BALL SIZE AND WEIGHT EFFECTS ON THROWING KINEMATICS AND KINETICS IN YOUTH BASEBALL ATHLETES

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In baseball, youth players play on smaller fields with shorter base path distance, pitching distance, and smaller mounds. Despite this, the baseball itself remains unchanged for youth athletes. This prospective cohort analyzed the kinematics and kinetics of 38 youth baseball pitchers while using modified sized and weighted baseballs. An ANOVA was used to determine statistical significance amongst ball modifications. ANOVA results show significance between the 3oz-5oz baseball with the 3oz baseball decreasing elbow varus torque. This is a preliminary study on the effects of modified baseballs on youth athletes.

KEYWORDS: biomechanics, varus torque, distraction force

INTRODUCTION: In sports, the proportions of the game are made smaller for youth athletes. These proportions, such as field size and ball dimensions, are then gradually increased as the athlete grows older, and overtime adapt into standard dimensions. In Little League Baseball, players younger than 12 years old play on smaller fields with shorter base path distance, pitching distance, and smaller mounds than standard adult fields. As youth pitchers become older, taller, and heavier, they adapt to the distances of a standard adult field. A study by Fleisig et al. (2018) found that 12 years old is when pitching biomechanics change to be more like adult biomechanics. This suggests that players under 12 should focus on development of proper throwing mechanics, while adolescent pitchers can focus more on improving strength and power to maximize pitching performance. The number of injured players in recent time has increased as players begin to train position specialization as early as 7 years old. A separate study done by Jayanthi et al. (2019) show that athletes that were identified as being “highly specialized athletes” scored worse on the YTS (Youth Throwing Score) in comparison to “low-specialization athletes”. The effect of early specialization further supports the idea that players who are below the age of 12 should primarily focus on building the foundations of their mechanics instead of position specialization. This suggest there are challenges that prevent younger athletes from achieving proper throwing mechanics.

In baseball, the dimensions of the ball do not change. Despite youth leagues changing the proportions of the playing field, the baseball itself remains unchanged. All baseballs, regardless of age or skill, weigh 5oz and have a 9-inch circumference. Player pitch baseball starts at age 7, but many young pitchers are unable to properly hold the baseball due to its size and weight in proportion to their smaller hands. These difficulties cause young players to hold the ball from underneath with a supinated forearm and throw the ball with a 3-finger grip as opposed to the correct 2-finger grip. These mechanical changes may lead to increased joint stress and place young players at a higher risk for injury. Additionally, the inability to teach proper mechanics at a young age may lead to frustration and loss of interest in playing baseball.

There is some hesitation from leagues and organizers to introduce a smaller and lighter baseball due to recent studies that determined lighter baseballs increased elbow varus torque and injury risk in older baseball pitchers (Fleisig et al., 2017). The purpose of this study is to determine the effects of throwing with a smaller, lighter, and smaller and lighter baseball on throwing arm stress in youth athletes. This study will also investigate how changing the ball size and weight will affect elbow varus torque, shoulder distraction force, and throwing arm internal rotation velocity.

Figure 1: Baseballs from left to right: 5oz 9in; 5oz 8.55in; 4oz 9in; 4oz 8.55in; 3oz 9in

METHODS: This study is a prospective cohort approved by the University Institutional Review Board. Proper informed consent was acquired by both participant and parental guardian(s) before participation. 3D motion data were collected using the 41 retro-reflective marker set required for PitchTrak (Aguinaldo et al., 2007), and a 12-camera motion analysis system (Qualisys AB, Goteborg, Sweden). Motion data was collected at 300 Hz. Full body kinematics and kinetics were calculated using Visual3D (C-motion). Participants threw 5 different types of baseballs 3 times each, with the order of each set of baseballs randomized for every player. Balls were thrown from a pitching mound to a target at 14m. Participants were told that the goal was to throw the ball straight at the target, but they did not have to hit the target. This instruction was given to avoid arching throws to reach the target. The balls used were a 5oz regular baseball, 5oz baseball with 5% reduced circumference (5oz -5%), 4oz baseball, 4oz baseball with 5% reduced circumference (4oz -5%), and a 3oz baseball (Figure 1). Participants were not told which ball they were throwing. A One-Way Analysis of Variance (ANOVA) was used to investigate differences in elbow varus torque, shoulder distraction force, and throwing arm internal rotation velocity among baseball types. A Tukey Post Hoc was used to further support the significance between modifications.

RESULTS: Data from a total of 38 youth baseball players were included in this study (age = 8.13±0.8 years, height = 1.37±0.06 m, weight = 33.36±5.87 kg). Average kinetics and kinematics for different ball types are recorded in Table 1.

Table 1. Kinetics and Kinematics for Different Ball Types

Ball Type	Max Throwing Arm Angular Velocity (deg/s)	Max Elbow Varus Torque (%BWxH)	Max Shoulder Distraction Force (%BW)
3 oz	4431.91 ± 687.05	4.06 ± 0.83	80.50 ± 21.92
4 oz	4370.52 ± 700.16	4.42 ± 1.003	83.55 ± 21.37
4 oz - 5%	4477.08 ± 621.94	4.28 ± 0.79	83.86 ± 20.45
5 oz	4387.64 ± 583.14	4.73 ± 1.06	85.14 ± 20.50
5 oz- 5%	4282.04 ± 644.67	4.55 ± 0.99	83.88 ± 22.88

Means and standard deviation are reported as mean ± SD. *BW*, Body Weight; *H*, height. -5% indicates a 5% decrease in circumference from the regular ball size.

An ANOVA test evaluated differences amongst ball modification groups and detected a difference in elbow varus torque generated amongst ball groups (p = 0.024). Within the elbow varus torque group, Tukey's Post Hoc Comparison Analyses revealed a moderate difference in elbow varus torque generated between the 5oz baseball and the 3oz modified baseball (*p* = 0.017, *d* = 0.677 (95% CI: 0.08, 1.27) (Table 2). Additionally, ANOVA testing evaluated differences amongst ball modification groups in shoulder distraction force and maximum throwing arm angular velocity. When compared, ball modification groups yielded no significant difference in shoulder distraction force (p = 0.912) and no significant difference in maximum throwing arm angular velocity (p = 0.749).

Table 2. Ball Modification Groups differences within Elbow Varus Torque

Ball Modification Comparisons by group	Effect Size	Lower Bound of 95% CI	Upper Bound of 95% CI	p-value

4oz-3oz	0.37	-0.23	0.96	0.434
4oz -5%-3oz	0.22	-0.37	0.82	0.836
5oz-3oz	**0.68**	**0.08**	**1.27**	**0.017***
5oz -5%-3oz	0.50	-0.10	1.09	0.149
4oz -5%-4oz	-0.14	-0.74	0.45	0.964
5oz-4oz	0.31	-0.28	0.90	0.605
5oz -5%-4oz	0.13	-0.47	0.72	0.975
5oz-4oz -5%	0.45	-0.14	1.05	0.225
5oz -5%-4oz	0.27	-0.32	0.87	0.715
5oz -5%-5oz	-0.18	-0.77	0.41	0.919

-5% indicates a 5% decrease in circumference from the regular ball size. * $p< 0.05$

DISCUSSION: When looking at previous literature regarding the effect of ball modifications, the results seem to vary. A study done by Fleisig et al. (2017) compared elbow varus torque to ball modifications in older adolescence (mean age = 18.3 ± 1.5 years). The elbow varus torque in this study was shown to decrease as the weight of the baseball increased. Another study reported by Reinold et al. (2018) suggests that using overloaded baseballs increase shoulder rotation, as well as elbow varus torque; however, they go on to elaborate that these trials included 27 throws at a 100% max effort. A similar study from O'Connell et al. (2022) reported that peak rotational velocities decreased as the weight of the ball increased. The authors go on to report that there was no significance between elbow and shoulder kinetics and ball types. It is important to note that previous studies included training with weighted balls and may not translate to the effect of modified baseballs at a single instance. However, these varied results do raise the question of whether it is 'safe' to give young athletes modified baseballs.

Before implementing training and play with a modified baseball, this pilot study aimed to determine the effect of using a smaller and/or lighter baseball in young athletes. The results of this study show that upon initial use, shoulder distraction forces and internal rotation velocities did not change with ball modifications, and elbow varus torque tended to decrease as the weight of the ball decreased. Elbow torque is a derived metric directly affected by the weight of the baseball and the speed of the arm. With no difference in shoulder rotation velocity, we would expect a lighter baseball to yield a smaller torque. However, we also saw a decrease in torque with a reduction in ball circumference, although not significant. This result warrants further investigation into other mechanics that may be changing to allow reduction in elbow torque. The results of this preliminary study suggest that if a youth athlete uses a lighter/smaller baseball, they may be able to develop proper throwing mechanics at an earlier age without increasing arm acceleration and throwing arm stress, which would lead to an increased risk of injury. Next steps would be to analyze the changes in throwing arm kinematics and kinetics when given time to acclimate to a modified baseball.

As with any research, this study has limitations. Baseball experience among the athletes in the study ranged from the first time ever participating in organized baseball, to five years' experience in t-ball and baseball. It is likely that those new to the sport did not notice the differences in baseballs, while those with more experience were able to discern modifications. Additionally, this vast range of experience made collection of ball velocities impractical. Some athletes could not throw the baseball the 14m to the target, and overall athletes only hit the target 50% of the time. How ball modifications effect velocity was not the goal of this study, especially given the age of the participants, but not including velocity does limit some interpretability of the results. Athletes were not given the opportunity to acclimate to the different baseballs, and most youth athletes have no experience with weighted balls. Results may change when athletes practice and play with modified balls for an extended period of time.

CONCLUSIONS: No significance was found between elbow varus torque and shoulder distraction force except for the 3oz-5oz baseball comparison, where the 3oz baseball decreased the elbow varus torque. These results demonstrate that youth athletes can throw lighter and smaller baseballs without increasing throwing arm stress. When further looking at the maximum internal rotation velocities, no statistical correlation was found, thus meaning that a decrease in mass does not mean an increase in arm acceleration as shown in older populations. A more in-depth look into the mechanical changes associated with each modified ball will give insight into the benefits of using a smaller and/or lighter baseball in young baseball athletes. This is a preliminary study observing the effects of ball modifications on youth baseball athletes to determine safety of the modified baseball. More studies should be conducted on the longitudinal effects of using a modified baseball as well as changes in throwing technique.

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