an injury to your shoulder or elbow?
If yes, what was that treatment? (Check all that apply)
<input type="checkbox"/> Rest <input type="checkbox"/> Therapy <input type="checkbox"/> Surgery | <input type="checkbox"/> | <input type="checkbox"/> |

Please check the **ONE category only** that best describes your current status:

- Playing without any arm trouble Playing, but with arm trouble
 Not playing due to arm trouble

1. Before You Begin

1 / 3

33%

Thank you for participating in our survey. Your feedback is very important and helpful to us, and it will only take about 5 minutes to complete. It is also very important to answer every question that you are asked in honesty. The more honest you are, the more you are helping us.

YOUR ANSWERS ARE PRIVATE! NO INFORMATION WILL BE SHARED WITH YOUR COACHES OR PARENTS WITHOUT YOUR PERMISSION.

If at any time you have questions, feel free to contact me, David Grove, at 770-715-2103 or david.grove@umconnect.umt.edu.

Hit the NEXT button below to get started!

Next

2.

2 / 3

67%

1. Which baseball team are you on?

- 18U Missoula Prospects
- 16U Missoula Prospects
- 13U Missoula Prospects

2. In the past 3 months, have you experienced any pain in your shoulder joint when throwing?

- Yes
- No

3. In the past 3 months, have you experienced any pain in your elbow joint when throwing?

- Yes
- No

4. In the past 3 months, how many days have you missed practice or a game due to injury to your shoulder or elbow joints?

- I have not missed any practices or games
- 1-14 days
- 15 days or more

5. In the past 3 months, how many days per week have you used the app "Throw Like a Pro"?

- 0-2 days per week
- 3-4 days per week
- 5-7 days per week

Prev

Next

3.

3 / 3

100%

6. In the past 3 months, how many days per week did you perform the recommended stretches?

- 0-2 days per week
- 3-4 days per week
- 5-7 days per week
- Other (please specify)

7. In the past 3 months, how many days per week did you perform the recommended resistance band exercises?

- 0 days per week
- 1-2 days per week
- 3 or more days per week

8. Before the season started, did you perform the recommended throwing progression program?

- No
- Yes, but I completed it faster or slower than recommended
- Yes, I completed it in the recommended timeline with the recommended time off between each progression

9. In the past 3 months, have you used the Pitch Count tracker?

- No, I did not pitch during the last 3 months
- No, although I did participate in pitching activities
- Yes, but I have not followed the recommended rest period between pitching sessions
- Yes, and I have taken the recommended time off between pitching sessions

10. In the past 3 months, mark all of the activities that you have performed:

- | | |
|--|---|
| <input type="checkbox"/> Pitching in a league without pitch counts or limits | <input type="checkbox"/> Pitching for multiple teams within the same season |
| <input type="checkbox"/> Pitching back-to-back days | <input type="checkbox"/> Playing the catcher position when not pitching |
| <input type="checkbox"/> Pitching in multiple games a day | <input type="checkbox"/> Playing only baseball, and no other competitive sport(s) |

11. In order to have your name in the drawing for the gift cards, please type your first and last name in the box below.

Name:

Prev

Done

1. Before You Begin

1 / 3

33%

Thank you for participating in our survey. Your feedback is very important and helpful to us, and it will only take about 5 minutes to complete. It is also very important to answer every question that you are asked in honesty. The more honest you are, the more you are helping us.

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Hit the NEXT button below to get started!

Next

2.

2 / 3

67%

1. Which baseball team are you on?

- 18U Missoula Prospects
- 16U Missoula Prospects
- 13U Missoula Prospects

2. In the past 3 months, have you experienced a throwing related injury to your shoulder or elbow joint?

- Yes
- No

3. In the past 3 months, how many days have you missed practice or a game due to injury to your shoulder or elbow joints?

- I have not missed any practices or games
- 1-14 days
- 15 days or more

4. In the past 3 months, how many days per week have you used the app "Throw Like a Pro"?

- 0-2 days per week
- 3-4 days per week
- 5-7 days per week

Prev

Next

3.

3 / 3

100%

5. In the past 3 months, how many days per week did you perform the recommended stretches?

- 0-2 days per week
- 3-4 days per week
- 5-7 days per week

6. In the past 3 months, how many days per week did you perform the recommended resistance band exercises?

- 0-2 days per week
- 3-4 days per week
- 5-7 days per week

7. Before the season started, did you perform the recommended throwing progression program?

- No
- Yes, but I completed it faster than recommended
- Yes, but I completed it slower than recommended
- Yes, I completed it in the recommended timeline with the recommended time off between each progression

8. In the past 3 months, have you used the Pitch Count tracker?

- No
- Yes, but I have not followed the recommended rest period between pitching sessions
- Yes, and I have taken the recommended time off between pitching sessions

9. In the past 3 months, mark all of the activities that you have performed:

- | | |
|--|---|
| <input type="checkbox"/> Pitching in a league without pitch counts or limits | <input type="checkbox"/> Pitching for multiple teams within the same season |
| <input type="checkbox"/> Pitching back-to-back days | <input type="checkbox"/> Playing the catcher position when not pitching |
| <input type="checkbox"/> Pitching in multiple games a day | <input type="checkbox"/> Playing only baseball, and no other competitive sport(s) |

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Done

1. Before You Begin

1 / 3

33%

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Hit the **NEXT** button below to get started!

Next

2.

2 / 3

67%

1. Which baseball team are you on?

- 18U Missoula Mavericks
 16U Missoula Pioneers

2. In the past 3 months, have you experienced any pain in your shoulder joint when throwing?

- Yes No

3. In the past 3 months, have you experienced any pain in your elbow joint when throwing?

- Yes No

4. In the past 3 months, how many days have you missed practice or a game due to injury to your shoulder or elbow joints?

- I have not missed any practices or games 1-14 days 15 days or more

Prev

Next

5. In the past 3 months, mark all of the activities that you have performed:

- | | |
|--|---|
| <input type="checkbox"/> Pitching in a league without pitch counts or limits | <input type="checkbox"/> Pitching for multiple teams within the same season |
| <input type="checkbox"/> Pitching back-to-back days | <input type="checkbox"/> Playing the catcher position when not pitching |
| <input type="checkbox"/> Pitching in multiple games a day | <input type="checkbox"/> Playing only baseball, and no other competitive sport(s) |

6. In order to have your name in the drawing for the gift cards, please type your first and last name in the box below.

Name:

Prev

Done

1. Before You Begin

1 / 3

33%

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Hit the **NEXT** button below to get started!

Next

2.

2 / 3

67%

1. Which baseball team are you on?

- 18U Missoula Mavericks
 16U Missoula Pioneers

2. In the past 3 months, have you experienced any pain in your shoulder joint when throwing?

- Yes No

3. In the past 3 months, have you experienced any pain in your elbow joint when throwing?

- Yes No

4. In the past 3 months, how many days have you missed practice or a game due to injury to your shoulder or elbow joints?

- I have not missed any practices or games 1-14 days 15 days or more

Prev

Next

5. In the past 3 months, mark all of the activities that you have performed:

- | | |
|--|---|
| <input type="checkbox"/> Pitching in a league without pitch counts or limits | <input type="checkbox"/> Pitching for multiple teams within the same season |
| <input type="checkbox"/> Pitching back-to-back days | <input type="checkbox"/> Playing the catcher position when not pitching |
| <input type="checkbox"/> Pitching in multiple games a day | <input type="checkbox"/> Playing only baseball, and no other competitive sport(s) |

6. In order to have your name in the drawing for the gift cards, please type your first and last name in the box below.

Name:

Prev

Done

Appendix I: Compliance Scoring Rubric

Scoring Rubric for TLP surveys		
Question	Answer	Point
In the past 3 months, how many days per week have you used the app "Throw Like a Pro"?	0 to 2	0
	3 to 4	1
	5 to 7	2
In the past 3 months, how many days per week did you perform the recommended stretches?	0 to 2	0
	3 to 4	1
	5 to 7	2
In the past 3 months, how many days per week did you perform the recommended resistance band exercises?	0	0
	1-2	1
	3 or more	2
Before the season started, did you perform the recommended throwing progression program?	No	0
	Yes, but fast or slow	1
	Yes, with days off	2
In the past 3 months, have you used the Pitch Count tracker?	Not a pitcher	0
	No, but pitched	1
	Yes, but not proper time off	2
	Yes, with proper time off	3

Provision

The preceding pages contain the Thesis Proposal, and do not reflect any changes made to the design or execution of the study. The subsequent pages contain the final manuscript for submission, and are inclusive of the changes to the study, and reflect the updated methods, analysis, and execution of the study.

Examining the Relationship Between Throwing Injuries in Adolescent Baseball Players and an
Injury Prevention Smartphone Application

Primary Investigator:
David S Grove, BS
The University of Montana, Missoula, MT

Second Author:
Valerie J. Moody, PhD
The University of Montana, Missoula, MT

32 Campus Drive
Missoula, Montana 59812
770-715-2103
david.grove@umconnect.umt.edu

ACKNOWLEDGMENTS

The application participants used, “Throw Like a Pro”, was given at no cost to participants by the company who produced the app, Abracadabra Health LLC.

Examining the Relationship Between Throwing Injuries in Adolescent Baseball Players and an Injury Prevention Smartphone Application

Objective: To describe the use rate of the injury prevention smartphone app “Throw Like a Pro” (TLP), and determine the relationship between use of the app and throwing injuries in adolescent baseball players.

Design and Setting: The smartphone application TLP was distributed to adolescent baseball players. Instruction was given on correct use of the application. Stretches, exercises, and application features were demonstrated to subjects. Data on use and injuries was compiled through self-reported surveys.

Subjects: A convenience sample of adolescent baseball players (n=20) aged 13-18 from the Babe Ruth Little League organization in Missoula, Montana were selected.

Measurements: A modified Kerlan-Jobe Orthopedic Clinic demographic questionnaire was collected on participants including age, current/previous history of shoulder or elbow injury, and years of playing experience. Self-reported surveys collected data pertaining to use of the smartphone application TLP and throwing injuries sustained during the baseball season.

Results: Thirty-nine separate time point responses were obtained from participants. Forty-one percent of total responses (n=16/39) revealed shoulder or elbow pain during the season. This is representative of national averages for adolescent baseball players. Athletes who stretched 3-4 times per week experienced less pain than athletes who did not. Pitchers who followed recommended rest periods saw a decreased likelihood of shoulder or elbow pain when compared to pitchers who did not follow recommended rest periods.

Conclusions: The incidence rate of overuse injuries in adolescent baseball players is rising. Many rehabilitative exercises post-injury exist, however preventative approaches are lacking. This research reveals the importance of both using pitch count to decrease likelihood of shoulder or elbow pain, as well as the need for ways to increase compliance among athletes. Further research is needed on the use of smartphone applications as a viable source of treatment protocol and injury prevention.

Key Words: smartphone, pitch count, throwing injuries, adolescents

INTRODUCTION

There are currently around 9 million youth baseball players between the ages of 6 to 17.¹ Baseball is a relatively safe sport, however arm pain is a very common finding among players and increases with age.¹ Nearly half of adolescent baseball players experienced shoulder or elbow pain while pitching.^{2,3} Factors differ between common arm pain due to muscle soreness that many experience through activity, and isolated acute pain in the shoulder and elbow joint, suggesting differences in etiology of the injury.¹ The number of high school and college baseball players that have undergone surgical intervention to correct throwing related injuries (TRI) to the shoulder and elbow has grown dramatically in the past few years.⁴ While existing research focuses on stretching, exercises, and throwing progression programs to assist in rehabilitation of the athlete, a lack of educational programs and implementation of these preventative measures exists.

The healthcare industry is now utilizing smartphone apps to deliver a variety of information and rehabilitation treatment protocols to patients⁵; however very little research has focused on this form of information dissemination. Smartphone apps have been used to reach patients and help implement medical plan of care, monitor mental health conditions⁶, provide a remote-based exercise protocol for cardiac rehabilitation patients⁷, as well as used for rehabilitation of ankle injuries.⁸ Despite the growing dependence of smartphones and other mobile devices for a variety of tasks, very little research has focused on the use of smartphone apps to integrate exercise prescription programs for the general population. As 70% of teens aged 13-17 own smartphones⁹,

implementation of an injury prevention smartphone app is a practical alternative to current techniques.

The need for more medically oriented content provided by applications exists, as 53% of orthopedic surgeons are currently using smartphone apps in practice, and of those 96% said they would like more apps to be available for referencing information and techniques.⁵ The desire to track personal health on a smartphone among those with mental health conditions is almost 80% among the 30 year-old and younger population.⁶ Currently, the National Institute for Health Innovation and the Department of Sport and Exercise Science at the University of Auckland, New Zealand, are studying the effect of a remote personalized exercise prescription program to increase exercise adherence delivered via smartphone.⁷

Still, no research exists that explores the efficacy of an injury prevention smartphone app for TRI. In 2014, Dr. James R. Andrews and Dr. Kevin Wilk worked in collaboration with Abracadabra Health, LLC to develop the smartphone application “Throw Like a Pro” (TLP) with the intention of reducing the number of TRI. The application aims to enhance endurance, increase flexibility of the shoulder, and improve strength of the throwing arm by strengthening the rotator cuff muscles. As baseball continues to see high rates of participation and injury, educating players and coaches directly about effective ways to decrease injury rate is paramount. Our research focuses on exploring the efficacy of using a smartphone application to provide injury prevention techniques to adolescent baseball players, and whether use of the application demonstrates a significant relationship to decreased throwing injuries.

METHODS

Subjects A total of 31 participants volunteered for the study. Eleven participants were excluded from the study based on exclusion criteria of not participating in the Babe Ruth League baseball organization aged 13-18 years old; not having access to "Throw Like a Pro" app, or currently exhibiting a TRI to the shoulder or elbow. Volunteers were from the Missoula Montana Babe Ruth Little League baseball organization (n=20) aged 15.16 ± 1.85 years old. Before participating, all players signed an informed consent form approved by the university's Institutional Review Board.

Instruments Surveys were created using the internet-based survey collection software Survey Monkey (Appendix 1). The survey consisted of four ordinal, four categorical, two open-ended, and one closed-ended questions. Data collected included number of TRI sustained to the shoulder and elbow joint, times per week the participation performed the recommended stretches, resistance band exercises, and pitch count tracker, and participated in risk-related activities during the prior two weeks. The primary investigator conducted in-person surveys twice during the study. Printed surveys distributed to the participants were identical to the online survey, and were completed before a regular season practice.

An adapted version of the Kerlan-Jobe Orthopedic Clinic (KJOC) Shoulder and Elbow score was developed to acquire demographic information and past baseball activities and injuries. Content validity for the online survey and KJOC Shoulder and Elbow Score was established by UM faculty, coaches, and former baseball players who reviewed the surveys and made suggestions on accuracy and clarity of the questions,

readability of the survey, and an estimate of time to completion of the survey. Corrections were made based on expert opinion and feedback from the review group.

Participants received the application “Throw Like a Pro” (Abracadabra Health LLC, Birmingham, Alabama, version 1.1) free of cost via download codes provided by the company. The application consists of three main components: overview, comprised of information on throwing injuries, current rates of injury, and goals of TLP; pre-season, laying out the Thrower’s Ten exercises, stretches, and throwing progression program; and in-season, providing stretches and strengthening exercises, as well as a pitch count tracker to use with recommendations on days of rest. This study focused solely on the in-season phase of the application.

Procedures During the initial meeting, the primary investigator collected the adapted KJOC Shoulder and Elbow Score from participants and provided detailed information on downloading and using the smartphone app. Resistance bands (Thera-Band® Exercise Tubing – Hygenic Corporation, Akron, OH) were distributed to the athletes, and the primary investigator demonstrated proper techniques of recommended stretches and therapeutic exercises. Follow up surveys were conducted a total of seven times (five online (n=18), two in-person (n=21)), every two weeks for 14 weeks. The participants were contacted via email and/or phone to encourage continued participation in the study.

Statistical Analysis Independent variables consisted of times per week the participant performed the recommended stretches and exercises, and accessed the pitch count tracker during each two-week time point. The dependent variable was incidences of injury, defined as pain to the shoulder or elbow joint, during each two-week time point. A Chi-Square for association was run to determine the relationship between the independent

variables and the dependent variable during each two-week window. Descriptive statistics were run for all variables. All statistical analyses were computed with the Statistical Package for the Social Sciences (version 22.0; SPSS Inc, Chicago, IL). The P value for statistical significance was set at .05 *a priori*.

RESULTS

Initially, 31 participants volunteered to be included in the study. A total of 11 participants were excluded from the study because they did not have access to TLP, had a current shoulder or elbow injury, or did not complete any follow-up surveys. Statistics were analyzed from 39 individual survey responses from the 20 participants. The response rate from surveys was 27.9% (n=39/140).

A total of 16 incidents of shoulder or elbow pain were recorded from 39 responses (41.0%) during the season. Figure 3 shows 41.0% (n=16) reported high participation in

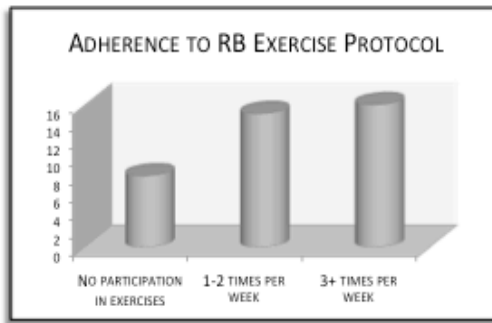


Figure 3. Use of Resistance Band Exercises

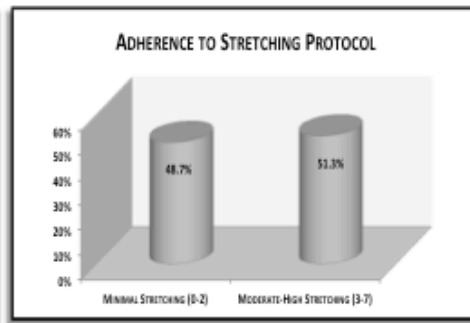


Figure 4. Use of Stretching Exercises

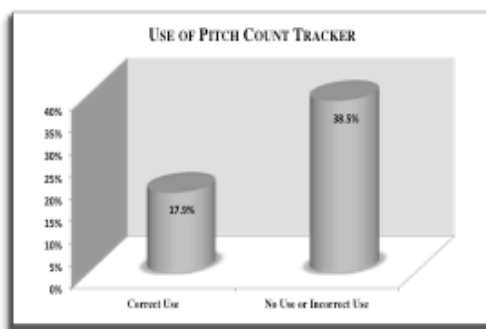


Figure 5. Use of Pitch Count Tracker

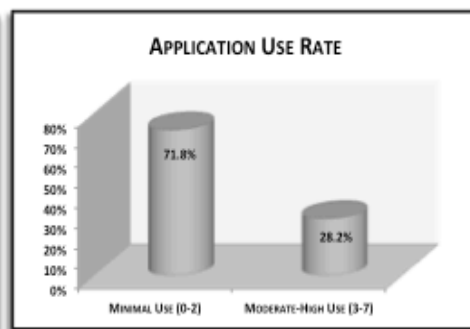


Figure 6. Application Use Rate

resistance band exercises (exercising 3+ days per week), while 38.5% (n=15) showed minimal participation in resistant band

exercises (1-2 days per week), and 20.5% (n=8) of responses revealed no use of the exercises (exercising 0 days per week). Participants showed moderate to high rates of performing the stretches (stretching 3-7 days per week) in 48.7% (n=19) of responses, while 51.3% (n=20) of responses showed little to no participation in the stretches (stretching 0-2 days per week)(Figure 4). Survey results indicated correct use of the pitch count tracker in merely 17.9% (n=7) of responses, while 38.5% (n=15) of responses demonstrated either no use of the pitch count tracker, or participants ignoring the recommended time off between throwing sessions (Figure 5). Lastly, only 28.2% (n=11) of responses showed a moderate to high use rate of the app, while 71.8% (n=28) of responses showed little to no use of the app (Figure 6).

Risk-Related Activities Figure 1 shows responses of risk-related activities. Playing only baseball and no other sports during the season was the highest risk-related activity the

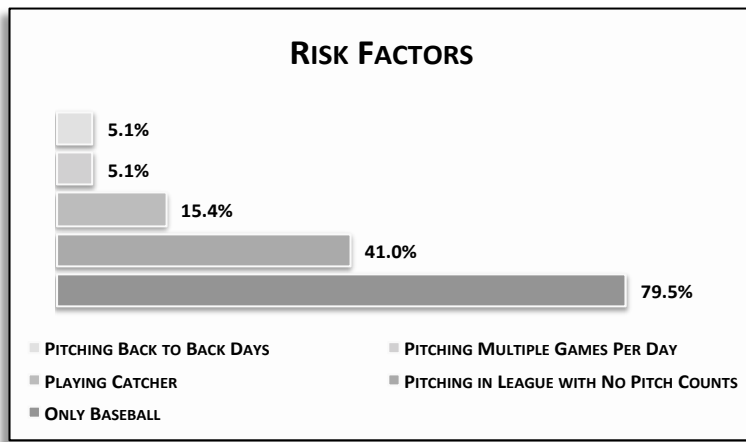


Figure 1. Risk related responses

participants engaged in, at 79.5% (n=31) of responses. Pitching in a league without pitch counts, playing catcher while not pitching, pitching in multiple games per day, and pitching back to back days

were also present in the participants at 41.0% (n=16), 15.4% (n=6), 5.1% (n=2), and 5.1% (n=2) of responses respectively. Chi square analysis showed no significant relationship between use rate of TLP recommended

stretches ($p=.340$, $n=39$), exercises ($p=.159$, $n=39$), or pitch count tracker ($p=.098$, $n=39$) and throwing injuries sustained.

DISCUSSION

Millions of adolescent baseball players participate in both recreational and competitive leagues each year.¹⁰ Little League Baseball is the largest operating youth sports program, and reports having more than 2.4 million participants each year in over 80 countries¹¹, and the Babe Ruth League reports over 1 million participants each year.¹² Participation in baseball is increasing, as sample weights provided by the National Electronic Injury Surveillance System (NEISS) show more than 15.5 million baseball participants in 2002¹³, and in 2008 USA Baseball reported more than 19 million adolescent baseball players.¹⁴ Baseball ranked as the third most popular high school sponsored sport in 2013 among male athletes.¹⁵ Although baseball is a relatively safe sport to participate in compared to other sports, injuries are still prevalent and injured athletes are subject to potentially costly long-term disability, especially pitchers.¹⁶ Early research from Larsen et al.¹⁷ showed a prevalence of only 20% of pitchers in their study experience elbow pain during the season. However, recent research by Lyman et al.² demonstrated that 35% of pitchers sampled revealed shoulder pain during their baseball season. Ochi et al.¹⁸ found 38% of pitchers during a national championship tournament self-reported elbow or shoulder pain. Our findings reveal similar incidence rates (Figure 2) with an overall rate of 41% of responses ($n=16/39$) showing shoulder or elbow pain. With 40% of responses from pitchers signifying elbow or shoulder pain, and an average

of 37% of respondents revealing pain regardless of position, more focus should be placed on injury prevention measures for all youth baseball players, not just pitchers.

Many risk-related activities have been defined as contributing to a higher level of injuries in this population.^{4,19-22} Yang et al.²⁰ described six distinct risk-related activities prevalent among adolescent baseball pitchers: pitching in a league without pitch counts or limits; pitching back-to-back days; pitching in multiple games a day; pitching for multiple teams within the same season; playing the catcher position when not pitching; and playing only baseball, and no other competitive sport(s). Research on high pitch counts have been extensively studied as a contributing factor to TRI.^{2,4,21-24} Responses in our study revealed a high frequency (38.5%, n=15) of participants who either did not track the amount of pitches they threw, or disregarded rest recommendations after pitching. Our participants directly increased their risk for throwing injuries by not tracking their pitch counts. Parents and coaches could easily address this risk factor, as it still represents a large threat to youth baseball players.

Research reveals that 85% of youth baseball players aged 4-18 have never heard of USA Baseball Medical and Safety Advisory Committee (USA-MSAC) throwing guidelines, and baseball players 13-16 years old are the least knowledgeable about the risk factors associated with TRI.²⁵ Athletes in our study also display other risk factors such as playing catcher while not pitching, and pitching in multiple games per day or pitching on back to back days. This is consistent with findings in research by Yang et al.²⁰ that showed 43.4% of pitchers pitched on consecutive days, with 19.0% pitching in multiple games per day. It is apparent through their activities that coaches were also not knowledgeable or abiding by the recommendations set forth by the USA-MSAC. More

research focusing on coaches' knowledge of USA-MSAC guidelines and recommendations is warranted.

During in person survey collections, participants reported subjective data. When asked if they were stretching and using the resistance band exercises, participants responded that those without arm injuries were performing more stretches and exercises than those who had sore arms. This anecdotal evidence provides some insight as to the mentality of this age group. It appears that once pain occurred to the shoulder or elbow joint, the subjects gave up and discontinued the treatment protocol, which could prove beneficial in rehabilitation of the injury. More research is needed on this population to determine alternative ways to increase compliance and adherence to the treatment protocols.

LIMITATIONS

This study had several limitations that hindered data collection, and should be addressed in order to provide recommendations for strengthening future research. Response bias was present due to the fact we used self-reported surveys to collect information from the participants. The majority of the follow-up surveys completed by the participants were via Survey Monkey, an online survey software. Participants had to be reminded by email and phone to complete the surveys, and often times the parents of minors were relied on to relay the information to them. This lends to a reasonable amount of recall bias, with participants needing to recall the past two weeks of activity. However, this is more frequent and provided greater potential accuracy than Yang et al.²⁰ found as their survey required recall from the previous 12 months. Further, utilizing

online survey software has inherent limitations such as participants needing a reliable internet connection, and self-selection bias from the participants.²⁶

Twice during the study the primary investigator conducted an in-person visit to retrieve follow-up surveys, and those two meetings collected a majority of the responses. Future data collection from this population might require more frequent in-person surveys in order to ensure adequate data collection. While meeting with the participants, common comments were made that the survey was too frequent, and they assumed it would be fine to just complete one or two during the duration of the study. The inclusion of a control group of participants in this population not using the TLP app would be beneficial in determining the relationship of application use to injury rates.

CONCLUSION

The increasing rate of throwing injuries in adolescent baseball players have become a significant health concern as more surgeries are required, and more time loss for players. As many athletes are participating in risk factors that increase possibility for injury, knowledge of common risk factors is paramount for coaches, parents, and athletes alike. Further research is needed in identifying the need for education of coaches, parents, and athletes of the USA-MSAC guidelines. Greater emphasis on preventative programs in this population is necessary, with future research focused on increasing compliance of adolescent athletes.

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Appendix 1: Follow Up Survey distributed every two weeks

"Throw Like a Pro" Follow Up Survey

1. Before You Begin

Thank you for participating in our survey! Your feedback is very important and helpful to us, and it will only take about 5 minutes to complete. It is also very important to answer every question that you are asked in honesty. The more honest you are, the more you are helping us!

YOUR ANSWERS ARE PRIVATE! NO INFORMATION WILL BE SHARED WITH YOUR COACHES OR PARENTS WITHOUT YOUR PERMISSION.

Remember, if you fill out your name at the end of the survey, you will be entered into a raffle to WIN SPORTING GOOD EQUIPMENT!!!

If at any time you have questions, feel free to contact me, David Grove, at 770-715-2103 or david.grove@umconnect.umt.edu.

Hit the NEXT button below to get started!

"Throw Like a Pro" Follow Up Survey

2.

1. Which baseball team are you on?

- 18U Missoula Prospects
- 16U Missoula Prospects
- 13U Missoula Prospects

2. Please enter your jersey number below.

3. In the past 2 weeks, have you experienced any pain in your shoulder or elbow joint when throwing?

- Yes
- No

4. In the past 2 weeks, how many days have you missed practice or a game due to injury to your shoulder or elbow joints?

- I have not missed any practices or games
- 1-7 days
- 8 days or more

5. In the past 2 weeks, have you missed any practices or games due to another injury that has kept you from throwing? (For example: I sprained my ankle and missed two practices and one game)

6. In the past 2 weeks, how many days per week have you used the app "Throw Like a Pro"?

- 0-2 days per week
- 3-4 days per week
- 5-7 days per week

"Throw Like a Pro" Follow Up Survey

3.

7. In the past 2 weeks, how many days per week did you perform the recommended stretches?

- 0-2 days per week
- 3-4 days per week
- 5-7 days per week

8. In the past 2 weeks, how many days per week did you perform the recommended resistance band exercises?

- 0 days per week
- 1-2 days per week
- 3 or more days per week

9. In the past 2 weeks, have you used the Pitch Count tracker?

- No, I did not pitch during the last 3 months
- No, although I did participate in pitching activities
- Yes, but I have not followed the recommended rest period between pitching sessions
- Yes, and I have taken the recommended time off between pitching sessions

10. In the past 2 weeks, mark all of the activities that you have performed:

- | | |
|--|---|
| <input type="checkbox"/> Pitching in a league without pitch counts or limits | <input type="checkbox"/> Pitching for multiple teams within the same season |
| <input type="checkbox"/> Pitching back-to-back days | <input type="checkbox"/> Playing the catcher position when not pitching |
| <input type="checkbox"/> Pitching in multiple games a day | <input type="checkbox"/> Playing only baseball, and no other competitive sport(s) |

11. In order to have your name in the drawing for the gift cards, please type your first and last name in the box below.

Name: