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Abstract

Overhand throwing velocity, underhand throwing velocity and off the bat velocity are measures that impact performance of softball athletes. The purpose of strength and conditioning programs is to improve athletic performance for athletes. Strength and conditioning coaches can achieve this through programming. One aspect of programming that this study looked at is periodization. The purpose of this study was to examine the effects of a periodized strength and conditioning program on these performance measurements in NCAA DIII collegiate softball athletes. Sixteen (n=16) NCAA DIII softball athletes were selected based on their participation on the Otterbein softball team. The athletes underwent pre and post testing of body composition, squat and chest press 1RM, anaerobic power, overhand throwing velocity, underhand throwing velocity, and off the bat velocity. The athletes participated in a 12 week periodized program. The 12 weeks were split into three, four-week blocks focusing on endurance, strength and power. The athletes showed significant difference in lean body mass, squat strength, chest press strength and anaerobic power. There was no significance in overhand throwing velocity, underhand throwing velocity and off the bat velocity in the athletes. These findings suggest that a periodized program elicits strength and anaerobic power gains in athletes. Due to a small sample size and softball trained population further research needs to be done to determine if there is a relationship between periodization and performance measures with a larger sample size, a longer period of time, or in a different age group.

Introduction

The sport of softball is a fast-paced power-driven game very similar to baseball in the rules and concept of the game. The main differences are that softball has smaller fielder dimensions, a bigger ball, runners are unable to leave the bag until the ball is pitched and the pitcher pitches the ball windmill style. The three main components of the game are pitching, defense and offense. Pitching involves using a windmill motion to throw the ball underhand towards the batter in their strike zone. Defense involves the ball being hit at one of the nine defenders on the field. The defenders must catch the ball before it touches the ground or field the ball off the ground and throw it to first base before the batter reaches the base or is tagged out by the defenders. The last component is offense which involves the batter having three strikes to hit the ball in fair territory and reach first before the defense can get an out. Ideally, the batter hits the ball hard enough that it gets past the infielders, or the outfielders. The three variables that impact the pace of the game are overhand throwing velocity, underhand throwing velocity and off the bat velocity (source Mar 31, 2022).

Velocity is defined as the speed and direction an object is going (Baechle and Earle, 2008). Based on the definition of velocity, overhand throwing velocity can be described as the speed the ball is traveling in the direction of the play. Martinez et al. (2021) identified overhead throwing velocity as a performance indicator in overhead athletes such as baseball and softball athletes. The *Next College Student Athlete* (Mar 20, 2022) recognized desirable home to first times to be recruited for NCAA softball to be 2.8-3.3 seconds. Considering the athlete does not have to finish their swing and then accelerate, this number gets even smaller when players are stealing second base or tagging up on a fly ball from the outfield. These are often crucial plays that are determined by milliseconds. Therefore, even the slightest increase in overhand throwing velocity can drastically change the outcome of many defensive plays.

Based on Baechle and Earle's (2008) definition of velocity, underhand throwing velocity applies to how fast the ball is being pitched by the pitcher. High underhand throwing velocity is advantageous to a team to minimize the reaction time of the batter. Minimal studies have been conducted on the correlation of a softball pitchers throwing velocity and performance. However, the fastest clocked pitcher in the world is Monica Abbott at 77 mph (Guiness, 2022). In the 2021 Summer Olympics, Abbott led the competition in strikeouts (31), appearances (6) and saves (2) and tied for first in Earned Run Average (0.0), wins (3), complete games (2) and shutouts (1). These statistics highlight that Abbott is an extremely high-level performer and part of the success can be attributed to the throwing velocity (WBSC, 2021).

Lastly, off the bat velocity is described as the speed of the ball off the hitter's bat. High off the bat velocity is advantageous to the hitter to maximize the distance the ball travels and minimize the reaction time of the defense to make a play. Singleton (2017) used the MLB's data from Statcast to evaluate off the bat velocity and offensive value in Major League Baseball athletes. Singleton concluded that athletes with a higher off the bat velocity were more likely to produce runs offensively and concluded that a goal of hitting coaches should be to increase exit velocity. Although there are many more variables, especially skill and technique to consider within the sport of softball, these performance measures are correlated with higher performance and are therefore worth increasing. At the collegiate level, technique and skill are typically solid and coaches must utilize non-technique-based methods to improve these measurements.

Literature Review

Strength and conditioning professionals design their programs with many factors in mind including time, space, exercise selection, repetitions, sets, rest, athlete experience, number of athletes, etc., (Baechle and Earle, 2008). There is no clear-cut program that will work for every athlete or team, but the goal of the program should be to maximize performance in the sport. Newton and McEvoy (1994), compared the strength gains and throwing velocity of baseball players completing a plyometric-based compared to a strength-based program. The study found that both programs significantly improved strength. However, the plyometric program did not have significant changes in throwing velocity whereas the strength program did have significant increases in throwing velocity. Escamilla et al. (2012) looked at three different baseball specific training programs in high school baseball athletes. One program was the Throwers Ten program, which utilized slow controlled movements to strengthen the muscles of the shoulder. One program used a Keiser Pneumatic resistance system to strengthen the muscles of the shoulder. The last program was a plyometric focused program using mostly med balls and plyometric movements to increase strength. The researchers found that within the three different training programs all three elicited increases in throwing velocity and the difference between the three programs was insignificant. These studies highlight the importance of any resistance training program for athletes, but also that there are many variables at play in making a program.

One program design technique used to maximize performance is implementing a structured periodized program. Program periodization involves varying volume (repetitions and sets), intensity (% of 1RM), rest time and exercise selection (Baechle and Earle 2008). According to Suchomel et al. (2018) periodized training has been shown to produce greater maximal strength

benefits compared to non- periodized training. According to Baechle and Earle (2008) there are four training goals utilized in creating programming: muscular endurance, hypertrophy, strength and power. Table 1 describes the volume, intensity and rest period for each training goal.

Table 1.
Program Design for Resistance Training (Baechle and Earle, Ch. 17)

Training Goal	Rep range	Sets	Intensity	Rest
Muscular Endurance	$\geq$ 12	2-6	$\leq$ 67%	$\leq$ 30 seconds
Hypertrophy	6-12	3-6	67-85% 1RM	30-90 seconds
Strength	$\leq$ 6	2-6	$\geq$ 85% 1RM	2-5 min
Power	1-5	3-5	75-90% 1RM	2-5 min

When designing a strength and conditioning program, it is important to include all four of these training goals. According to Herodek et al. (2012) periodization is based on the General Adaptation Syndrome (GAS). GAS is a stress response theory created by Hans Seyle that describes how the body responds to stress in three stages (alarm, resistance and exhaustion). Herodek describes Seyle's theory of how if the body is exposed to one stress for too long the body goes into exhaustion, or overtraining. Based on the GAS principle, periodization of programming allows the body to be exposed to different stimuli which cause stress, the body then recovers at a higher level, but the variance in the stress prevents exhaustion, or overtraining (Herodek et al. 2012).

A periodized strength program is advantageous to improve strength and decrease the chances of exhausting the body. One consideration within the periodized program is increasing sport specific exercises into the training. According to Kenney et al. (2015) "the training

program must stress the physiological systems that are critical for optimal performance in a given sport in order to achieve specific training adaptations and goals" (p. 227). In a strength and conditioning setting, this involves using volume, rest periods and intensity that can be replicated on the field. For example, for a softball program, doing 20 repetitions with 30 seconds of rest in between sets would not be replicated on the field. When the training focus is endurance the ideal repetition range would be at the lower end of the endurance repetition range. Although the endurance training focus is not the primary focus for softball athletes, it is still however important to train in the 12-20 repetition range for endurance. According to Baechle and Earle, 2008 p. 457), there is a repetition maximum continuum. This implies that when an athlete is training in an endurance training focus, they are still gaining power, hypertrophy, and strength. This highlights the importance of training all training foci while also staying aware of the athletes' sports demands.

The purpose of periodization is to improve performance but the other aspect of program design is exercise selection. One technique to do this is with sport specific training. Palmer et al. (2015) found an improvement in throwing velocity following a sport specific training program in NCAA DIII athletes. It is important to choose exercises that will improve sport performance. The squat is widely recognized as a core exercise for athletic programs and Shoenfeld (2010) described the squat as a supreme test of lower body strength. By designing a periodized program that also includes exercise selection to enhance the demands of softball specific skills the athletes will have improved measures of overhand, underhand and off the bat velocity.

Exercise selection can also include a variety of open and closed kinetic chain exercises. Closed kinetic chain exercises are exercises in which the part of the body completing the work is fixed on the ground (Lippert, 2017). One example is a push up or squat. An open kinetic chain

exercise would be an exercise where the part of the body doing the work is not fixed on the ground such as a pull up. A study on closed kinetic chain versus open kinetic chain exercise programming found that training regimens focusing on closed kinetic chain exercises increased strength and throwing velocity in athletes whereas the open kinetic chain regimen only saw increases in strength (Prokopy et al. 2008).

Increasing lean body mass is a desirable outcome out of any strength and conditioning program. It is especially important for power athletes. Nimphius et al. (2012) found improved performance measures when elite softball players had increased lean muscle mass. Lowe et al. (2010) found a significant relationship between body composition and bat velocity and concluded that strength coaches should focus on gaining lean body mass to increase power production. Szymanski et al. (2011) also found a significant relationship between several variables including lean body mass, upper body strength and lower body strength on throwing velocity in high school baseball players. According to the NCAA, the average body composition obtained from skin calipers of female collegiate softball players is 12-18% compared to the recommended range of 20-32% for healthy female adults (Rockwell, 2022). This is attributed to increased physical activity in female athletes compared with healthy adults. It is important to note the +3% error of skin calipers (Rockwell, 2022).

One technique to periodize a program is with a block model. This model has blocks of time frames that each have a training focus. The typical time frame is 3-6 weeks and is called a training microcycle. Each block shifts the training focus of the program using the volume, intensity and rest that is appropriate (Baechle and Earle, 2008). Moquin et al. (2021) found that college aged males of different strength levels all gained lean body mass during a 11-week block periodized program. The findings indicate that a block periodized program potentially can

improve lean body mass in softball players of different strength levels and by extension improve performance measures of softball athletes. Szymanski and DeRenne (2010) compared swings in EMG studies, kinematic studies, and forearm, hand, and wrist training studies. The researchers concluded based on the studies examined that strength and conditioning coaches should focus on increasing strength, power development, rotational force, and weighted implement training. Flesig et al. (2016), Reinold et al. (2018) and Reinold et al. (2020) all studied the effects of weighted ball training on throwing velocity and external rotation of baseball pitchers. The studies found that weighted ball training does increase throwing velocity and external rotation of the shoulder. However, the increased external rotation increased the athlete's injury risk. These studies indicate that coaches should find a technique to increase throwing velocity without the use of weighted balls to prevent increased injury risk. Some strength and conditioning coaches may look at the professional league coaches for program design influence. Ebben et al. (2005) conducted surveys of Major League Baseball strength and conditioning coaches' program designs. The survey results found that 18 of the 21 coaches that responded utilized periodized programming and 20 of the 21 coaches utilized plyometrics. Myers et al. (2015) did a systematic review of training modes and throwing velocity in overhead athletes and concluded that periodized and multimodal training are beneficial at increasing velocity in overhead athletes. Based on this research, periodized programming has been shown to be effective in increasing athletic performance measurements (Baechle and Earle, 2008; Moquin et al. 2021; Szymanski and DeRenne, 2010; Ebben et al. 2005; Myers et al. 2015).

The goal of this study was to evaluate relative strength gains and changes in throwing velocity. It is hypothesized that this periodized program will increase strength. According to Kenney et al. (2015) power is the product of force and speed. It was anticipated that this program

will increase strength which will in turn increase power (Kenney et al. 2015). It is hypothesized that increases in strength and power will increase overhand throwing velocity, underhand throwing velocity and off the bat velocity in division III collegiate softball players.

Method

Subjects

Sixteen division III National Collegiate Athletic Association (NCAA) softball athletes were selected to participate. The athletes were chosen based on their participation on the Otterbein Softball team during the fall semester (August through December) of 2021. The participants consisted of: five-first year participants, three-second year participants, three-third years participants and five-fourth year participants. Two of the participants primary position is pitching, three of the participants primary position was catching, four of the participants were utility players, four of the participants were primarily infielders and three of the participants were primarily outfielders. The participants were considered to be physically active after completing a 3-month summer workout packet designed for basic fitness based on the American College of Sports Medicine recommendations for weekly physical fitness. The participants health status ranged from normal weight to obese based on the Body Mass Index (BMI). Seven of the participants were considered to be of normal BMI, seven of the athletes were considered overweight and two of the athletes were considered obese. The participants body fat percentages were based on ACSM (2017) guidelines and ranged from good (16.8-20%), fair (20.7-23.5%), poor (24.4-28.6%) to very poor (30.9-38.4%). Two of the participants were considered good, two

of the participants were considered fair, six of the participants were considered poor and six of the participants were considered very poor.

Procedure

During the initial assessment, each participant was asked to conduct pre-testing the week before the first workout session to determine their baseline measurements. The pre-testing had three parts all performed on the same day: dry measurements, softball specific measurements, and power and strength measurements. Participant dry measurements were obtained first. The first measurement was height. The athlete got their weight and body composition measured using an InBody. The InBody uses bioelectrical impedance to determine the athlete's lean body mass. McLester et al. (2020) evaluated the reliability of the InBody compared to a DXA scan and concluded that the InBody was significantly reliable for testing fat free mass. The participants also tested their handgrip strength using a handgrip dynamometer. Each participant completed three trials on both their right and left hand. The highest trial for their dominant hand was used for data.

Following the dry measurements, the participants completed a dynamic warm up which included their typical practice warm up. Following the dynamic warm up the participants completed a hitting warm up and a throwing warm up which are also their typical practice warm up for those activities. Once the participants reported that they were warm they began testing their overhand and underhand throwing velocity. The procedure followed the testing procedure done by Razak (2018). Each participant completed one step and throw into a net. The researchers stood behind the net with a Pocket Radar radar gun. According to their website, the Pocket Radar gun is certified to be within +/- 1 MPH (Mar 20, 2022). The Pocket Radar measured the

throwing velocity of each throw. Each participant had three throws with at least 30 seconds in between each rep. The highest throwing velocity was recorded for the athletes. Next the participants tested their off the bat velocity using the Pocket Radar radar gun. Each participant hit three balls off of a tee into a net to get their off the bat velocity. The participants had 30 seconds in between each swing to ensure max power output. The athletes were instructed to swing as fast as possible on each swing. The highest velocity of each athlete was noted. Athletes that were switch hitters tested both sides and the highest velocity between the two sides was recorded. The side that was used for pre-testing was used for post testing. Next, athletes who were pitchers were asked to pitch three balls into the net as fast as possible. The athletes pitched the ball into the net and the researchers used the Pocket Radar radar gun to obtain the underhand throwing velocity. Each participant maximum underhand throwing velocity was recorded. Following the velocities, the participants conducted tests to get baseline strength and power measurements. The tests conducted were: anaerobic power step test, 1RM in Back Squat and 1RM in Bench Press. To test the participants' anaerobic power, they were asked to stand with their dominant leg on an 18-inch box. Participants were instructed to step all the way up and all the way down as many times as possible in one minute. Each participant had a partner counting their steps and the number was recorded. Following the anaerobic power step test, participants completed 1RM testing on chest press and squat. They were instructed to do a few warmup sets. Following the warmup, participants added weight they knew they could complete and added 5-10 pounds until they reached their 1RM. A participant was determined to be at their 1RM if they could not complete a repetition without compromising form, or if they failed a repetition they went back to their previous success. The post-testing followed the same protocol.

The participants trained 3x a week for 12 weeks. The training sessions were Monday, Wednesday and Friday. Monday's sessions worked primarily on bilateral strength and included exercises like back squat, barbell bench press, military press, deadlift, bent over rows and pull ups. Wednesday sessions consisted of unilateral work including exercises like lunges, dumbbell bench press, single leg deadlifts, dumbbell rows, landmine presses, and single-arm lat pulldowns. Friday's sessions were circuit style training with 10, 40 second stations completed four times. The circuit was implemented for participant engagement in the program.

The 12 weeks were divided into three 4- week long training phases. The first phase was a muscle endurance phase. The participants completed 3-4 sets of 12 repetitions at 50-75% of their 1RM. The next phase was the strength phase. The participants completed 4-5 sets of 6 repetitions at least 85% of their 1RM. The last phase was a power phase. This phase prioritized the speed of the movement. Plyometrics and power movements were also introduced to the participants during this phase. Plyometrics included box jumps, single leg hops and broad jumps. Power movements included dumbbell snatches, hex bar power shrugs and dumbbell power press. The participants completed 5 sets of 5 repetitions at less than 85% of their 1RM during this phase. The participants' 1RM was determined based on their pre-testing data. Participants were asked to attempt to be within their 1RM percentage range but could adjust weight accordingly. Appendix A is a base template for the workouts prescribed.

Results

Pre-and post-test measurements of all variables were analyzed in SPSS by completing a repeated measures ANOVA (Table 1). Differences in weight, body fat percentage, handgrip, off the bat velocity, overhand throwing velocity, and underhand throwing velocity were

insignificant. The mean of overhand throwing velocity on the pretest was 52.7±4.3 mph compared to 51.9±4.5 mph on the post test. The mean underhand throwing velocity on the pretest was 51±4.2 mph compared to the post test mean of 55.7±9.5mph. The mean off the bat velocity during the pretest was 62.1±4.9 mph compared to 63.8±4 mph. Lean body mass change was significant (p = .024), indicating that there was an increase in muscle mass over the 12-week program. The pre-test mean lean body mass was 57.5±7.5 pounds compared to the post-test lean muscle mass of 59.5±8.9 pounds. The participants also had significant change in squat strength (p <.0001), indicating lower body strength increased over the 12-week program. The pre-test squat mean was 165± 56.6 pounds compared to the post test squat mean of 202±60 pounds. Chest press strength was also significant (p =.007) significance indicating that upper body strength increased over the 12-week period. The pre-test mean of chest press was 92±16.7 pounds compared to the post test chest press mean of 99±13 pounds. Anaerobic power was also significant across the 12 weeks (p = *.018).*

Table 1.

Repeated Measures ANOVA of weight, lean body mass, squat strength, chest press strength, anaerobic power, off the bat velocity, underhand and overhand throwing velocity.

Variable	SS	df	MS	F	Sig.
Weight	23.978	1	23.978	1.132	.304
Body Fat	8.201	1	8.201	2.204	.158
Lean Body Mass	25.205	1	25.205	6.252	**.024**
Handgrip	36.125	1	36.125	1.127	.305
Squat Strength	10878.125	1	10878.125	39.348	**.000**
Chest Press Strength	367.500	1	367.500	9.894	**.007**

Anaerobic Power	247.531	1	247.531	7.006	**.018**
Off the Bat Velocity	19.531	1	19.531	2.526	.133
Overhand Throwing Velocity	5.281	1	5.281	2.020	.176
Underhand throwing velocity	.000	1	.000	.000	1.00

Discussion & Conclusions

This study aimed to identify a relationship between a periodized strength program and overhand throwing velocity, underhand throwing velocity, and off the bat velocities. Based on the outcomes, there is no evidence of a relationship between the two variables from the measurements obtained. The pre- and post-test means showed increases in underhand throwing velocity and off the bat velocity despite the lack of significance. It is important to recognize that the population being studied were collegiate athletes who were previously trained. The sample size of (n= 16) possibly affected the significance. The participants also were out of mandated practice for over eight weeks at the time of post testing. The participants did not have any coach mandated skill practice during the eight weeks which also may have affected the outcome. The lack of skill practice helps solidify the internal validity of the study because changes would not be caused by technique. However, the lack of technique training could have possibly decreased technique which could have affected the results.

The external validity of the study is limited. Baseball and softball coaches look for techniques to improve overhand throwing velocity, underhand throwing velocity and off the bat velocity using technique and strength training. The lack of technique training in conjunction with strength training is limited to a small sample of baseball and softball athletes. Based on previous research from Moquin et al. (2021), Myers et al. (2015) and Suchomel et al. (2018) it

was expected to see strength gains following the 12-week periodized program. The significance of the strength gains helps strengthen the evidence of periodized programming for strength gains.

Future research has the ability to strengthen the body of evidence. Future research in this discipline should study a larger sample size. Studying both baseball and softball athletes in one study would be an ideal way to increase sample size and increase evidence for both sports. Research may also focus on a younger population with more room for improvement. This research could also examine the effects of a combination in skills training with a periodized strength program to increase these measures. There is currently not a large body of research on youth baseball and softball athletes in regard to a strength program and throwing and off the bat velocity. Further research can also expand on the effect of body composition on the measures studied in this study. Further research would strengthen the idea that a periodized strength and conditioning program can increase overhand throwing velocity, underhand throwing velocity and off the bat velocity.

Appendix A

Exercises	Sets	Repetitions	Intensity
Squat (back squat, Reverse Lunge, Step up, etc)	3 OR 4 (Endurance) 4 OR 5 (Strength) 5 OR 6 (Power)	12 (Endurance) 6 (Strength) 5 (Power)	(50-75% 1RM) (>85% 1RM) (>85% 1RM)
Hinge (Hex Bar Deadlift, Romanian Deadlift, etc.)	3 OR 4 (Endurance) 4 OR 5 (Strength) 5 OR 6 (Power)	12 (Endurance) 6 (Strength) 5 (Power)	
Chest Press (Barbell, Dumbbell, Push Up, etc.)	3 OR 4 (Endurance) 4 OR 5 (Strength) 5 OR 6 (Power)	12 (Endurance) 6 (Strength) 5 (Power)	(50-75% 1RM) (>85% 1RM) (>85% 1RM)
Row (Barbell Bent Over Row, Inverted Row, Single Arm Row, etc.)	3 OR 4 (Endurance) 4 OR 5 (Strength) 5 OR 6 (Power)	12 (Endurance) 6 (Strength) 5 (Power)	
Pull down (Lat pull down, pull up, single arm lat pulldown, etc.)	3 OR 4 (Endurance) 4 OR 5 (Strength) 5 OR 6 (Power)	12 (Endurance) 6 (Strength) 5 (Power)	
Shoulder Press (Push Press, Dumbbell Press, Landmine Press, etc.)	3 OR 4 (Endurance) 4 OR 5 (Strength) 5 OR 6 (Power)	12 (Endurance) 6 (Strength) 5 (Power)	
Core Accessory (plank, palloff press)	2-3	8-12	
Carry Accessory (farmers carry, overhead carry, etc) OR Internal/ External Rotation	2-3	8-12	

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