Effect of Progressive Calisthenic Push-up Training on Muscle Strength and Thickness

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Abstract

Kotarsky, CJ, Christensen, BK, Miller, JS, and Hackney, KJ. Effect of progressive calisthenic push-up training on muscle strength and thickness. *J Strength Cond Res* 32(3): 651–659, 2018—Calisthenics, a form of resistance training, continue to increase in popularity; however, few studies have examined their effectiveness for muscle strength improvement. The purpose of this study was to determine whether progressive calisthenic push-up training (PUSH) is comparable with traditional bench press training (BENCH) as a technique for increasing muscle strength and thickness. Twenty-three healthy, moderately trained men (mean ± *SD*: age 23 ± 6.8 years) completed the study. Subjects were randomly assigned to PUSH ($n = 14$) and BENCH ($n = 9$) groups and were trained 3 days per week for 4 weeks. Muscle thickness (MT), seated medicine ball put (MBP), 1 repetition maximum (1RM) bench press, and push-up progression (PUP) were measured before and after training. Results revealed significant increases in 1RM ($p < 0.001$) and PUP ($p < 0.001$) for both groups after training. The increase in PUP was significantly greater for PUSH ($p < 0.001$). No significant differences were found within groups for MT and MBP ($p > 0.05$). This study is the first to demonstrate that calisthenics, using different progressive variations to maintain strength training programming variables, can improve upper-body muscle strength.

Key Words bodyweight, resistance training, strength training, variations, bench press, free weights

Introduction

Calisthenic exercise, also known as bodyweight training, is a form of resistance training (RT) that continues to increase in popularity over the past couple of years. In fact, calisthenics were listed as the number 2 fitness trend for 2017 and 2016, number 1 for 2015, through surveys by the American College of Sports Medicine (23–25). Although calisthenics are popular, other methods of RT are more commonly associated with strength training. Traditional free weight and dumbbell exercises, such as the bench press and back squat, have been extensively researched and are the preferred method to increase muscle strength (4,9,15,22). This may be due to the ease of manipulating training variables, such as external resistance, that facilitate muscle strength development (2,12,15,19).

Studies on calisthenics are limited, and the few that have tested the effectiveness of these exercises to improve muscle strength have not reported any increases (7,17,21,26). A major limitation of these studies, however, is that strength training variables were not accurately applied to the calisthenic exercises. Training variables used in these studies closely resembled muscular endurance training; given researchers increased the number of repetitions per exercise, rather than using a more difficult variation to keep the subjects' repetitions lower and within the strength training guidelines. The application of increasingly difficult calisthenic variations provides a novel approach to traditional strength training. This is significant when considering that calisthenics require minimal to no equipment, making them both an efficient and cost-effective alternative to traditional RT that can be performed nearly anywhere. Therefore, the effectiveness of calisthenics should be compared with traditional RT to test whether increasing the difficulty of calisthenics can produce similar training-induced adaptations when recommended strength training variables are maintained.

The purpose of this study was to determine whether progressive calisthenic push-up training is comparable with traditional bench press training as a technique for increasing muscle strength and thickness.

Methods

Experimental Approach to the Problem

Twenty-seven subjects were recruited to participate in this study. In the first session, subjects were educated on the protocol, and in the second session, subjects performed a pretraining fitness assessment. The assessment included measurement of left pectoralis muscle thickness (MT),

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Table 1. Push-up progressions.*

Progression (level)	Variation	Beginning repetitions	Total volume
1	Wall push-up	3 sets of 6 reps	3 sets of 6 reps
2	Incline push-up	3 sets of 6 reps	3 sets of 6 reps
3	Kneeling push-up	3 sets of 6 reps	3 sets of 6 reps
4	Half push-up	3 sets of 6 reps	3 sets of 6 reps
5	Full push-up	3 sets of 6 reps	3 sets of 6 reps
6	Close push-up	3 sets of 6 reps	3 sets of 6 reps
7	Uneven push-up	3 sets of 3 reps per side	3 sets of 6 reps
8	½ one-arm push-up	3 sets of 3 reps per side	3 sets of 6 reps
9	Archer push-up	3 sets of 3 reps per side	3 sets of 6 reps
10	One-arm push-up	3 sets of 3 reps per side	3 sets of 6 reps

*reps = repetitions.

medicine ball put (MBP) distance, 1 repetition maximum (1RM) bench press, and push-up progression (PUP) estimation. Data from the assessment were used to determine the starting bench press weight or which PUP level, presented in the following sections, a subject would use during their first training session. Four subjects withdrew from the study for reasons unrelated to the exercise training. Thus, 23 subjects completed a randomized control trial, performing a 4-week training program of either bench press or push-ups that maintained the same strength training principles. To determine the effectiveness of the bench press and push-up training, subjects performed a post-training fitness assessment that included the same measurements as the pretraining fitness assessment. The study was designed to answer the following research questions: "Can progressive push-up training increase upper-body muscle strength or thickness?" and "Are progressive push-ups as effective as traditional weight training in developing upper-body muscle strength or thickness?"

Subjects

Twenty-three moderately trained men aged 18–45 years (mean ± *SD*: age 23 ± 6.8 years, height 180.8 ± 5.7 cm, body mass 81.9 ± 14.1 kg, and body fat 10.4 ± 3.7%) completed the study. Moderately resistance trained was defined as someone who was currently performing resistance exercise at least twice a week for the past 2–6 months (3). Before inclusion in the study, subjects provided written informed consent, a self-reported health history, and a Physical Activity Readiness Questionnaire (PARQ). Additional exclusion criteria included individuals with any history of joint pain, shoulder impingement syndrome, musculoskeletal disorders, such as rheumatoid arthritis, or specific injuries to the hands or shoulders. Each subject completed 15 sessions in the following order: 1 familiarization session, a pretraining fitness assessment, 12 training sessions, and a post-training fitness assessment. Subjects were trained 3 days per week, separated by 48 hours, and randomly assigned to a PUP group (PUSH, $n = 14$; mean ± *SD*: age 24 ± 8.5 years, height 180.7 ± 5.7 cm, body mass 79.6 ± 14.4 kg, and body fat 9.9 ± 1.1%) or a bench press group (BENCH, $n = 9$; mean ± *SD*: age 21 ± 2.3 years, height 180.9 ± 6.1 cm, body mass 85.6 ± 13.7 kg, and body fat 11.3 ± 1.0%). Descriptive measures were recorded during pretraining fitness assessment. All procedures were approved in advance by the North Dakota State University's Institutional Review Board, and written consent was obtained.

Procedures

Familiarization Session. During the familiarization session, participants learned about the purpose of the study, the fitness assessments, and training exercises, including proper form and body position, the specific training variables that were to be used during training sessions, and the cadence that was to be followed while performing each exercise. Participants were encouraged to ask questions about the study until they fully understood what was required of them.

Pretraining and Post-training Fitness Assessment Sessions. During the pretraining and post-training fitness assessment sessions, each subject underwent a series of tests to determine baseline and final measurements. Baseline measurements were conducted during the pretraining fitness assessment session at least 48 hours before the first training session. Final measurements were conducted during the post-training fitness assessment session 48 hours after the last training session. The order of the assessments was a muscle ultrasound measurement, seated MBP test, 1RM bench press test, and PUP estimation. Each subject's age, height, body mass, and body fat percentage were recorded before the ultrasound measurement. Weight was recorded using an eye level scale (Detecto, Webb City, MO, USA), and height was measured using a stadiometer (Seca, Chino, CA, USA). A bioelectrical impedance, body composition analyzer (model

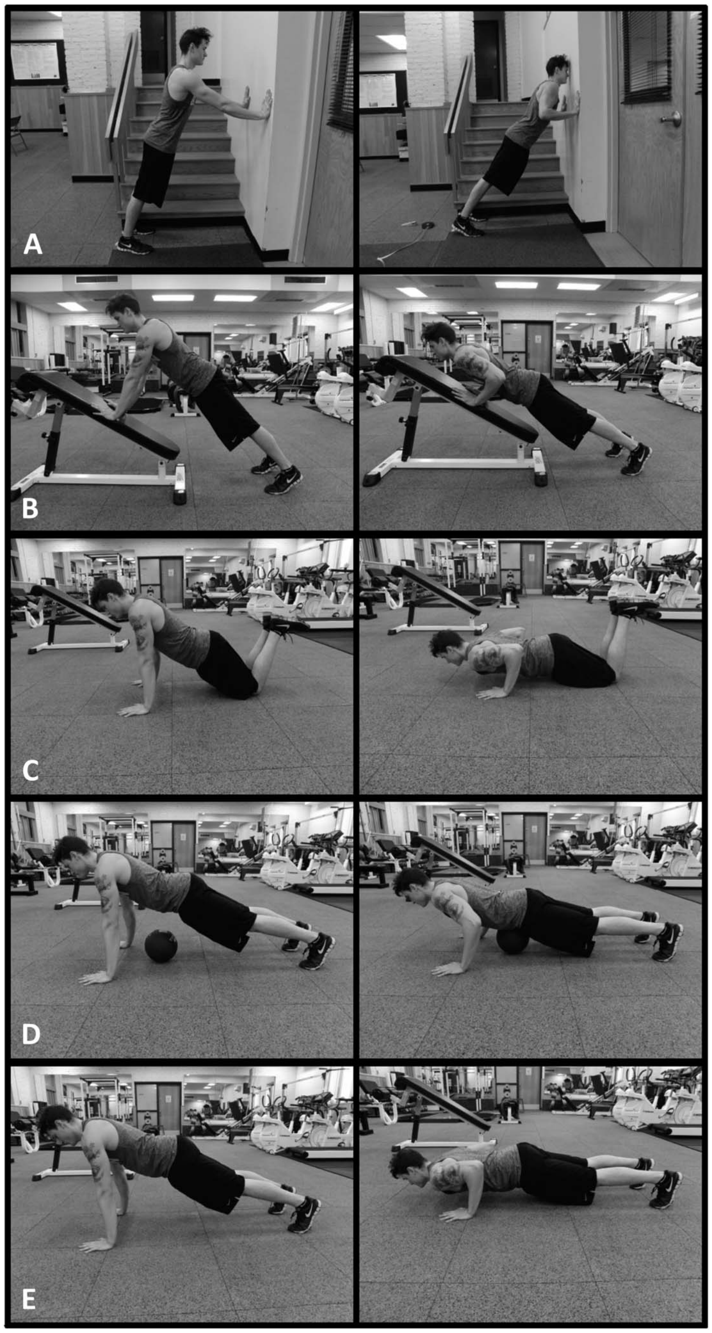

Figure 1. Demonstration of wall push-up (A), incline push-up (B), kneeling push-up (C), half push-up (D), and full push-up (E). Column 1 displays starting position. Column 2 displays finish position.

TBF-300A; Tanita, Arlington Heights, IL, USA) was used to determine participant body fat percentage. All data were collected on workout sheets created by the researcher.

Muscle Thickness. Thickness of the left pectoralis major muscle was measured using B-mode on an ultrasound system (model HD11 XE; Philips Ultrasound, Bothell, WA, USA) with a L12-5 50-mm linear array probe. The protocol for the ultrasound and method for measuring MT was conducted according to Yasuda, Fujita, Ogasawara, Sato, and Abe (28). A one image technique was used to compare MT between baseline and final measurements. The site of ultrasound measurement was at 60% of the measured distance from the left clavicle to the left nipple, with the ultrasound head placed directly under the 60% indicator mark. The images were captured at a frequency of 37 Hz with a depth of 7 cm and gain of 100. Muscle thickness for each image was determined by averaging 4 evenly spaced measurements. Test-retest reliability of this one image technique was 2.5% using coefficient of variation and 0.953 using intraclass correlation coefficient.

Seated Medicine Ball Put Test. The MBP test was used to measure power of the upper-body muscles. Although this study was designed to increase muscle strength, strength is a factor of power. Any post-training improvements were likely due to increases in subject's upper-body muscle strength. The test was meant to be an alternative measure of muscle performance because it was not a specific exercise used in the PUSH or BENCH training. The protocol for the seated MBP was conducted according to Clemons et al. (10). A 5.44-kg medicine ball (Power Systems, Knoxville, TN, USA) was used for testing.

One Repetition Maximum Bench Press Test. The purpose of the 1RM bench press test was to measure the maximum strength of the chest muscle group. The measurement of

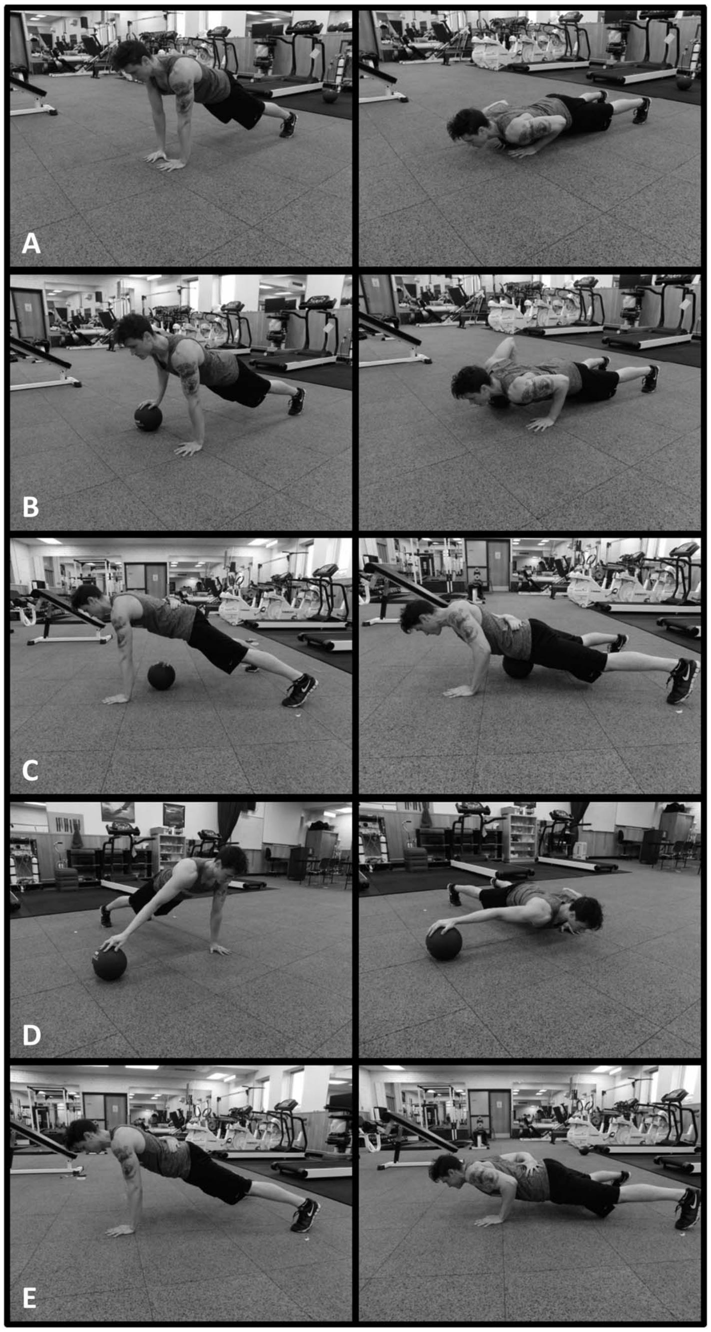

Figure 2. Demonstration of close push-up (A), uneven push-up (B), ½ one-arm push-up (C), archer push-up (D), and one-arm push-up (E). Column 1 displays starting position. Column 2 displays finish position.

Push-up Progression Estimation Test (Experimental Approach). The starting PUP for the estimation test was determined by the researcher, considering the subjects training familiarity with the PUP levels in Table 1. All subjects were moderately trained and had experience with the push-up exercise, so estimation began at level 5 or 6. At the estimated progression level, each subject attempted to complete 3 sets of 6 repetitions (6/6/6) for double arm progressions or 3 sets of 3 repetitions (3/3/3) per side for single arm progressions. A 2-minute rest was given between sets. Subjects who successfully completed the prescribed number of sets and repetitions with proper form for their starting push-up variation advanced to the next PUP level. This process continued until subjects failed to complete the prescribed number of sets and repetitions with proper form for the PUP level they were currently testing on. Once failure occurred, the previous push-up level the subjects successfully completed was considered their baseline progression. Subjects randomly assigned to the PUSH used their baseline progression level as their initial push-up variation during the first training session.

Training Sessions. All subjects completed a dynamic warm-up consisting of jogging in place (1 minute), jumping jacks (1 minute), jogging in place (1 minute), shoulders rolls (20 repetitions), arm circles (20 repetitions), and chest openers (20 repetitions), followed by a subsequent warm-up specific to their training group. Correct form for the BENCH and PUSH was monitored by trained staff. Push-up form varied for each PUP level in Table 1. Research staff thoroughly monitored form in both groups to ensure conditions were the same for all subjects. A verbal cadence of 2 seconds

the 1RM during the bench press was conducted according to the National Strength and Conditioning Associations (NSCA) protocol (3). A standard adjustable flat bench and weight clips and a standard 20.41-kg Olympic barbell with weight plates ranging from 1.13 to 20.41 kg were used to complete the 1RM test.

during the eccentric phase and 2 seconds during the concentric phase was used to avoid any discrepancies in the subjects' velocity in both training groups. The cadence was voiced by the same researcher, for each subject, each session, to ensure consistency between subjects.

Bench. After the dynamic warm-up, subjects began a lift-specific warm-up with the bench press exercise by performing 8 repetitions at 40% of their estimated 1RM, followed by 1 minute of rest (18). The subjects then completed a second warm-up set of 6 repetitions at 60% of their estimated 1RM, followed by a 2-minute rest. Subjects began training sequence at 3 sets of 6 repetitions using 75% of their 1RM to effectively train in the desired repetition range. The estimated number of repetitions that can be performed at any percentage of 1RM is based on a single set, so, with a 2-second eccentric and concentric cadence, using 85% of 1RM would be difficult for the moderately trained subjects to complete for 3 sets (3). During each training session, subjects attempted to complete 1 additional repetition for each set. Once subjects performed 3 sets of 8 repetitions, on 2 consecutive training sessions, intensity was increased by adding weight in 4.54-kg increments. After adding additional weight, subjects went back to performing 3 sets of 6 repetitions. The increase in weight ensured subjects maintained appropriate strength training progression to elicit the desired training response.

Push. After the dynamic warm-up, subjects performed 2 warm-up sets of a PUP that was 2 levels below their baseline progression. For the first warm-up set, subjects performed 8 repetitions for double arm progressions or 4 repetitions per side for single arm progressions followed by 1 minute of rest. For the second warm-up set, subjects performed 6 repetitions for double arm progressions or 3 repetitions per side for single arm progressions followed by 2 minutes of rest. After the warm-up sets were completed, subjects completed the actual training sequence. Training sequence began at 3 sets of 6 repetitions for double arm progressions or 3 sets of 3 repetitions per side for single arm progressions, utilizing a 3-minute rest interval between sets. Subjects attempted to complete 1 additional repetition per set each training session. Once subjects were able to complete 3 sets of 8 repetitions for double arm progressions or 3 sets of 4 repetitions per side for single arm progressions, on 2 consecutive training sessions, intensity was increased by progressing to the next push-up variation in Table 1. After progressing to a more difficult variation, subjects went back to performing the 3 sets of 6 repetitions for double arm progressions or the 3 sets of 3 repetitions per side for single arm progressions for the new progression level.

Example: a subject at the close push-up (level 6) began the first training session by attempting to complete 3 sets of 6 repetitions (6/6/6). If the subject achieved 3 sets of 6 repetitions (6/6/6) during the first session, the subject then attempted to complete 3 sets of 7 repetitions (7/7/7) during the second training session. If, during the second session, the subject completed 1 set of 7 repetitions (7/6/6) or 2 sets of 7 repetitions (7/7/6), the subject remained at 3 sets of 7 repetitions (7/7/7) until the repetitions were achieved in a single training session. Once 3 sets of 7 repetitions (7/7/7) was achieved, the subject then worked to complete 3 sets of 8 repetitions (8/8/8). This process continued each training session until the subject successfully completed 3 sets of 8 repetitions (8/8/8) for his current push-up level on 2 consecutive training sessions. Once subject achieved 3 sets of 8 repetitions (8/8/8) on 2 consecutive sessions, the subject progressed to the next push-up variation in Table 1. Close push-up (level 6) subject completed 2 consecutive training sessions of 3 sets of 8 repetitions (8/8/8), so he began the next training session with uneven push-ups (level 7). Training sessions for this progression began by attempting to complete 3 sets of 3 repetitions (3/3/3) for each side, a total training volume of 3 sets of 6 repetitions (6/6/6) because the uneven push-up is a single arm progression. Once subject achieved 3 sets of 4 repetitions (4/4/4) for each side, a total training volume of 3 sets of 8 repetitions (8/8/8),

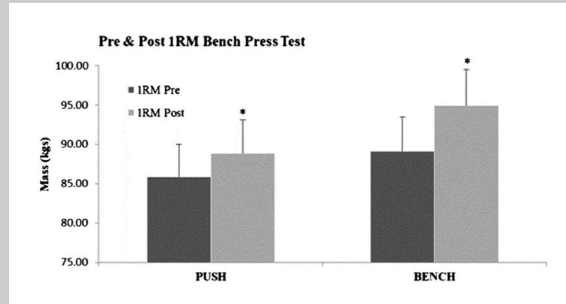

Figure 3. Comparison of 1 repetition maximum (1RM) strength values (mean ± *SE*) for the push-up progression group (PUSH) and the bench press group (BENCH) pretraining and post-training. *Significantly greater than corresponding pretraining value.

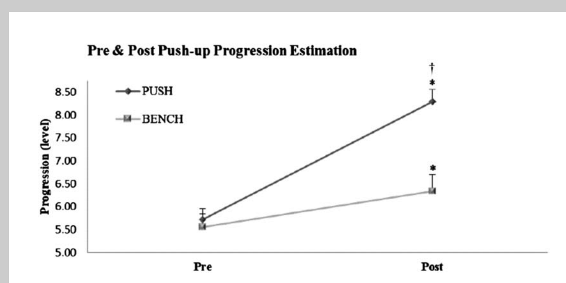

Figure 4. Comparison of push-up progression estimation (mean ± *SE*) for the push-up progression group (PUSH) and the bench press group (BENCH) pretraining and post-training. *Significantly greater than corresponding pretraining value. †Significantly greater than BENCH post-training value.

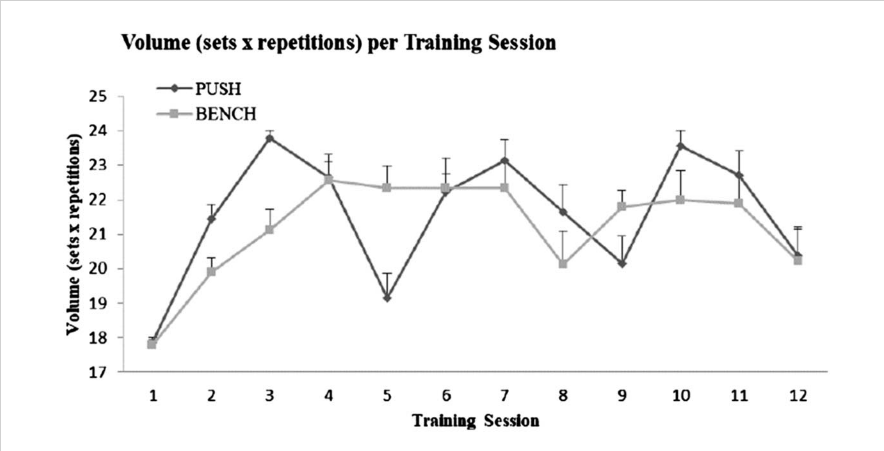

Figure 5. Comparison of volume (sets × repetitions) between the push-up progression group (PUSH) and the bench press group (BENCH) for each training session (mean ± *SE*).

on 2 consecutive training sessions, he progressed to the next push-up variation in Table 1. This process continued for each PUP.

Push-up Progressions. The PUP levels, and their order, were inspired by Wade (27) and selected for their ability to stress the body and elicit the desired training response for individuals at any fitness level(Figures 1 and 2). The training variables applied to these progressive push-up variations were selected based on current RT guidelines for increasing muscle strength (3,4,8,11,15). Because subjects in the study were moderately trained, baseline progressions started between levels 5 and 7. Although baseline progressions were not lower than level 5, all progressions and their directions were included in the study to demonstrate how an individual could use the variations to continue muscle strength improvement.

A few of the PUPs used in the study alternated the stress of the exercise on a single side of the body and required the use of a 3.63-kg medicine ball (Power Systems, Knoxville, TN, USA). For these single arm push-up exercises, subjects began with their nondominant arm first. When performing single arm push-up exercises with their dominant arm, subjects completed the exact number of repetitions achieved with their nondominant arm. This was to help subjects overcome any muscle imbalances. Subjects completed one half of the desired repetitions per set on each side before a 3-minute rest was given. The total number of repetitions per set was split to more accurately maintain the training volumes between the PUSH and BENCH. Emphasis was made during each single arm set incorporating a medicine ball to maintain a consistent pressing force on the side without the medicine ball support. Once a subject was unable to maintain the same amount of force, utilizing more force on the side with the medicine ball to assist with the pressing movement, the set was stopped. This was performed to ensure that each side of the body was stressed with the same amount of force for each repetition. The quality, not the quantity, of repetitions was most important. Below is a description of each PUP included in Figures 1 and 2.

Starting Position. The starting alignment for PUP levels 1–2, 4–5, 7, and 9 was with feet and hand(s) shoulder width apart. Level 3 kept feet and knees together, while keeping hands shoulder width apart. Level 6 placed feet shoulder width apart, but centered hands under the chest with the thumbs of each hand touching and the index fingers no more than 3 inches apart. More advanced single arm variations, levels 8 and 10, kept hand (s) shoulder width apart, and positioned feet within 1 length wider than the subject's foot size outside shoulder width to improve stability and balance.

Movement Phase. All push-up variations were initiated at the elbow(s), with the upper arm(s) pressing against the sides of the body. For single arm variations, levels 7–10, emphasis was made to keep the body as straight as possible during the movement phase by instructing subjects to control their body straight up and down. If too much twisting of the torso and hips (lateral flexion) occurred, the set was stopped.

Finish Position. Once upper arm(s) were parallel with the side (s) of the body, levels 1–7 and 9, or the body (hips or chest) contacted the medicine ball, levels 4 and 7–8, the movement ended and subjects pressed back up to starting position. For single arm variations, levels 7–10, one half of the desired repetitions for each set were completed with the nondominant arm before switching to the dominate side.

Wall Push-up (Level 1). Arm length was measured from shoulder to wrist. Subjects stood within one and half times their measured arm length from a wall. With arms raised perpendicular to body, subjects leaned forward until palms were flat against the wall.

Incline Push-up (Level 2). Hands were placed on a 2-foot, inclined surface at a 45° angle.

Kneeling Push-up (Level 3). Lower legs were flexed to 90°, shifting the weight off the knees and onto the lower thigh to keep the body in alignment and tension off the knees.

Half Push-up (Level 4). A 3.63-kg medicine ball was placed under subject's hips.

Full Push-up (Level 5). Emphasis was made to ensure subjects upper arms were pressed against the sides of their body.

Close Push-up (Level 6). Same as level 5 but with hands placed under chest and thumbs touching.

Uneven Push-up (Level 7). First single arm exercise. Dominant hand was placed on top of a 3.63-kg medicine ball. Movement phase began with subjects focusing on a single side of the body.

½ One-Arm Push-up (Level 8). A 3.63-kg medicine ball was placed under each subject's hips. After body was in proper alignment, subjects lifted 1 arm off the floor and placed it palm up on their lower back.

Archer Push-up (Level 9). After body was in proper alignment, subjects extended their dominant arm perpendicular to their body and placed their fingertips on a 3.63-kg medicine ball. During movement phase, the medicine ball rolled from the subject's finger tips to the palm of their hand. This allowed the medicine ball to act as a moveable kickstand, helping subjects maintain balance while increasing the demands on each side of the body. As subjects returned to the starting position, the medicine ball rolled back to the finger tips.

One-Arm Push-up (Level 10). After body was in starting position, subjects lifted 1 arm off the floor and placed it palm up on their lower back.

Statistical Analyses

For age, height, body mass, and body composition, descriptive statistics were used. For dependent variables (MT, MBP test, 1RM, and push-up progression), separate 2 (Training: PUSH and BENCH) × 2 (Time: pre and post) analysis of variances with repeated measures were used. An alpha level of $p \leq 0.05$ was used to determine differences. If a significant interaction was found, independent and paired t tests with Bonferroni corrections were used to compare the post-training adaptations.

Results

No significant differences were observed between the PUSH and BENCH for all pretraining descriptive variables, including age [$t(21) = 1.041, p = 0.310$], height [$t(21) = -0.080, p = 0.938$], and body mass [$t(21) = -1.000, p = 0.330$]. For 1RM, there was no significant interaction effect [$F(1,21) = 2.470, p = 0.131$]. The PUSH and BENCH significantly increased 1RM compared with baseline [$F(1,21) = 22.604, p < 0.001$], with no significant differences between groups (Figure 3). A significant interaction effect was found for the PUP estimation [$F(1,21) = 52.994, p < 0.001$]. Post hoc tests for PUP estimation showed no difference at baseline [$t(21) = 0.412, p = 0.685$], but there was a significant increase pretraining to post-training for the PUSH [$t(13) = -18.735, p < 0.001$] and BENCH [$t(8) = -3.500 = p < 0.010$], with the change in the PUSH being significantly greater than the BENCH [$t(21) = 4.380, p < 0.001$] at the post-training time point (Figure 4). The training volume (sets × repetitions) between groups was not significantly different [$t(21) = 2.073, p = 0.051$] but appeared to be slightly larger in the PUSH (mean ± *SE*: 258.64 ± 1.15) compared with the BENCH (mean ± *SE*: 254.33 ± 1.89) (Figure 5). No significant differences were found within or between groups for the change in MBP distance [$F(1,21) = 2.937, p = 0.101$] for the PUSH pretraining (mean ± *SE*: distance 4.1 ± 0.12 m) to post-training (mean ± *SE*: distance 4.1 ± 0.14 m) and the BENCH pretraining (mean ± *SE*: distance 4.2 ± 0.15 m) to post-training (mean ± *SE*: distance 4.1 ± 0.18 m). No significant differences were found within or between groups for change in MT [$F(1,21) = 1.105, p = 0.305$] for the PUSH pretraining (mean ± *SE*: thickness 3.01 ± 0.12 cm) to post-training (mean ± *SE*: thickness 3.13 ± 0.14 cm) and the BENCH pretraining (mean ± *SE*: thickness 3.38 ± 0.25 cm) to post-training (mean ± *SE*: thickness 3.42 ± 0.25 cm).

Discussion

This was the first study to determine whether progressive calisthenic push-up training is comparable with traditional bench press training as a technique for increasing muscle strength and thickness. The main finding of this study was that the utilization of progressive push-up variations increased upper-body strength comparable with the bench press exercise by eliciting the intensity needed to maintain strength training variables.

Previous studies have failed to report improvements in muscle strength when utilizing calisthenic exercises (7,17,21,26). These studies increased the training intensity of the calisthenic exercises by adding repetitions, rather than varying the exercise to keep repetitions low, leading to a training intensity that was likely not high enough to stimulate strength adaptations. This type of training is common for increasing muscle endurance, not muscle strength. The calisthenic training implemented in our study demonstrates how the push-up, through the manipulation of body and hand position, can produce the necessary training intensity to increase muscle strength.

Calatayud et al. (6) found that push-ups with elastic bands, for added resistance, induced similar muscle activation levels and strength gains as the bench press exercise. The study demonstrated that, regardless of how the intensity is achieved, biomechanically comparable exercises that yield similar surface electromyography levels can be equally effective at producing strength gains when training variables are maintained (5,6,20). Although surface electromyography was not used in our study, the similar increases in muscle strength between the PUSH and BENCH may enhance the plausibility that the push-up variations provide a similar neuromuscular overload to cause adaptations. Although no statistical differences were observed between the PUSH and BENCH 1RM, we do acknowledge that the BENCH appeared to have a twofold mean increase post-training (6.52%) than the PUSH (3.4%). This may have resulted from training with the same exercise used for the testing (1), leading to improvements in both form and technique. Another explanation for the difference may have been the experimental selection of baseline PUPs for the PUSH. Subjects in the PUSH may not have started their training with a push-up variation intense enough to enhance strength adaptations during the first week of training. Nevertheless, the ability of the PUSH to improve 1RM strength with only bodyweight progressions is novel.

Our results also show an improvement in each group's PUP estimation from baseline, with the PUSH improving their push-up level significantly greater than the BENCH. It is important to note that the mean improvement in BENCH (0.78 levels) compared with the PUSH (2.57 levels), while statistically significant, is not a full progression level. Thus, although the PUSH specifically trained with push-ups, and likely improved form and technique with each progression, we do not see the same crossover improvements in the BENCH for this test as seen in the PUSH for the 1RM test. This suggests that additional factors, such as core strength and shoulder stability, may have played the larger role in the BENCH being unable to perform the more demanding push-up variations, and that the push-ups may strengthen a wider range of muscles to allow completion of advanced progressions, especially single arm variations, and increases in 1RM strength.

No significant differences in MBP distance pretraining and post-training were discovered for the PUSH or BENCH. Although upper-body muscle strength did improve both groups 1RM, and strength is a factor of power, the slower training velocity and higher volume may have reduced the subjects' ability to quickly generate the force needed to propel the medicine ball a greater distance (15). There were also no significant differences in MT pretraining and post-training in either group. Considering the training variables used for this study were designed to increase muscle strength, and not hypertrophy (muscle growth), in moderately trained men, this result was not unexpected (2,13,15). Studies have shown an increase in muscle hypertrophy, and thus strength, during the early phases (1–8 weeks) of training (14,16); however, more studies have demonstrated that the contribution to strength in the early phases is due to increased voluntary muscle action rather than hypertrophy (14). Our study supports that more than 4 weeks of training may be required to build significant muscle mass, and that neuromuscular adaptations may have influenced the increase in strength of both groups.

The training volume (sets × repetitions) between groups was not significantly different but appeared to be slightly larger in the PUSH (mean ± *SE*: 258.64 ± 1.15) compared with the BENCH (mean ± *SE*: 254.33 ± 1.89). The difference is likely due to the inability of the PUSH to split 3 sets of 7 repetitions for the single arm push-up variations. Instead of progressing from 3 sets of 6 repetitions to 3 sets of 7 repetitions, like the BENCH or for double arm push-up variations, the PUSH progressed directly to 3 sets of 8 repetitions. This means that the PUSH completed more training sessions at 3 sets of 8 repetitions. Training volume also supported our 75% of 1RM load selection for the BENCH. By observing the average training volume for day 2 (20 repetitions) and 3 (21 repetitions), we know that volume would have been 21 and 24 repetitions, respectfully, if the load was too easy for the subjects to complete. In fact, only 2 subjects successfully managed to complete 24 repetitions on day 3 and 4 subjects on day 4, with only 1 increasing weight on day 5. Load based volume (sets × repetitions × load) was not compared because of the difficultly of accurately estimating the specific load an individual in the PUSH would be moving during any push-up variation.

Based on these findings, it is important to discuss the capability of progressive calisthenic push-up training to prolong strength improvement after reaching the level 10 variation used in this study. Although a lot of training is necessary to successfully perform the one-arm push-up variation with great form for several repetitions, additional variations will eventually be needed to continue progression in the strength repetition range and avoid ceiling effects. It is true that calisthenic exercise may not be as convenient as traditional free weights in their ability to add external resistance; however, 1 positive about calisthenic exercise is how easily they can be manipulated to meet the needs of the trainee with little to no equipment. Many variations, including planche push-ups, and techniques, such as leg raising and using declined surfaces, can intensify, replace, and expand the calisthenic push-up variations used in this study to continue increases in muscle strength. In addition, the combination of external resistance, such as elastic bands and weighted vests, and calisthenics exists. These exercises would no longer be considered true calisthenics, but the variations could continue strength improvements beyond the initial ceiling. More research is needed to discover and support the benefits of calisthenic exercise, especially in longer training studies.

As the first known study to apply recommended strength training variables to the push-up exercise, no similar studies are available to compare training techniques or methods. We observed no differences between the PUSH and BENCH in the short term; however, as training advances to the highest push-up variations, the bench press may excel in developing upper-body muscle strength. Therefore, research is needed to compare the effectiveness of progressive calisthenic push-ups in long-term training and to test new variations for advancing beyond the PUPs used in this study. As a training technique for developing upper-body muscle strength, progressive push-ups appear to be a viable alternative to the bench press in the short term. Other core lifts, such as the squat and deadlift, may not have such viable calisthenic replacements. Although single-leg pistol squat progressions present an alternative to the back squat, no research has been performed to measure the effectiveness of these exercises. Further research is needed to compare the effects of different progressive calisthenic exercises on muscle strength and other musculoskeletal characteristics and their ability to enhance core strength and stability.

The potential benefits calisthenic exercises have on joint health and injury prevention may also be a valuable research topic. Calisthenics uses a resistance that is never heavier than the lifters own mass. In addition, these bodyweight exercises require the recruitment of multiple muscle groups for stabilization and balance which may help these muscles develop proportionally. This differs from traditional weight training, which requires the lifting of progressively heavier external loads, and often involves the isolation of muscle groups.

Our study is the first to apply recommended strength training variables to the push-up exercise through progressive variations and validate calisthenics as a technique for improving upper-body muscle strength comparable to the bench press in moderately trained men. The results from our study may not be transferrable to other populations or calisthenic exercises involving different muscles, variations, or training procedures.

Practical Applications

Progressive calisthenic push-up exercises appear to improve upper-body strength after short-term training. Although studies are needed to validate their use in the long term, a viable application for these progressive variations may be during off-season training and periods when athletes no longer have access to their weight room. These push-up exercises present athletes with an opportunity to maintain, or even develop, upper-body strength. This is particularly valuable for physical therapists, trainers, and the recreationally active who are looking for techniques to improve muscle strength but do not have access to a variety of training equipment.

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