

Comparison of Dynamic Push-Up Training and Plyometric Push-Up Training on Upper-Body Power and Strength

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ABSTRACT

The purpose of this study was to compare dynamic push-up (DPU) and plyometric push-up (PPU) training programs on 2 criterion measures: (a) the distance achieved on a sitting, 2-handed medicine ball put, and (b) the maximum weight for 1 repetition of a sitting, 2-handed chest press. Thirty-five healthy women completed 18 training sessions over a 6-week period, with training time and repetitions matched for the DPU ($n = 17$) and PPU ($n = 18$) groups. Dynamic push-ups were completed from the knees, using a 2-second-up–2-second-down cadence. Plyometric push-ups were also completed from the knees, with the subjects allowing themselves to fall forward onto their hands and then propelling themselves upward and back to the starting position, with 1 push-up completed every 4 seconds. The PPU group experienced significantly greater improvements than the DPU group on the medicine ball put ($p = 0.03$). There was no significant difference between groups for the chest press, although the PPU group experienced greater increases.

Key Words: plyometric exercise, isotonic exercise, strength training, power training

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Introduction

Plyometrics is a nontraditional form of resistance training emphasizing the loading of muscles during an eccentric muscle action, which is quickly followed by a rebound concentric action (12, 20). Although applicable to both the upper and lower body, training studies have focused overwhelmingly on the power of the knee extensor muscles (1–3, 5, 12, 20). Typically, plyometric exercises have involved jumping

movements, starting with a rapid lowering of the body's center of gravity (the eccentric muscle action component) from a standing position (termed a countermovement jump) or from an elevated surface (termed a drop jump). This is followed immediately by a jump in which the athlete tries to attain maximum height or distance (the concentric muscle action component) (6, 7). Plyometric training is most frequently completed using body weight rather than a mechanical load to provide the resistance, although weights can be attached to the athlete to increase the resistance (4, 13, 18, 19). Weighted implements, such as medicine balls, can also be used for training the upper extremities (9, 14).

Two basic approaches have been used to study the effectiveness of plyometric exercises. Plyometric exercises have been added to a typical training program, such as weight training or team practices, and then compared with the typical program (2, 3, 8, 10, 11, 13, 16–20). Alternately, a distinct plyometric program has been compared with a distinct nonplyometric program (1, 4, 14, 22). Some authors (8, 10, 11, 18, 19) have found plyometric exercises to be a beneficial adjunct to traditional training methods, while others have found plyometrics to be of no advantage (1–4, 10, 13, 14, 16, 17, 20, 22). However, the effectiveness of plyometrics alone could not be directly addressed in these studies because the plyometrics were combined with another mode of training. In studies comparing distinct plyometric programs directly with other distinct nonplyometric programs, none reported plyometrics to be more effective (1, 4, 14, 22). To date, no standard training methods for plyometric exercise programs have been clearly established. There is uncertainty concerning heights used during weighted drops and the number of repetitions or sets performed, and exercises for specific body parts have not been estab-

Table 1. Subject characteristics (mean \pm SD).

Training program	Age (y)	Height (cm)	Mass (kg)
Dynamic push-up ($n = 18$)	17.4 (2.1)	165.2 (7.5)	56.9 (8.5)
Plyometric push-up ($n = 17$)	17.3 (2.1)	162.9 (7.0)	56.6 (6.4)

lished. The purpose of this study was to compare the effect of dynamic push-ups (DPU) and plyometric push-ups (PPU) on the power and strength of the chest and shoulder girdle musculature.

Methods

Subjects

Forty-one healthy women participated in the study. To be selected, subjects had to have no history of any major upper-extremity or back injury, and could not be involved in formal athletic competition or formal weight training for the duration of the study. However, subjects were allowed to continue their normal recreational activities. Subjects were randomly assigned to either dynamic push-up (DPU) or plyometric push-up (PPU) training programs. All subjects signed an informed consent and were free to withdraw from the study at any time. Six subjects (4 in the PPU group and 2 in the DPU group) did not complete all of the requirements and were dropped from the study. Subject characteristics are presented in Table 1.

Tests

Before the start of the study and again after 6 weeks of training, 2 tests were used to measure the power and strength of the chest and shoulder girdle musculature. All tests were preceded by a general warm-up that included 5 minutes of stationary cycling followed by flexibility exercises for the chest and shoulder girdle musculature. The 2 tests, the medicine ball put and the 1 repetition maximum (1RM) chest press, were completed on 1 occasion with about 5 minutes rest between each. The order of tests was the same and subjects were tested in the same sequence each time. To ensure reliability of the tests chosen and to familiarize subjects with the testing protocol, each subject was tested on 2 consecutive days 2 weeks prior to the study. During these trial days, subjects did not perform any exercise, but rather positioned themselves correctly and performed the required test. Intraclass correlation coefficients were $R = 0.99$ and $R = 0.97$ for the 1RM chest press and medicine ball put, respectively. There was no significant difference between groups for either test prior to training.

Medicine Ball Put. The medicine ball (Dynamax Inc. Dallas, TX) put approximated a basketball chest put, completed from a sitting position. Each subject was seated on an adjustable bench with her back oriented vertically against a back support, thighs horizontal,

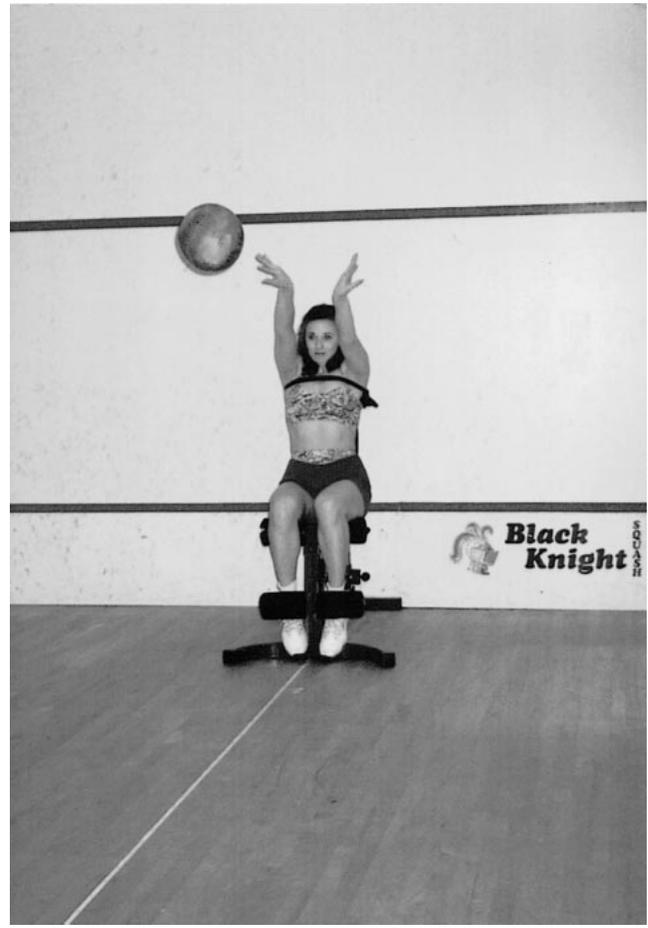


Figure 1. Photograph of a subject performing the medicine ball put test.

knees flexed at 90° , and ankles fixed behind swivel pads at the base of the bench (Figure 1). Subjects were secured to the bench with elastic strapping placed around the trunk and the backrest at midchest level under the axillae. This position and mode of stabilization minimized trunk movements during the put.

Subjects were instructed to hold the 2.7-kg medicine ball (65 cm in diameter) in their laps with both hands, bring the ball up quickly to touch their chest at about nipple level, and then explosively perform a chest-type pass, pushing the ball outward and upward at an angle approximately 30° above horizontal. The same instructions and demonstrations were given to each subject before each test.

To facilitate measurement of distance, the skin of the medicine ball was lightly dampened to leave an imprint on the floor where first contact was made. Distance was measured from the base of the bench to the closest edge of the medicine ball imprint. Subjects completed 10 medicine ball puts, with an approximate 45-second rest between each trial. Distances were revealed to the subjects after each trial. The farthest put was marked on the floor with white tape, to be used as a target distance. To account for slight variation be-



Figure 2. Photograph of a subject performing the chest press test.

tween each put, the mean of 6 trials was used as the criterion measure.

1RM Chest Press. During the 1RM chest press test, each subject was seated on the bench of the Nautilus double chest machine (Independence, VA), with her back against the backrest inclined at an angle approximately 45° from the vertical (Figure 2). A seatbelt was fastened around the anterior superior iliac spines to secure the pelvis to the seat and backrest. The test movement began from a position of arm extension, which was followed by arm flexion, bringing the handles toward the subject’s chest (2-second duration) and then arm extension (2-second duration), with relatively constant movement. Subjects were instructed to keep their backs against the backrest during the test. An elastic strap was fastened between the 2 handles of the apparatus. Subjects were required to bring the handles back toward their body until the elastic strap touched their chest. Immediately after contact, the motion was reversed and the resistance was pushed back to the starting position.

Two submaximal lifts were completed as practice before any maximal efforts. Depending on the ease or difficulty of each attempt, weight was added or removed from the weight stack in 4.5–45-N (1–10-lb) (0.5–4.6 Kg) increments. Subjects were allowed to rest for approximately 90 seconds between efforts. The criterion measure, a 1RM lift, was usually determined within 4–8 lifts.

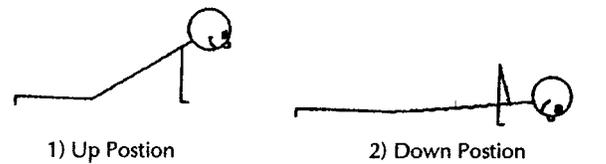
Training Program

Subjects were required to complete 18 training sessions, at a frequency of 3 sessions per week and with at least 48 hours between sessions. The DPU and PPU training programs were matched for repetitions, sets, progression, and rest intervals between sets (Table 2).

Instructions included safety issues and subjects were advised to use an exercise mat for all training sessions. Most subjects trained in groups of 3–7 at a local gymnasium or a grass playing field. The senior

Table 2. Time sequence and training program used by both the dynamic push-up and the plyometric push-up groups.

Week	Sets × repetitions
Pretest	Tests only
1	3 × 10
2	3 × 10
3	3 × 11
4	3 × 12
5	4 × 10
6	4 × 11
Posttest	Tests only



Plyometric Push-Up

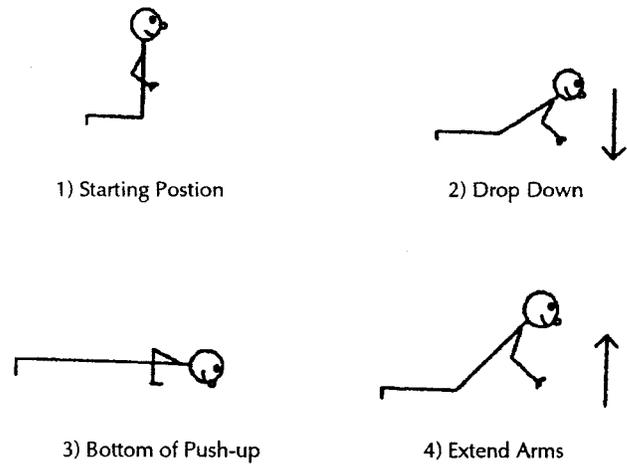


Figure 3. Stick figure diagrams of the dynamic push-up and plyometric push-up exercises.

author contacted each subject regularly to ask if there were any questions and to encourage subjects to comply with training.

Dynamic Push-Up. Dynamic push-ups were completed from the knees, with the body remaining straight from the head to the knees, and the knees and toes remaining in contact with the floor throughout the exercise (Figure 3). Subjects started in the up or inclined position with their hands placed just beyond shoulder width apart on the floor, and their fingers pointing

forward. When viewed from the side, their hands fell directly below their shoulders. From this position, the subject lowered her body until her chest almost touched the floor. Without pausing, the subject changed direction and straightened her arms, pushing the trunk up to the starting position. Subjects were instructed to follow a cadence of 2-seconds-down and 2-seconds-up with a relatively constant velocity of movement. This cadence was necessary to control for the intensity of the workout session.

Plyometric Push-Up. Plyometric push-ups were completed from the kneeling position, with the knees and feet remaining in contact with the floor (Figure 3). Subjects started with their trunk vertical and their arms relaxed and hanging at their sides. From this position they allowed themselves to fall forward, extending their arms forward with slight elbow flexion, in preparation for contact. At contact, the subject gradually absorbed the force of the fall by further flexing the elbows and gradually stopped the movement with the chest nearly touching the floor. Immediately after stopping the downward motion, the subject reversed the action by rapidly extending her arms and propelling her trunk back to the starting position. A plyometric push-up was repeated every 4 seconds until the assigned repetitions were completed.

If the subject was unable to return to the starting position during the ascent phase, she was allowed to break form at the highest return point and help herself back to the starting position by flexing at the hips and going into a quadruped position. In this case, the subject was instructed to perform the plyometric push-up with the goal of achieving maximal height and developing the ability to return to the starting position as soon as possible. Although approximately 50% of the subjects could not propel themselves back to the starting position during the first day of training, they were able to do so consistently by the fifth training session. Subjects were instructed that the ascent phase was similar to a clap push-up (without the hand clap) with the hands leaving the ground, and that they were to perform each repetition with maximum effort, emphasizing a fast switch from trunk descent to trunk ascent.

Statistical Analysis

An SPSS-PC statistical package (SPSS Inc., Chicago, IL) was used to perform an analysis of variance (ANOVA) procedure to assess the differences between groups on the 2 tests. Whenever significance was indicated, multiple comparisons were performed. Significance in this study was chosen at the 0.05 level.

Results

Both groups demonstrated significant improvements for both criterion measures ($p < 0.05$). On the medicine ball put, the PPU group experienced significantly greater increases than the DPU group ($p < 0.05$). On

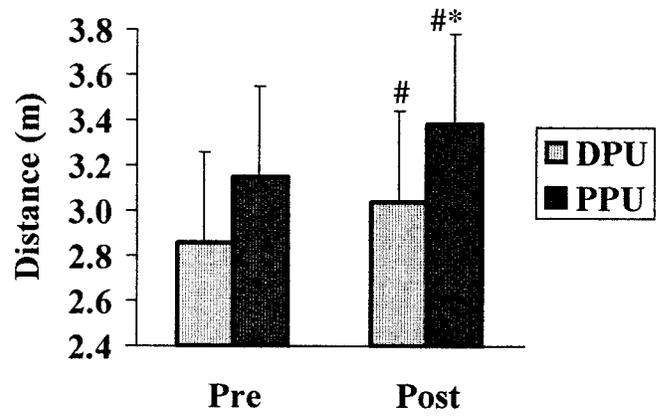


Figure 4. Graph of performance scores on the medicine ball put test (means and standard deviations). * = $p < 0.05$ from corresponding DPU values. # = $p < 0.05$ from corresponding prevalues.

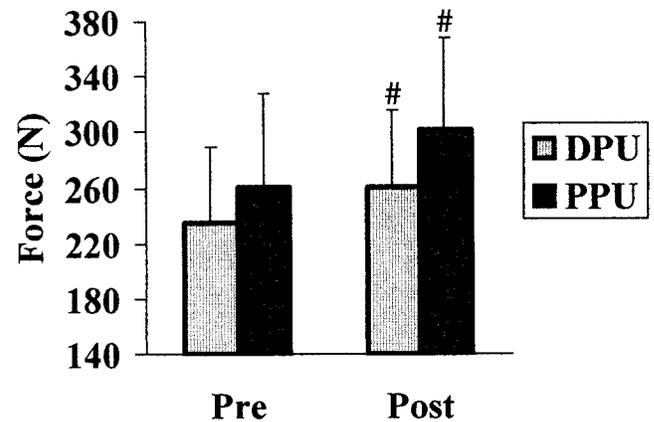


Figure 5. Graph of performance scores on the chest press test (means and standard deviations). # = $p < 0.05$ from corresponding prevalues.

the chest press, the PPU group demonstrated greater improvement than the DPU group, but there was no significant difference between the 2 groups on this measure. Subjects in the DPU and PPU groups increased their 1RM Nautilus chest press scores by an average of 2.7 and 4.17 kg, respectively. Additionally, the medicine ball put scores increased for both groups, by a total of 18 cm for the DPU group and 23 cm for the PPU group. Figures 4 and 5 depict the measures for the 2 groups, both pre- and posttraining.

Discussion

The subjects in both training groups considered their exercises to be demanding, yet simple to learn and to perform. Of the 6 subjects who withdrew from the study (2 from the DPU group and 4 from the PPU group), 4 withdrew as a consequence of missing more than 4 training sessions due to a lack of interest, motivation, illness, or a combination of these factors. However, 2 subjects from the PPU program dropped

out because of muscular discomfort that did not go away after 2 weeks of training. Nevertheless, no injuries were reported as a result of training.

In the present study, each program produced significant improvements in both the medicine ball put and the chest press tests ($p < 0.01$). Overall, the PPU group demonstrated greater improvements, which were significant for the ball put ($p = 0.03$) and approached statistical significance for the chest press ($p < 0.15$). These results suggest that the plyometric program was more effective in improving upper-body power and strength. These findings are in agreement with observations by Crowder et al. (11), who studied plyometric and isotonic push-ups added to a weight training program. They used the medicine ball put as their test, and found the plyometric group demonstrated superior gains. While the addition of plyometric exercises to another training program provides 1 method for examining the effectiveness of plyometric exercise. However, the combined program and the athlete's response to the program make it difficult to isolate the contributions of plyometric and isotonic training to upper-body power. Heiderscheit et al. (14) compared distinct isokinetic and plyometric training programs for the shoulder internal rotators. They found that an isokinetic program produced significant improvements in isokinetic power, whereas a plyometric program (weighted ball throwing) produced no significant improvements; however, the improvement in ball throwing exhibited by the plyometric group was 5 times the improvement of the isokinetic group. In the present study, the 2 tests emphasized different aspects of conditioning. In the ball put, the weight of the ball remained constant and improvement was considered to be largely attributable to greater ball velocity, whereas for the chest press, velocity of movement remained constant and gains were considered to be attributable to increased force (lifting more weight). The finding of superior improvement in the plyometric group may be attributable to a greater workload required in the PPU program. This greater workload is attributable to the momentum of the falling trunk, which contributes to the resistance provided by the individual's body weight and must be overcome by the upper extremities during the plyometric push-up. Because the kinetic energy the subject must overcome is a function of mass and velocity, the greater velocity of the falling trunk results in greater work to decelerate and then accelerate the body during the plyometric push-up (work = kinetic energy = $\frac{1}{2}mv^2$). Perhaps a similar rationale may underlie the results of other studies reporting plyometrics to be more effective.

Practical Applications

Both the DPU and PPU training programs yielded significant improvements on both the ball put and chest

press tests. Although the PPU program was characterized by greater improvements, these gains were only significant for the ball put test ($p = 0.03$). These results suggest that plyometric training may be advantageous for developing upper-body power and strength. Whether or not plyometric exercise results in superior improvements in athletic performance remains to be determined. Athletes and coaches should be cautious when incorporating plyometric training into their programs (15). If proper care is not taken, the potential for injury increases. However, if safety precautions are taken, realistic exercises are chosen, and adequate rest is included, athletes can significantly improve their power and strength with plyometric training.

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