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Abstract

The purpose of this study was to determine the effect of hydro-resistance training on bat velocity during mimicked baseball swings in twenty-five female college students. Subjects were pre-tested for bat velocity and assigned to dry land (n = 8), water (n = 8), and control (n = 9) groups. The dry land group swung a 737 g (26 oz) Easton T1 Thunderstick baseball bat for three sets of 15 swings, three days per week, for eight weeks. The water group performed the swings in shoulder deep water. The dry land and water groups also participated in mandatory team general resistance training three days per week. The control group performed no bat swing or resistance-training regimens. Mean bat velocity was measured with an electronic eye-timing device. A 3 x 2 (Group x Time) ANOVA with repeated measures was used for statistical analysis, followed up with Tukey's post hoc test. Bat velocity decreased significantly for the dry land and water groups (24.0 ± 3.6 m/s to 20.6 ± 4.1 m/s and 23.8 ± 3.5 to 18.8 ± 4.1 m/s, respectively). Bat velocity did not change for the control group (21.5 ± 3.0 m/s to 20.2 ± 2.1 m/s). We speculate that the decreased bat velocity in the dry land and water groups was caused by the mandatory team general resistance-training program.

Keywords

softball, bat speed

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Authors

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EFFECT OF HYDRO-RESISTANCE TRAINING ON BAT VELOCITY

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ABSTRACT

EFFECT OF HYDRO-RESISTANCE TRAINING ON BAT VELOCITY. **Stuempfle KJ, Crawford BE, Petrie DF, Kirkpatrick MT**. **JEP**online. 2004;7(2):63-69. The purpose of this study was to determine the effect of hydro-resistance training on bat velocity during mimicked baseball swings in twenty-five female college students. Subjects were pre-tested for bat velocity and assigned to dry land (n = 8), water (n = 8), and control (n = 9) groups. The dry land group swung a 737 g (26 oz) Easton T1 Thunderstick baseball bat for three sets of 15 swings, three days per week, for eight weeks. The water group performed the swings in shoulder deep water. The dry land and water groups also participated in mandatory team general resistance training three days per week. The control group performed no bat swing or resistance-training regimens. Mean bat velocity was measured with an electronic eye-timing device. A 3 x 2 (Group x Time) ANOVA with repeated measures was used for statistical analysis, followed up with Tukey's post hoc test. Bat velocity decreased significantly for the dry land and water groups (24.0 ± 3.6 m/s to 20.6 ± 4.1 m/s and 23.8 ± 3.5 to 18.8 ± 4.1 m/s, respectively). Bat velocity did not change for the control group (21.5 ± 3.0 m/s to 20.2 ± 2.1 m/s). We speculate that the decreased bat velocity in the dry land and water groups was caused by the mandatory team general resistance-training program.

Key Words: softball, bat speed.

INTRODUCTION

Bat velocity is a vital component of successful hitting in baseball and softball (1). Increased bat velocity gives a batter more time to decide whether or not to swing at a pitch, and results in a greater force being applied to the batted ball (2). Bat velocity can be increased with an improvement in hitting mechanics (3) and/or by sport-specific resistance training (4). The ideal sport-specific resistance program includes the following components: overload, training through the entire range of motion of the primary movement (i.e., bat swing), and duplication of the acceleration pattern of the primary movement (4).

Several studies have investigated the effect of sport-specific resistance training on bat velocity in baseball players. DeRenne et al. (2) reported that bat velocity could be increased by swinging a standard bat (851 g; 30 oz) or by swinging a combination of overweight (879 – 964 g; 31 – 34 oz), underweight (766 – 822 g; 27

– 29 oz), and standard bats. Sergo and Boatwright (5) concluded that swinging a bat of any weight (1758 g/62 oz overload bat, 879 g/31 oz control bat, or fungo underweight bat) improved bat velocity. In contrast, Verduzco (6) found that swinging a combination of overweight (964 g; 34 oz), standard (851 g; 30 oz), and underweight (737 g; 26 oz) bats improved bat velocity, but that swinging a standard bat decreased bat velocity.

Two articles published in the popular press suggested that a training program of bat swings under water will increase bat velocity (7,8). To our knowledge, no research has been done to test this claim. This type of hydro-resistance training violates the principles of sport-specific resistance training. Although an overload is applied through the full range of motion, the training is performed at a speed slower than competition speed. Others have reported that there is a high degree of velocity specificity in resistance training, with improvement in strength only occurring at the speed at which training occurred (9). Based on this knowledge that sport-specific resistance training should be velocity specific, it was hypothesized that performing bat swings under water would have a detrimental effect on bat velocity. Therefore, the purpose of the present study was to determine the effect of hydro-resistance training on bat velocity in female collegiate softball players.

METHODS

Design and Setting

We assessed changes in bat velocity in three groups of subjects following an eight-week training program of general resistance training and sport-specific resistance training consisting of bat swings with a 737 g (26 oz) Easton T1 Thunderstick, performed on dry land or in shoulder deep water. The dry land group performed bat swings on land and participated in a mandatory team general resistance-training program. The water group performed bat swings in shoulder deep water and participated in the same mandatory general resistance-training program. The control group did not perform bat swings or lift weights during the training period. The training period occurred immediately prior to the start of the softball season in March.

Subjects

Twenty-five female college students participated in this study. The dry land and water groups consisted of members of a NCAA Division III college softball team (11.7 ± 2.7 years of playing experience). The experimental subjects were assigned to their respective groups based on their pre-test bat velocities, as described later under procedures. Females who had played fast pitch softball competitively (5.9 ± 2.9 years of playing experience) in junior high, senior high, and/or college, but were not current members of the college softball team, comprised the control group. Our school institutional review board approved this study, and subjects read and signed an informed consent document. Table 1 presents the physical characteristics of the subjects.

Table 1. Physical characteristics of the subjects. Values expressed as mean ± SD.

Group	*N*	*Age (y)*	*Height (cm)*	*Weight (kg)*
Dry land	8	19.8 ± 1.3	162.9 ± 5.1	66.3 ± 11.9
Water	8	20.1 ± 1.6	164.3 ± 5.6	62.8 ± 7.8
Control	9	19.7 ± 1.3	166.6 ± 5.2	65.7 ± 9.0
Total	25	19.8 ± 1.3	164.7 ± 5.2	65.0 ± 9.4

Equipment

An Easton T1 Thunderstick was used during bat velocity testing and during the training program. Thunderstick dimensions were 2.54 cm (1 in) diameter, 76.20 cm (30 in) length, and 737 g (26 oz) weight. The Thunderstick was similar to the length and weight of the standard bats (76.20 – 81.28 cm or 30-32 in length; 680 – 794 g or 24-28 oz. weight) used by the softball team. The primary difference between the Thunderstick and the standard bats was that the Thunderstick was uniform in diameter. The Thunderstick was selected for the training program by the softball coach, with the rationale that the uniform diameter of the Thunderstick would be less likely to alter the swing mechanics of the subjects performing bat swings in water compared to using a standard softball bat.

Bat velocity was measured with an electronic eye-timing device (“electronic eye”), which consisted of an infrared transmitter/detector arrangement interfaced with a computer via a Universal Laboratory Interface (ULI) manufactured by Vernier Software and Technology. The motion of the bat was detected by an infrared transmitter and detector positioned above and below the strike zone of the batter (Figure 1). The infrared detector provided a voltage to the ULI that depended on whether the infrared beam was blocked or not.

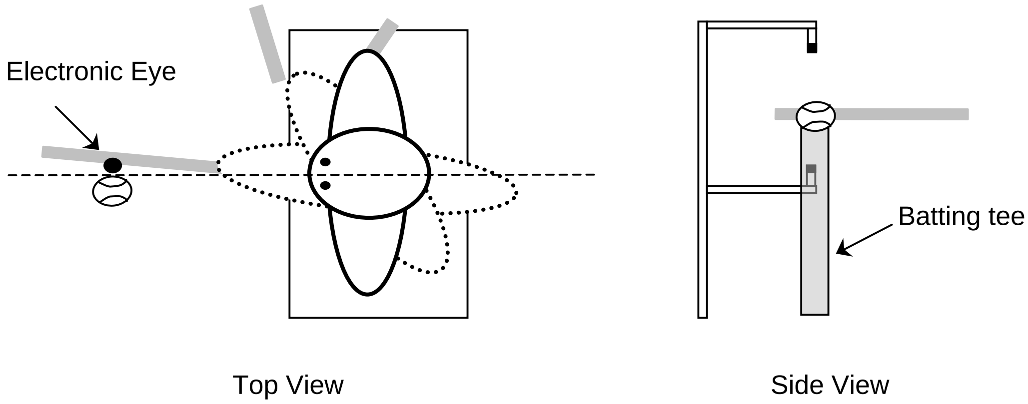

Figure 1. Top and side views of the experimental setup. The electronic eye vertically straddled the strike zone of the batter such that the vertical plane of the electric eye was 4.5 cm in front of the batting tee.

By continuous monitoring of the detector voltage, the ULI timed intervals between any changes and recorded the results on the computer using the ULITimer software from Vernier. In this way, the time during which the beam was broken by the presence of the Thunderstick was measured. From the blocked time, the bat velocity was easily calculated. The timing device was not calibrated to a known velocity, so the quoted bat velocities should be understood only as parts of a relative measurement between the pre- and post-tests. The relative measurement, which is our interest here, is insensitive to a known velocity calibration. The sampling rate of the ULI was 13,000 Hz, which leads to <8% uncertainty in the measurement of the blocked time for even the fastest bat swings (blocked time ~1ms). Hence, the random uncertainty introduced by the timing measurement is significantly smaller than the roughly 20% variation in velocities produced by the batters themselves from swing to swing. The timing device, therefore, contributes only a small fraction of the random fluctuation in bat velocities seen in the data. Possible systemic errors have been considered and estimates indicate they are at most at the 5% level. Any overall effect of systemic errors was experimentally tested through a control group, for which we saw no statistically significant change in bat velocities between the pre- and post-tests. Thus, the statistically significant change in the other two experimental groups is valid, and not a result of systematic errors.

Procedures

Subjects were pre-tested for bat velocity in a field house during the week prior to the start of the eight-week training program. Subjects were positioned in their normal batting stance at the inside edge of the batter's box. A softball was placed on a batting tee in the center of the plate at a height equal to the subject's greater trochanter height. The electronic eye was placed 4.5 cm in front of the batting tee. Thus, the bat velocity was measured just prior to contact with the softball (Figure 1). Subjects were then asked to take 10 normal swings, as if hitting in a game situation. A five second rest interval was required between swings. The amount of time the electronic eye was blocked was measured in milliseconds. Bat velocity in m/s was calculated as follows: (bat width (0.0258 m) * 1000) / blocked time (ms). The mean of the final three trials was designated as the bat velocity.

Members of the college softball team were then assigned to one of two matched groups (n = 8 dry land, n = 8 water) based on their pre-test bat velocity. The sixteen softball players were ranked one (fastest) through 16 (slowest) by their pre-test bat velocity. Player one was assigned to the water group, players two and three to the dry land group, player four to the water group, player 5 to the dry land group, players six and seven to the water group, player eight to the dry land group, and so on. The dry land group swung the Thunderstick bat 45 times a day (three sets of 15 swings with approximately 30 seconds rest between sets), three days a week, for eight weeks in a field house. The water group followed the same protocol, except the swings were performed in shoulder deep water in a swimming pool. The protocol for the bat swings was designed and monitored by the softball coach.

Throughout the training period, the dry land and water groups also participated in a mandatory team general resistance training program three days per week. The program was designed and supervised by the softball coach and consisted of isotonic resistance training exercises aimed to increase overall muscular strength. A three day split routine was used which included the following exercises: bench press, dips, pushdowns, biceps curls, latissimus dorsi pull-downs, seated row, push press, lateral dumbell raise, rear lateral raise, incline bench press, EZ curls, alternate dumbell curls, cleans, squats, leg curls, calf raises, and abdominal curls. Initial training intensity was determined by using approximately 70% of the athlete's one repetition maximum for each exercise. Athletes were instructed to complete three sets of eight repetitions with the goal of reaching muscular fatigue during the third set. By the end of the eight-week training period, the relative intensity of the exercise had been progressively increased to 95% of the athlete's one repetition maximum, and repetitions had been decreased to three sets of approximately three repetitions. The control group did not do bat swings or lift weights during the training period, nor were they participating in a regular exercise program.

Subjects were post-tested for bat velocity in a field house during the week following the completion of the eight-week training program. The bat velocity of the subjects was measured using the same equipment and procedure that had been used for the initial bat velocity test.

Statistical Analyses

A 3 x 2 (Group x Time) ANOVA with repeated measures was used for statistical analysis, followed up with Tukey's post hoc test. The alpha level for all statistical tests was set at $p < 0.05$. Data are presented as mean ± SD.

RESULTS

The 3 x 2 (Group x Time) ANOVA with repeated measures indicated that there was not a significant group effect or group x time interaction. The time effect was significant (F = 19.52, *p* = 0.0002, power = 0.99, effect size = 0.17), indicating a significant decrease in bat velocity over the training period. Follow-up Tukey's post hoc tests (Figure 2) revealed a significant decrease in bat velocity for both the dry land and water groups. There was not a significant change in bat velocity for the control group pre-test to post-test.

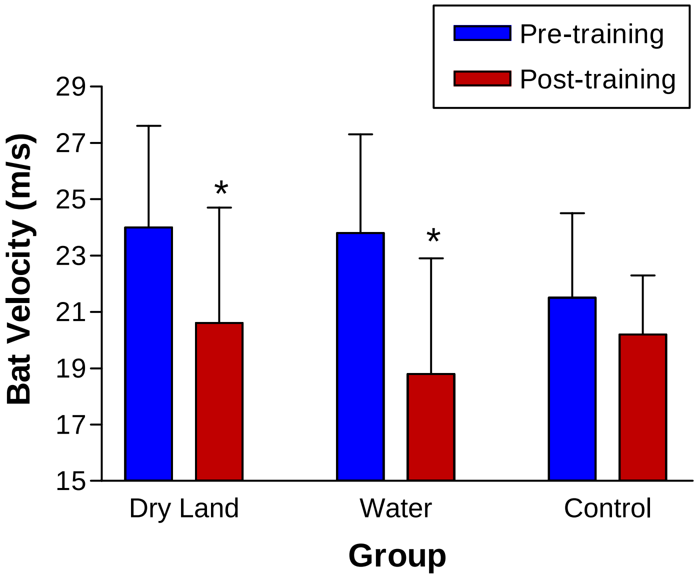

Figure 2. Mean (± SD) bat velocity (m/s) for pre-and post-test for each group.

DISCUSSION

Bat velocity is a critical characteristic of successful hitters (1). Theories on the optimal resistance training program to improve bat velocity have varied over the years. Traditionally, it has been suggested that a general resistance training program that strengthens the muscle groups involved in the swinging motion (lower extremity, trunk, and upper extremity muscles) will increase bat velocity. However, this general resistance training often occurs at slow speeds and does not include the entire range of motion of the primary movement (i.e. hitting) (10). More recently, sport-specific resistance training has been proposed to improve bat velocity (4). Sport-specific resistance training mimics the range of motion and speed of hitting. Researchers have shown that there is a high degree of velocity specificity in resistance training (9). Resistance training at high speeds results in better performance on tests at high speeds, but not on tests at slow speeds. Likewise, resistance training at slow speeds results in better performance on tests at slow speeds, but not on tests at high speeds.

Strength gains that occur during either general or sport-specific resistance training initially are the result of neural adaptations, which are followed by muscle adaptations (11). A motor unit consists of a motor neuron that innervates specific groups of Type I, IIa, or IIb fibers. During muscle contraction, motor unit recruitment occurs in a specific sequence from smaller motor units of slow twitch Type I fibers to larger motor units of fast twitch Type IIb fibers, a concept termed the size principle (10). The smaller motor units have a lower threshold, are recruited during low force or low power exercises, and result in a slow contraction speed. The larger motor units have a higher threshold, are recruited during high force or high power exercises, and cause a fast contraction speed (10). General resistance training at slow speeds primarily causes neural adaptations in the slow motor units, through increased recruitment and firing rate of the slow motor units (12,13). This results in strength gains at slow speeds, and therefore is not beneficial to a fast velocity skill like hitting. In contrast, high speed sport-specific resistance training targets fast twitch motor units and increases strength gains at fast speeds due to an increased ability to rapidly recruit fast motor units, and increased firing rate of fast motor units (12,13). These neural adaptations are beneficial to bat velocity. Neural adaptations during strength training are followed by muscle adaptations, primarily muscle hypertrophy (11). General resistance training at slow speeds results primarily in hypertrophy of Type I fibers (10), and may result in a shift from fast muscle fibers (Type IIb) to slower muscle fibers (Type IIa) (10,14). Since bat speed likely depends on Type IIb fibers, these changes resulting from slow speed general resistance training may be detrimental to bat velocity. In contrast, high speed sport-specific resistance training typically results in hypertrophy of fast Type IIb fibers, which is beneficial to bat velocity (12,13).

One of the interesting findings of the present study was that bat velocity significantly decreased for both the dry land and water groups following an eight-week training program of general and sport-specific resistance training. In contrast, bat velocity did not change for the control group, which did not participate in general or sport-specific resistance training.

The general resistance training program consisted of isotonic exercises aimed to increase overall muscular strength, as described previously. We speculate that this mandatory team general resistance training program may have had a detrimental effect on bat velocity for both the dry land and water groups. The slow speed general resistance training may have caused hypertrophy of slow twitch Type I fibers, and the transition of fast twitch Type IIb fibers to the slower Type IIa fibers, which would be detrimental to bat velocity. This speculation is supported by the findings of Mayhew et al. (15) who reported that as 1 RM increased in football players, high speed strength decreased. Furthermore, Edwards (16) found a decrease in throwing velocity following general resistance training.

In addition to neural and muscular adaptations resulting from general resistance training, bat velocity may have decreased in both the dry land and water groups due to fatigue of the trunk musculature. Muscles of the trunk (abdominals, spine, and hip musculature) are known to be important during hitting (17). However, the general resistance-training program designed by the softball coach did not emphasize the trunk musculature. Fatigue of these core muscles may have contributed to the decrease in bat velocity observed in the dry land and water groups.

In the present study, the dry land and water groups also participated in sport-specific resistance training. The dry land and water groups trained for eight weeks with a 26 oz Thunderstick (45 swings per day, 3 days per week, 8 week training program; 1,080 total swings). The dry land group performed the swings on land, and the water group performed the swings in shoulder deep water. As described previously, ideal sport-specific trainings provides overload, and occurs through the full range of motion and at the speed of the primary movement (i.e. bat swing) (4). Although the dry land group met the range of motion and speed criteria, the overload component was not present. This may have contributed to the observed decrease in bat velocity. These results are in agreement with the findings of Verduzco (6), who reported a decrease in bat velocity in collegiate baseball players following eight weeks of dry land swings with a standard weight 30 oz baseball bat. (Subjects completed a total of 1,920 swings: 80 swings per day, 3 days per week, 8 week training program). In contrast, Sergo (5) reported an increase in bat velocity after a dry land bat swing program of 100 swings per day, 3 days per week, for 6 weeks (1,800 total swings) with a standard weight 31 oz baseball bat. Similarly, DeRenne (2) found an increase in bat velocity following twelve weeks of dry land swings with a standard weight 30 oz baseball bat (150 swings per day, 4 days per week, 12 weeks; 7,200 total swings). It is unclear why the results of the present study and the Verduzco report (6) differ from the findings of Sergo (5) and DeRenne (2); although, differences in the training programs (weight of bat, swings per day, days per week, number of weeks) may have been contributing factors.

Although not statistically significant, the water group had an even greater loss in bat velocity (-21%) compared to the dry land group (-14%). The water group met the overload (from the resistance of the water) and range of motion requirements of sport-specific resistance training. However, the water group performed the bat swings at a much slower speed than competition speed due to the resistance of the water, which may have contributed to the greater loss of bat velocity for this group compared to the dry land group. Furthermore, the resistance of the water may have provided too much overload for the sport-specific resistance training. This is referred to as the "too heavy" theory, and may result in decreased bat velocity due to an alteration in swing mechanics (18). The "too heavy" theory is supported by the findings of DeRenne (1,19). Warming up with a weighted implement more than 10% heavier than a standard weight baseball bat decreased bat velocity (1). Similarly, training with a ball more than 20% heavier than a standard weight baseball resulted in decreased throwing velocity (19).

CONCLUSIONS

Bat velocity was decreased in collegiate softball players following eight weeks of general resistance training and sport-specific resistance training swinging a 26 oz Thunderstick on either dry land or in water. Although not statistically significant, the loss of velocity was greater for the water group compared to the dry land group. Additional research needs to address the effect of general and sport-specific resistance training on bat velocity. This information would be of interest to baseball and softball coaches at all levels of competition.

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