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A Feasibility Study Investigating the Sustainability and Safety of a Non-Periodized Protocol with Linear Load Progression during the Initial 12 Weeks of Strength Training

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ABSTRACT

Petrizzo J, Dimenna FJ, Douris PC, Jung M, Feigenbaum J, Page R, Machaby J, Wygand J, Otto RM. A Feasibility Study Investigating the Sustainability and Safety of a Non-Periodized Protocol with Linear Load Progression during the Initial 12 Weeks of Strength Training. **JEPonline** 2018;21(5):84-96. This study determined the sustainability and safety of a linearly-progressive, non-periodized resistance training protocol for beginners by having the subjects attempt to complete 12 wks of training comprising the squat exercise. Fifty-eight subjects with no previous history of resistance training participated in this study. The main finding from this feasibility study was that 60% of the subjects were able to linearly progress their load on the squat during each session of a 12-wk intervention. Our findings show that it is feasible for a majority of young strength-training novices to complete 12 wks of non-periodized resistance training involving the squat exercise performed with a load that is linearly progressed during every workout session.

Key Words: Periodization, Squat, Strength, Training

INTRODUCTION

In recent years, chronic progressive resistance exercise (PRE, “strength training”) has been shown to have an increasingly wide range of benefits on markers of overall health and athletic performance across a variety of populations (17,23,24). In addition to its well-established effect on body composition (3), research confirms that chronic PRE positively influences cardiovascular function (22), insulin action (13), plasma lipid composition (10), inflammation (14), vascular compliance (10), hypertension (1) and all-cause mortality (21). Moreover, the strength gains associated with chronic PRE result in improved athletic performance (16) along with reduced risk of overuse injury (7). Consequently, PRE is recognized as an integral component of a comprehensive health/fitness regimen for both athletes and non-athletes (3). However, despite this growing appreciation for PRE and its myriad benefits, the specific program that optimizes strength gain remains elusive (6,12). It has been suggested that a “periodized” approach that involves systematic manipulation of training variables (e.g., sets, repetitions, load, frequency, intensity of effort and/or rest) results in greater improvement compared to non-periodized training (2,18). Purported benefits include the ability to stimulate different adaptive responses and provide for periods of recuperation during a training cycle (25). This approach is, therefore, well suited for competitive athletes because training variables can be adjusted to pursue different goals depending upon time of year relative to competition (2,18).

A number of periodization paradigms have been advanced for athletes, but similar to the optimal PRE program, the best periodization scheme has yet to be identified (8,9). The first model introduced was linear periodization, which involves a high-volume, low-load approach at the beginning of a cycle followed by a gradual taper to low-volume, high-load training upon completion (i.e., after several weeks or months) (6). More recently, a varied approach with set and repetition schemes changed systematically in a predetermined fashion (e.g., on a week-to-week or even day-to-day basis; “undulating periodization”) has been suggested to optimize the adaptive response (6). A more specific approach is autoregulatory periodization, which involves manipulation of training variables that is, instead, based on the individual’s performance on a workout-to-workout basis (12). The advantage of this approach is that it allows for lifter autonomy, which is lacking with traditional linear or undulating models.

In addition to athletes, an autoregulatory periodized approach might be advantageous for improving strength and eliciting the health benefits that PRE can bring for strength-training beginners in the general population. However, we are aware of only two studies that have been devoted to exploring this possibility and both employed an acute paradigm where novice lifters’ perceived effort while performing at various loads relative to their one-repetition maximum (1RM) weight was assessed (15,26). In one of these studies, novice squatters reported a lower rating of perceived exertion (RPE) at their 1RM and also were able to execute repetitions faster at specific submaximal RMs (60, 75, and 90%) compared to their experienced counterparts (26). These findings imply that the feedback-related requirements of an autoregulatory paradigm might be difficult to master for beginners who are not experienced with quantifying perception of effort, especially during “maximal” exercise. Furthermore, the complex manipulation of training variables that characterizes periodized PRE per se might be unnecessary and even counterproductive for these individuals because there is not yet the need to change stimuli to ones that are suboptimal for strength gain (e.g., high-repetition/low-weight approach and/or reduction to submaximal intensity of effort to allow for recuperation) (19).

Instead, for beginners, it might be advantageous to follow a prescribed non-periodized protocol with sets and reps held constant at levels that are optimal for strength gain (e.g., three and five, respectively) (19). Indeed, given their relatively large "window for adaptation," beginners adhering to such a program might be able to achieve linear stimulus progression by increasing training load in a linear manner from session to session (19). In addition to providing an aggressive progressive stimulus, the linear nature of this approach would eliminate the need for autoregulation on a workout-to-workout basis. Unfortunately, in "the field," beginners typically choose their initial load and subsequent progression in a somewhat arbitrary manner. However, if these individuals were prescribed an initial load in a systematic fashion (e.g., according to repetition maximum) and a rate of linear progression was established, they might be able to benefit from a non-periodized protocol with linear load progression at least for the initial stage of training (e.g., first 12 wks).

The purpose of this feasibility study was to determine the sustainability and safety of a linearly-progressive, non-periodized training protocol for beginners by having subjects inexperienced with PRE attempt to complete 12 wks of training comprising the barbell back-squat exercise. Subjects increased load from session to session in a linear manner with supervision provided. However, to make this model applicable to what takes place in the "real world," determinations regarding the rate of linear progression and frequency of training (2 or 3 non-consecutive $d \cdot wk^{-1}$) were left to the discretion of the subject. Each subject's self-chosen weekly rate of progression was recorded as was their ability (COMP) or lack thereof (STALL) to complete the entire 12 wks of training. This allowed us to explore the degree to which the assessment of subject characteristics at baseline might be useful for determining a rate of progression that increases the likelihood for successful completion of the protocol. We also divided our cohort a posteriori into those who chose a more aggressive approach to progression (i.e., a weekly rate of progression that was greater than the median value for the cohort) to assess whether this method of classification allowed for the identification of those who were less likely to reach the protocol endpoint. Finally, we examined whether this type of training would result in significant changes in the body mass and/or waist-to-hip ratio of our subjects.

METHODS

We recruited a group of novice weight trainees to participate in a 12-wk linearly-progressive non-periodized training program. Both sexes were included and beginners with a relatively heterogeneous initial strength level relative to body mass were recruited so that the degree to which these subject-specific factors influenced sustainability of the program and the choices made by the subject (i.e., rate of linear progression and frequency of training) could be assessed. Each subject's 5RM was determined prior to beginning the protocol to establish the initial training load. We also measured the subject's body mass and waist-to-hip ratio before and after the intervention.

Subjects

Fifty-eight subjects, 27 males and 31 females (age, 22 ± 5 yrs; stature, 170 ± 10 cm; body mass, 70.9 ± 15.7 kg) with no previous history of resistance training were recruited to participate in this investigation. This project was approved by Adelphi University's Institutional Review Board, and all of the involved investigators received training in the treatment of human subjects through the NIH Office of Extramural Research. All subjects volunteered to participate in this study, and were briefed as to potential risks and benefits. A written informed consent was signed by each subject prior to their participation.

Procedures

On their initial visit to the facility, subjects were familiarized with the training protocol they would be performing. In addition to the criterion exercise task (i.e., the barbell back squat), they were also taught how to correctly perform the barbell bench press, barbell standing shoulder press and barbell deadlift so that these exercises could be done in addition to the squat to derive a full-body training stimulus. These four exercises were performed in accordance with the standards described in "Starting Strength: Basic Barbell Training" (20) and performance was assessed by a certified strength coach. During this familiarization session, the subjects' 5RM was determined as the heaviest load the subjects could safely lift for 5 reps without degradation of form. Additionally, body mass was measured so that the subjects' 5RM could be normalized for comparison across subjects. The subjects' stature and waist and hip circumferences were also measured during this session.

Once this initial training was complete, the subjects received detailed written instruction as to how to proceed. Specifically, they were told to minimize participation in other forms of exercise or athletic activities while taking part in this investigation. They were also instructed to continue to eat as they normally would throughout the intervention. The protocol required performance of the barbell back squat for 3 sets of 5 reps at the beginning of each training session. Subjects were informed of their initial training load (see above); however, choices regarding rate of linear progression, frequency of training (2 or 3 non-consecutive $d \cdot wk^{-1}$), and rest between sets were left to the discretion of the subjects. Following the back squat, the subjects were instructed to perform either the barbell bench press or the shoulder press (3 sets of 5 reps) in an alternating workout-to-workout manner with the deadlift (1 set of 5 reps) performed a minimum of one time per week. All exercises were preceded by a series of progressively-heavier "warm-up" sets.

The subjects were instructed to increase at the linear rate of progression they chose provided they successfully completed their assigned sets and repetitions from the previous workout. They were given access to a set of fractional Olympic plates (Rogue Fitness, Columbus, OH) that allowed for increases of as little as 8 ounces per session. Each subject also had access to both a standard 20-kg Olympic barbell as well as a 15-kg women's Olympic barbell (Rogue Fitness, Columbus, OH) in addition to a full set of bumper plates and standard Olympic plates. Training sessions were supervised directly in real time to ensure that proper form was maintained on all lifts. Training commenced for a period of 12 wks or until a subject could no longer increase training load at their self-chosen linear rate on the barbell back squat exercise.

Once each subject reached their endpoint, weeks completed was recorded and subjects were designated to one of two groups depending upon whether or not they completed the 12 wks of training (COMP and STALL, respectively). With respect to the latter, STALL only included the subjects who did not complete 12 wks of training due to the inability to continue to progress their training load or injury. Conversely, individuals who were unable to complete 12 wks of training for other reasons were excluded from this group and subsequent analysis. For individuals in COMP and STALL, the chosen rate of linear progression per workout (expressed as a percentage of their baseline 5RM) was multiplied by the frequency of training to derive the percent progression per week. Furthermore, to quantify the approach employed as aggressive or conservative a posteriori, we calculated the median value of percent progression per week for all subjects in COMP and STALL to categorize subjects as AGG or CON (a rate of linear progression > or < the median for the cohort, respectively). Finally, body mass and waist-to-hip ratio were again assessed upon completion of training for COMP and STALL. All data were recorded and stored using Qualtrics survey software (Qualtrics North America, Provo, UT).

Statistical Analyses

Using IBM SPSS Statistical Analysis Software (IBM, Armonk, NY), we performed an independent-samples *t*-test to compare baseline and training parameters between COMP and STALL and between AGG and CON. To assess changes in body mass and/or waist-to-hip ratio elicited by training for COMP and STALL, we used a 2 x 2 repeated-measures independent-samples group-by-time ANOVA. We also used a 2 x 2 repeated-measures independent-samples group-by-time ANOVA to assess whether changes in BM and/or waist-to-hip ratio elicited by training were different between the male and the female subjects.

Finally, for COMP only, we used linear regression to assess whether baseline measurements of body mass, waist-to-hip ratio, 5RM, and/or 5RM-to-body-mass ratio were significantly correlated with the rate of weekly linear progression chosen by these subjects. When a significant correlation was found, a Bland Altman plot was used to explore the limits of agreement between the successful approach employed by subjects in COMP and that which was used by subjects in STALL. All data are presented as mean ± SD. Statistical significance was accepted when $P<0.05$.

RESULTS

Protocol Completion

Of the 58 subjects who were recruited to participate in this study, 18 dropped out prior to completion of 12 wks of training due to reasons other than an inability to continue to linearly progress their assigned load or injury. Reasons for these dropouts were lack of time to commit to training (n = 16) and non-training-related illness (n = 2). Consequently, data of 40 subjects were collected for analysis with 24 comprising COMP and 16 comprising STALL (60% and 40% of the cohort, respectively). The STALL group comprised 15 subjects who did not complete the program due to an inability to continue to linearly progress their assigned load (weeks completed, 9.3 ± 1.7; range, 8 to 11 wks) and 1 subject who was injured and dropped out during week 5.

Table 1 provides the baseline and training parameters for these two groups. The COMP group comprised 10 males and 14 females while the STALL group comprised 8 males and 8 females. Other than the workouts completed, there were no significant differences between COMP and STALL for any of the baseline or training variables that were measured.

Table 1. Baseline and Training Parameters for the Study Participants Divided According to Status Achieved (COMPLETED or STALLED)

	COMP (n = 24)	**STALL** (n = 16)	**P**
Sex (Male/Female)	10/14	8/8	
Approach (Aggressive/Conservative)	12/12	8/8	
Baseline			
Age (yrs)	21.5 ± 5.1	23.2 ± 7.9	0.415
Height (cm)	169 ± 11	170 ± 9	0.726
Body Mass (kg)	71.8 ± 18.2	72.6 ± 17.0	0.885
Waist-to-Hip Ratio	0.78 ± 0.06	0.79 ± 0.07	0.376
5RM (kg)	50.9 ± 32.4	58.3 ± 31.9	0.479
5RM-to-Body-Mass Ratio	0.67 ± 0.30	0.79 ± 0.32	0.258
Training			
Frequency per Week (days)	2.6 ± 0.5	2.8 ± 0.4	0.280
Percent Progression per Week (%)	3.5 ± 2.6	3.6 ± 3.7	0.881
Workouts Completed	31.0 ± 6.0	25.6 ± 7.1*	0.014

*significant difference vs. COMP (P<0.05)

Figure 1 depicts the associations between baseline parameters related to body composition and strength and the rate of weekly linear progression chosen by the subjects in COMP. Significant correlations were found between the rate of weekly progression chosen by the subjects and both 5RM and 5RM-to-body-mass ratio with the latter providing the better fit. From this relationship, the percent progression per week chosen by the subjects who successfully completed the 12 wks of training could be predicted by the equation:

$$y = -11.93x + 16.35$$

x is calculated by dividing the individual's baseline 5RM in kg by their body mass in kg. Figure 2 illustrates a Bland Altman plot depicting the mean bias and 95% limits of agreement for the rate of weekly progression indicated by the aforementioned equation and that which was employed by the subjects who did not complete the 12 wks of training due to an inability to linearly progress their load (n = 15). Mean bias was 2.2% with a wide limit of agreement (9.7%) suggesting that subjects who were unable to linearly progress for 12 wks at a self-selected progression rate and frequency of training overestimated their capacity for progression compared to the standard established by those who were able to complete the program.

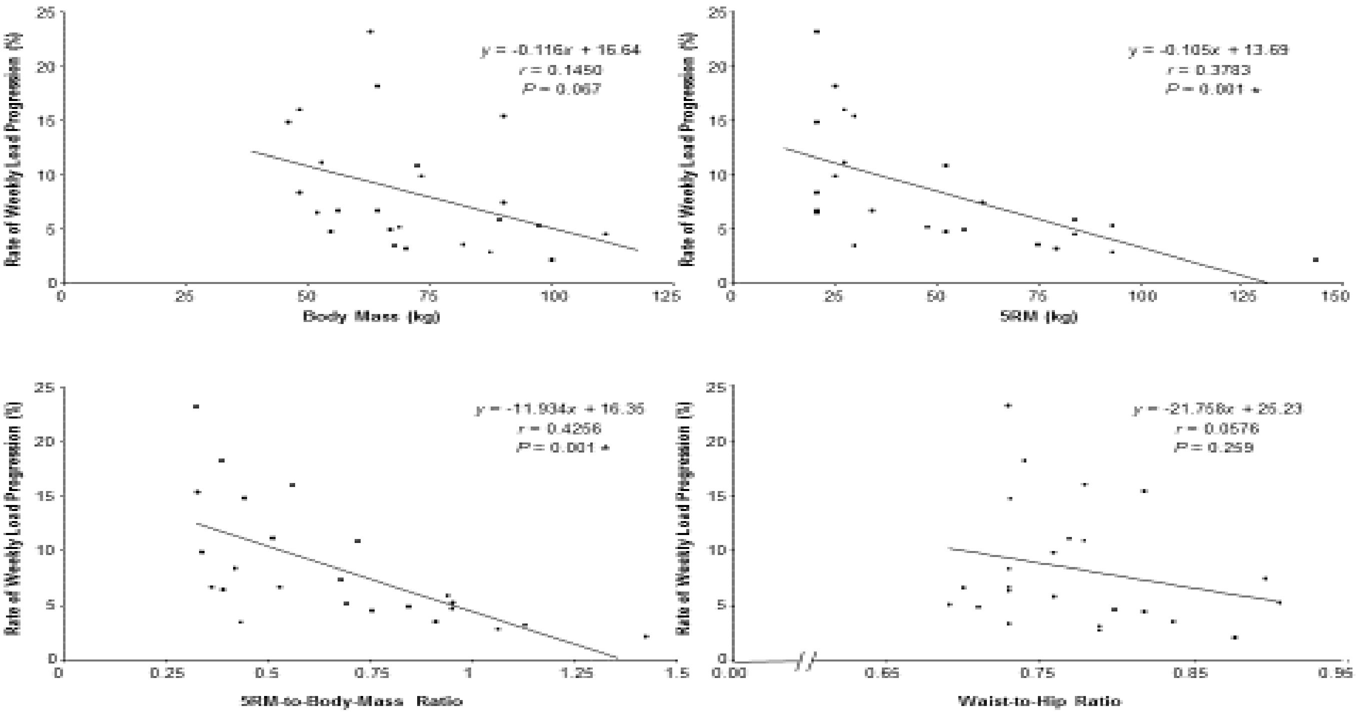

Figure 1. Correlations between baseline measurements of body composition and/or strength and the weekly rate of linear load progression chosen by participants who were able to complete the initial 12 wks of training (COMP; n = 24). *P<0.05.

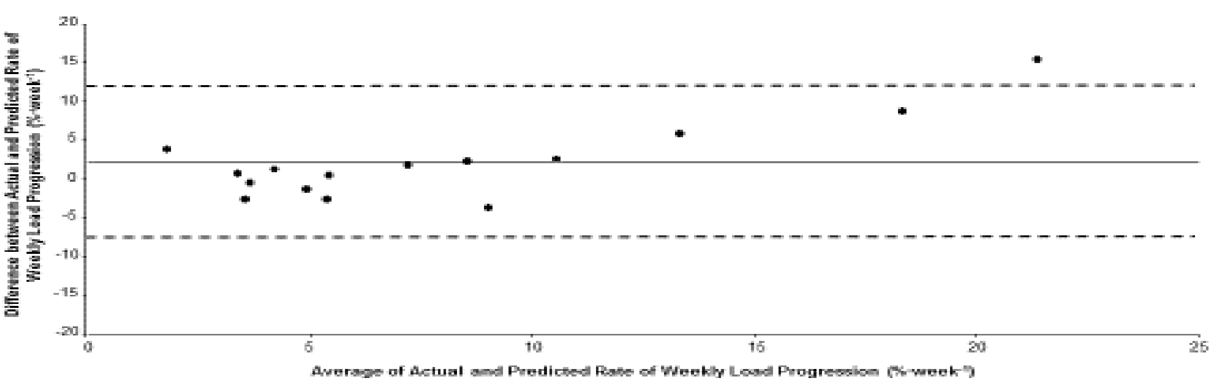

Figure 2. A Bland-Altman plot depicting the mean bias (continuous line) and limits of agreement (dashed lines) between the actual weekly rate of linear load progression chosen by the subjects who were unable to complete the initial 12 wks of training due to an inability to continue to linearly progress from session to session (n = 15) and the weekly rate of linear load progression indicated by the regression equation developed using data from the COMP group (y = -11.93x + 16.35 where y is the percent load progression per week and x is the individual's 5RM-to-body-mass ratio).

Approach Employed

The median value for percent progression per week for all individuals in COMP and STALL was 6.6% (range, 2.1 to 29.2%). Hence, the subjects who chose a percent progression per week between 2.1 and 6.5% were classified as having employed a conservative approach (CONS) compared to the aggressive approach (AGG) employed by the subjects who chose a percentage progression per week between 6.6 and 29.2%. Table 2 provides the baseline and training parameters for these two groups. Each group comprised 12 subjects who were able to complete the 12 wks of training and 8 subjects who could not. The AGG group comprised 6 males and 14 females while the CONS group consisted of 12 males and 8 females. Significant differences in height, 5RM, and 5RM-to-body-mass ratio were present at baseline between AGG and CONS while a "trend" for a difference in body mass was also observed. With respect to training, the CONS group trained significantly more times per week at a significantly lower percent progression per week compared to the AGG group.

Table 2. Baseline and Training Parameters for the Study Participants Divided According to Approach Employed (AGGRESSIVE or CONSERVATIVE).

	AGG (n = 20)	CONS (n = 20)	P
Sex (Male/Female)	6/14	12/8	
Status (Completed/Stalled)	12/8	12/8	
		Baseline	
Age (yrs)	21.9 ± 7.0	22.5 ± 5.7	0.787
Height (cm)	65 ± 3	68 ± 4*	0.012
Body Mass (kg)	66.8 ± 10.4	77.4 ± 4.1	0.055
Waist-to-Hip Ratio	0.77 ± 0.06	0.80 ± 0.06	0.177
5RM (kg)	33.6 ± 16.8	74.1 ± 30.8*	0.000
5RM-to-Body-Mass Ratio	0.50 ± 0.18	0.94 ± 0.25*	0.000
		Training	
Frequency per Week (days)	2.5 ± 0.5	2.9 ± 0.4*	0.007
Percent Progression per Week (%)	13.0 ± 6.4	4.2 ± 1.2*	0.000
Workouts Completed	25.9 ± 7.4	31.8 ± 5.0*	0.005

*significant difference vs. AGG (P<0.05)

Pre/Post Changes in Body Composition

A main effect of time was observed for body mass, which increased by ~2% due to training (pre, 72.1 ± 17.5 kg; post, 73.6 ± 18.6 kg; P = 0.006) with a "trend" for a decrease in waist-to-hip ratio also observed (pre, 0.78 ± 0.06; post, 0.77 ± 0.06; P = 0.064). There was no significant group x time interaction between COMP and STALL for either of these changes (P = 0.673 and 0.615, respectively). When the entire cohort was divided by sex, a trend for a greater increase in body mass was present for male compared to female subjects (male: pre, 86.2 ± 13.3 kg; post, 88.8 ± 14.0 kg; female: pre, 60.5 ± 10.7 kg; post, 61.2 ± 11.2; $P = 0.058$).

DISCUSSION

The main finding from this feasibility study was that 60% of the members of a group of young individuals inexperienced with PRE were able to linearly progress their load on the barbell-back squat exercise during each session of a 12-wk training intervention. Although the subjects were prescribed their initial load, decisions regarding rate of linear progression and frequency of training were left to the discretion of each subject. Using the percent rate of weekly progression to define an aggressive approach compared to a conservative approach did not provide insight as to the likelihood for completion of the protocol. However, for subjects who did reach the program endpoint, their 5RM-to-body-mass ratio at baseline was significantly correlated with the percent weekly progression they chose to employ. Consequently, we have advanced a prediction equation that can be used to prescribe a rate of weekly progression for young individuals inexperienced with PRE to increase the likelihood for sustainability during the initial 12 wks of training with the barbell back-squat exercise.

There are a number of unique characteristics of the training paradigm employed during the present investigation compared to strength-training programs that are typically advanced in the literature. A major difference is that our program did not include the systematic manipulation of training variables that characterizes the "periodized" approach to training (2). Indeed, other than the load being lifted, all other variables including specific exercises that were performed and the frequency and volume of training were held constant over the course of the intervention. While such an invariant approach might be detrimental for a competitive athlete or experienced strength trainee due to their greater potential to experience the "staleness" associated with long-term repetitive training (18), we reasoned that the lack of experience of the beginner should protect them from any such maladaptation.

Moreover, beginners possess a large window for positive adaptation. Thus, it is possible that intentionally "sub-maximizing" the strength-training stimulus to provide variability during the initial period of training might also sub-optimize gain (20). To investigate these issues, we had the subjects perform "heavy-load" training comprising 3 sets of 5 reps per workout throughout the 12-wk training intervention. And, interestingly, our findings indicate that 60% of the subjects were able to successfully complete the protocol while linearly progressing their load. Except for 1 subject who "stalled" due to injury, all the subjects that were unable to progress for the entire 12 wks were able to complete at least 8 wks of training. Collectively, these findings are consistent with the contention that a non-periodized approach is feasible for a majority of young individuals during the initial 12 wks of strength training.

Another unique aspect of the present investigation was that we allowed our subjects to self-select their rate of linear progression and the frequency at which they chose to train. Our goal was to make our findings applicable to what might occur in the "real world" where these decisions are typically left to the discretion of the exerciser. Allowing the subjects to choose their rate of progression also allowed us to determine whether specific characteristics of the individual at baseline could be used to predict the progressive approach that would more likely lead to protocol completion. In this regard, we found a high correlation between the subject's

5RM-to-body-mass ratio and the percent weekly progression that was chosen for the subjects in the group that were able to reach the protocol endpoint. Consequently, we were able to derive a prediction equation that can be used to prescribe a rate of progression that subjects can follow to increase the likelihood of being able to complete 12 wks of linearly-progressive training with the barbell back-squat exercise.

Conversely, we found a positive mean bias which indicated that the subjects who could not complete 12 wks of linear progression had overestimated their capacity for progression compared to the successful approach employed by the subjects who completed the program. Interestingly, when we divided the subjects into two equal groups according to the aggressiveness of the approach they employed (i.e., > or < the median value for weekly percent progression for the entire cohort), the completion/stalled status of each group was the same (12 and 8 subjects, respectively). This finding is consistent with the contention that rate of weekly progression should be prescribed in a subject-specific manner based on baseline characteristics as opposed to a “one size fits all” percentage. Importantly, the model we are advancing which does so is also “field friendly” because the two measurements used to derive the rate of weekly progression (i.e., 5RM and body mass) are relatively easy to measure.

A third unique aspect of our program is that it did not include exercises performed on strength-training machines. There is general consensus that free-weight training is more psychologically intimidating and, therefore, inappropriate for strength-training beginners (4). Also, it is often argued that machines might be safer for those inexperienced with strength training. However, empirical support for these beliefs is lacking and, indeed, in the present study, training that was exclusively done with barbells was well received by our subjects. Furthermore, of the 58 individuals who took part in this investigation, only 1 subject reported an injury and was unable to complete 12 wks of progressive training as a result of it. This subject dropped out during week 5 after his primary-care physician discouraged him from further participation due to a mild case of medial epicondylitis. Given that the injury is classified as an upper-body injury, it is unlikely that the overuse which caused it was a function of the barbell back squat, which was the exercise used for evaluation in this study. The other three exercises that were included to ensure a comprehensive program involved the barbell being actively held in the hands (as opposed to the back squat that requires it to be supported on the upper back and held in place by the hands) were done with an in-line grip and neutral (deadlift) or slightly extended (bench press and shoulder press) wrist. In conjunction with the fact that there is no laterally-directed shear force at the elbow for any of the 4 exercises that were performed for this program, it seems reasonable to conclude that these 4 exercises should provide minimal stress to the musculature of the medial epicondyle. Consequently, the injury that caused 1 of the 58 subjects to be unable to complete the program due to injury would likely be an improbable occurrence from this form of training. Also, it important to note that there were no reports of chronic injury to the hips, knees, and/or lumbar region of the spine (i.e., the most susceptible body regions during performance of the barbell squat) and there were also no acute injuries reported by any of the subjects during training. This data is in accordance with the previous research that has shown weight training to be a relatively safe activity, especially when compared to other forms of sporting activities (5).

For assessing the feasibility of our program and, specifically, drawing the conclusion that there was a 60% feasibility rate (i.e., 26 of 40 the subjects completed the protocol), it is important to note that the group we considered as “stalled” (n = 14) only comprised subjects who were unable to complete the program due to a lack of ability to linearly progress their load from session to session at their self-chosen rate to the endpoint of the study or injury. We included these individuals because they dropped out for reasons which indicate that this particular program was not sustainable (n = 13) or safe (n = 1). Conversely, in addition to the 24 subjects who completed the protocol, the stalled status was not assigned to 18 of our 58 subjects who dropped out for reasons that did not suggest unattainability of this particular program's endpoint. For example, 2 subjects dropped out because of illness unrelated to training while 16 did so due to having insufficient time to devote to training. While one might reason that these 16 subjects should have been included in STALL (and, therefore a feasibility rate of 26/56 = 46%), the reason we chose not to do so is based on the time efficiency of the protocol we were assessing. Indeed, compared to typical beginner programs that usually include single-joint exercises and higher-repetition sets, our protocol required a relatively low commitment of time per week. Consequently, it appears that it is a strength training program per se and not this specific one that was not feasible for these 16 subjects.

CONCLUSIONS

The findings in the present study indicate that it is feasible for a majority of young strength-training beginners to complete a 12-wk non-periodized PRE protocol involving the back-squat exercise performed with a load that is linearly progressed during every workout session. For the present study, we had subjects self-select a rate of linear progression and frequency of training so that the data of those that successfully reached the protocol endpoint could be assessed a posteriori to identify common characteristics of the successful approach. In this regard, we found that an advisable rate of weekly progression could be determined by using baseline measurements of body mass and 5RM. In addition to randomized controlled trials exploring this non-periodized linearly-progressive model during the initial stages of strength training, we hope that this preliminary research sets the stage for future studies designed to determine whether a similar rate of linear session-to-session progression might be feasible for other populations (e.g., older adults) performing the barbell back-squat exercise and also for barbell-based exercises that target regions not specifically trained by the barbell squat.

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