Comparison of Powerlifting Performance in Trained Men Using Traditional and Flexible Daily Undulating Periodization

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Abstract

Colquhoun, RJ, Gai, CM, Walters, J, Brannon, AR, Kilpatrick, MW, D'Agostino, DP, and Campbell, WI. Comparison of powerlifting performance in trained men using traditional and flexible daily undulating periodization. *J Strength Cond Res* 31(2): 283–291, 2017–Daily undulating periodization (DUP) is a growing trend, both in practice and in the scientific literature. A new form of DUP, flexible daily undulating periodization (FDUP), allows for athletes to have some autonomy by choosing the order of their training. The purpose of this study was to compare an FDUP model to a traditional model of DUP on powerlifting performance in resistance-trained men. Twenty-five resistance-trained men were randomly assigned to one of 2 groups: FDUP ($N = 14$) or DUP ($N = 11$). All participants possessed a minimum of 6 months of resistance training experience and were required to squat, bench press, and deadlift 125, 100, and 150% of their body mass, respectively. Dependent variables assessed at baseline and after the 9-week training program included bench press 1 repetition maximum (1RM), squat 1RM, deadlift 1RM, powerlifting total, Wilks Coefficient, fat mass, and fat-free mass (FFM). Dependent variables assessed during each individual training session were motivation to train, Session Rating of Perceived Exertion (Session RPE), and satisfaction with training session. After the 9-week training program, no significant differences in intensity or volume were found between groups. Both groups significantly improved bench press 1RM (FDUP: +6.5 kg; DUP: +8.8 kg), squat 1RM (FDUP: +15.6 kg; DUP: +18.0 kg), deadlift 1RM (FDUP: +14.8 kg; DUP: +13.6 kg), powerlifting total (FDUP: +36.8 kg; DUP: +40.4 kg), and Wilks Coefficient (FDUP: +24.8; DUP: +26.0) over the course of study ($p = <0.001$ for each variable). There was also a significant increase in FFM (FDUP: +0.8 kg; DUP: +0.8 kg) for both groups ($p = 0.003$). There were no differences in motivation to train, session RPE, or satisfaction with training session measurements between groups ($p = 0.369$–0.702, respectively). In conclusion, FDUP seems to offer similar resistance training adaptations when compared with a traditional DUP in resistance-trained men.

Key Words resistance training, squat, bench press, deadlift, body composition

Introduction

Resistance training has become increasingly popular in the scientific literature, with investigations reporting both central and peripheral adaptations (1,2,8) across a variety of populations (3,9,10,28). Periodization is commonly used by coaches and practitioners when developing a resistance training program. It can be defined as "the preplanned, systematic variation in training specificity, intensity, and volume organized in periods or cycles within an overall program" (1). There seems to be consistency in the scientific literature that a periodized resistance training program is superior to a nonperiodized training program in regard to strength development (18). However, within the scientific and coaching communities, there is ongoing debate regarding the optimal model of periodization to be implemented to maximize muscular strength. Within a periodized resistance training program, the 2 most common variables manipulated are volume and intensity. Volume is commonly calculated as the product of sets, reps, and load lifted. Intensity (also called as relative load) can be defined as a percentage of one's 1 repetition maximum (1RM).

There are several different models of periodization, with the most commonly researched models known as undulating (nonlinear) and linear (3,9–13,16,20,23,28). An undulating model generally varies the volume and intensity throughout a given period, such as a week or month. The most popular form of undulating periodization is daily

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undulating periodization (DUP), in which volume and intensity are varied on a daily basis. A linear periodization (LP) model involves the progressive shift from high volume, low intensity in the early stages, to low volume, high intensity in the later portion of the training period. Although there is no consensus on which model of periodization is best, recent literature has shown DUP programs produce similar (3) or superior (12,13,20,23) gains in muscular strength in comparison with LP programs. However, the conclusion that DUP is superior to LP has been brought into question by a recent meta-analysis (6). A relatively new concept in the realm of periodization literature is the concept of flexible nonlinear periodization (FNLP). Flexible nonlinear periodization follows an undulating distribution of volume and intensity, but allows the lifter to choose the order of the training sessions within a given time frame. Although there has been limited research conducted on this topic, results thus far show promise in producing favorable outcomes in both strength and body composition (10,11).

Whether a resistance training program is prescribed in an athletic, recreational, or clinical situation, participant adherence is always a major variable in determining the program's effectiveness. A potential benefit of FNLP is athlete autonomy, which could be achieved by allowing the participant to have control over the order of sessions. By giving the participants control over session order, the participant could potentially become more invested in the resistance training program, leading to increased motivation and effort, as well as improved program adherence. In addition, the self-regulated modification of the order of the training sessions could potentially lead to enhanced recovery and athlete preparedness, which may lead to greater adaptation to the training stimulus. Therefore, the purpose of this study was to compare the effects of a traditionally prescribed DUP program vs. a flexible daily undulating periodization (FDUP) on powerlifting performance in resistance-trained men.

Methods

Experimental Approach to the Problem

The present investigation used a randomized, parallel group design. Only resistance-trained men (between the ages of 18 and 45) were recruited for participation. This study was designed to compare powerlifting performance in resistance-trained men using an FDUP and a traditional model of DUP. The powerlifts include the squat, bench press, and deadlift. These lifts were performed in this specific sequence for all training and testing sessions, as this is the order the lifts are completed during a powerlifting meet (24). The dependent variables assessed at pretesting and posttesting (9 weeks later) included squat, bench press, and deadlift 1RM, as well as body composition (including body fat percentage [BF%], fat mass [FM], and fat-free mass [FFM]). Dependent variables assessed at each resistance training session were motivation to train, session RPE, and satisfaction with training session.

Both groups completed the exact same training sessions in a given week. However, the DUP group was given a structured order, whereas the FDUP group was told to choose the workouts in whatever order they chose. Because both groups completed the same 3 workouts in a week, both volume and intensity were equated weekly and throughout the entire duration of the study.

Subjects

To qualify for entry into the study, participants had to meet the minimum requirement of at least 6 months of consistent (minimum of ×3 per week) resistance training experience, as well as the minimum 1RM strength requirements of 125% of their body mass in the squat, 100% of their body mass in the bench press, and 150% of their body mass in the deadlift. Of the 34 participants enrolled in the study, 32 participants (age: 23.1 ± 6.3; age range: 18–46 years; training age: 3.1 ± 1.6 years; body mass: 79.7 ± 11.9 kg) met the 1RM strength requirements and moved on to the training portion of the study (Figure 1). Before any testing, participants were given a basic medical clearance form, an informed consent document, and a Physical Activity Readiness Questionnaire. The participants also completed a demographic survey providing their age, sex, race, and training status, as well as a brief description of their previous supplementation, training programs, and injury history. Participants were instructed to cease all supplementation (except vitamin/mineral and protein supplementation) 6 weeks before the study and were asked to maintain a similar diet throughout the entire study. In addition, participants were asked to refrain from any extraneous activity (e.g., resistance training, aerobic training, etc.) for the duration of the study. Participants were also informed that if they missed more than 3 training sessions they would be disqualified from the study. Participants took part voluntarily in the study after being informed of the procedures, risks, and benefits and signed an informed consent form. This study was approved by the University of South Florida's Institutional Review Board.

Procedures

Participants entered the Performance & Physique Enhancement Laboratory on 2 separate occasions before and after the 9-week training program to undergo body composition assessment and 1RM strength testing. All baseline body composition measures were conducted before maximal strength testing. Participants were instructed to abstain from resistance training 24 hours before the assessment and were also instructed to avoid any additional training until the study protocol began the following week.

Body Composition Assessment

The week before the initiation of the training program, participants entered the laboratory in an overnight fasted state (a minimum of 8 hours) for body composition assessment and familiarization with 1RM procedures. On entering the laboratory, the participant's height and body mass were taken on a calibrated Health-o-Meter physician beam scale (model 420KL; McCook, IL, USA). Next, body composition was

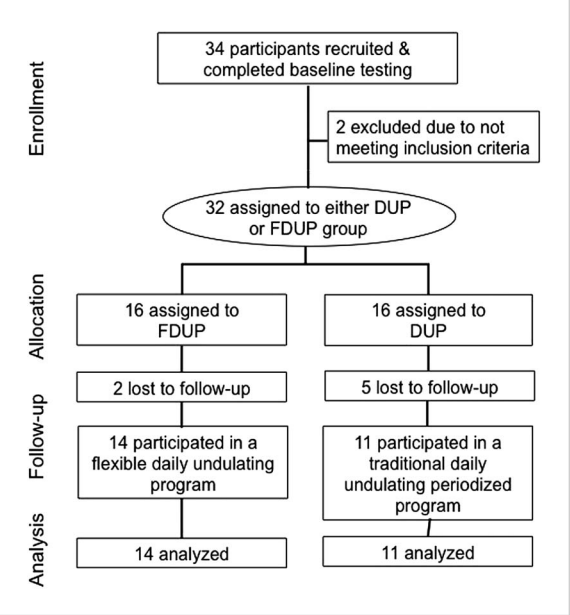

Figure 1. Participant flow. DUP = daily undulating periodization; FDUP = flexible daily undulating periodization.

assessed using the Body-Metrix BX-2000 A-mode ultrasound (IntelaMetrix, Livermore, CA, USA) with a standard 2.5 MHz probe. This device has been reported to be a valid tool for estimating FFM in male athletes when compared with hydrostatic weighing (25).

The ultrasound probe was connected by USB to a standard laptop computer with corresponding proprietary software (BodyView Professional Software; General Electric Company, Milwaukee, WI, USA), which was subsequently used to measure the fat thickness at 7 different sites. All measurements were taken while the participant was in the standing position. Measurements were taken on the right side of the body using the seven-site skinfold locations in accordance with Jackson et al. (7). The 7 anatomical sites that were measured included the chest, midaxillary, triceps, subscapular, abdomen, suprailiac, and thigh. Measurements were made by applying transmission gel to the probe and lightly placing the probe perpendicular to the site. Each site was measured 2–3 times, based on the software's agreement between measurements. The subcutaneous fat thickness was calculated by the device software using an average of the trials. The site-specific subcutaneous fat thickness values were used to calculate BF% using the Jackson Pollock 7-site skinfold equation (7). All body composition assessments were completed by the same investigator. After the completion of body composition, participants were informed of the procedures for 1RM testing in the squat, bench press, and deadlift, which took place approximately 24 hours after the body composition assessment. If the participant had any questions about the procedures or wished to practice any of the lifts, they were asked to complete 3 sets of 3 repetitions with an estimated 10RM while using proper form to familiarize themselves with the testing protocol.

Maximal Strength Testing

Maximal strength testing took place approximately 24 hours after body composition assessment, and occurred 48 hours before the initiation of the resistance training program. Participants entered the laboratory for 1RM testing on the squat, bench press, and deadlift–which were performed in this order to simulate the order of a powerlifting meet. After completing a body mass warm-up, participants followed the National Strength and Conditioning Association's 1RM testing protocol (1). 1RMs were found within 5 attempts for all lifters on each lift. Each lift followed the instructions set by USA Powerlifting (24). For every lift, the same 2 research personnel observed each maximal repetition attempt. If both agreed the repetition attempt was satisfactory, it was counted as a successful repetition and the load lifted was recorded. However, if one or both of the research personnel observed the attempt as an unsatisfactory lift, it was not counted as a successful repetition. As stated previously, for a lift to be considered satisfactory, it must have complied

Table 1. Overview of training and assessment schedule for FDUP* and DUP training groups.†

Day of the week	Week 1 (baseline testing)	Weeks 2–9	Week 10 (final week of training and posttesting)
Monday	No training	Hypertrophy day (Green Day)	Hypertrophy day (Green Day)
Tuesday	No training	No training	No training
Wednesday	No training	Strength day (Red Day)	Strength day (Red Day)
Thursday	Baseline body composition testing	No training	Body composition posttesting
Friday	Baseline 1RM testing	Strength day (Blue Day)	1RM posttesting

*FDUP group was allowed to choose their own workouts and are therefore varied throughout the duration of the study protocol.
†FDUP = flexible daily undulating periodization; DUP = daily undulating periodization; 1RM = 1 repetition maximum.

with the rules set forth by USA Powerlifting (24). For example, a successful squat is (among other rules) one in which the lifter's hip crease is below the top of the patella. Therefore, if a lifter did not reach this depth, the lift was ruled unsatisfactory and was not counted. In addition, USA Powerlifting rules state that all bench press repetitions must include a pause on the lifter's chest, in which the bar is motionless. Once this was achieved, the lifter then received a "press" command. On this command, the lifter must then press the bar upward and extend the elbows for the repetition to be deemed successful. The 1RMs of each lift were then added together to calculate each participant's powerlifting total (PLT). Wilks Coefficient is used by USAPL to rank lifters based on body mass and lifting performance. Wilks Coefficient was calculated by multiplying the PLT by a standardized body mass coefficient number that was previously validated in the scientific literature (26). At the conclusion of the 1RM testing, participants were ranked based on Wilks Coefficient and then randomly assigned to the traditional DUP (DUP) group or flexible DUP (FDUP) group. The participant with the highest Wilks Coefficient was randomly assigned to either the FDUP or DUP group. The next 2 strongest participants were assigned to the opposite group, and then, this process was repeated until all participants were randomly assigned to the treatment groups.

Table 3. Overview of the training program.*

Monday (hypertrophy)	Wednesday (power)	Friday (strength)
Squat	Squat	Squat
Bench press	Bench press	Bench press
Dumbbell lateral raise	Deadlift	Deadlift
Dumbbell curls	Pull-ups	Barbell row
Dumbbell triceps extension	Abdominal exercise	Abdominal exercise

*Standardized order for daily undulating periodization group. Flexible daily undulating periodization group could choose the order of the 3 workouts they wanted to complete during the week.

Psychological Assessments

Before the first training session, participants received scales assessing motivation to train, satisfaction with training session, and session RPE. Motivation to train and satisfaction with training session were assessed using a 5-point Likert scale. Session RPE was assessed using an OMNI Perceived Exertion Scale for Resistance Exercise (OMNI-RES) (14,15). Each chart was explained to each participant and any questions were answered before the initiation of training. Throughout the study and before the warm-up portion of each training session, each participant was asked to identify their motivation to train as an assessment of their motivation to participate in that day's training session. At the conclusion of each training session, participants were asked to identify a score for their satisfaction with training session as a measure of how they felt their performance was during that training session. In addition to satisfaction with training session, participants were asked to mark down session RPE to determine how hard they thought the day's training session was.

Resistance Training Protocol

Most of the resistance exercise workouts were supervised by qualified personnel in the research laboratory. Specifically, 94% of the training sessions (600 of 638 workouts) were directly supervised. For the purpose of avoiding bias in participants to a particular workout, workouts were given the names Green Day, Blue Day, and Red Day, with the workouts being labeled the same for each group (Table 1). This was performed to discourage participants from associating a specific workout with a "training outcome." For example, participants may have been inclined to pick a workout labeled "hypertrophy" earlier in the week if they believed performing this workout early in

Table 2. Progression chart.

Repetitions completed	Adjusted load
5+ reps under goal	Drop 7.5 kg next workout
3–4 reps under goal	Drop 5 kg next workout
1–2 reps under goal	Drop 2.5 kg next workout
0–1 reps above goal	Same weight next workout
2–3 reps above goal	Add 2.5 kg next workout
4–5 reps above goal	Add 5 kg next workout
6+ reps above goal	Add 7.5 kg next workout

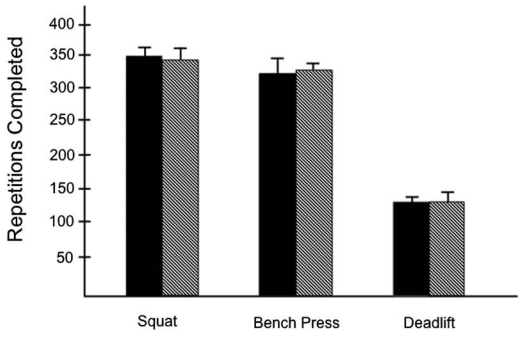

Figure 2. Repetitions completed.

Table 4. Average intensity (as a percentage of 1 repetition maximum) for each group.

Lift	Daily undulating periodization group (%)	Flexible daily undulating periodization group (%)
Squat	87	86
Bench press	86	87
Deadlift	87	83

the week would lead to increased muscle hypertrophy. In addition, participants may have been biased toward a particular type of workout if they had a background in this type of training.

Participants in the DUP group were assigned a standardized order of workouts. The Green Day was completed on Monday and was considered the hypertrophy day. The Red Day was completed on Wednesday and was considered the Power Day. Finally, the Blue Day was completed on Friday, which was considered the strength day. The FDUP group was provided with a choice in the order, but completed the same 3 training sessions as the DUP group in a given week. Therefore, if the participant in the FDUP group chose to do the Blue Day (strength workout) on Monday, and the Green Day (hypertrophy workout) on Wednesday, they then had to complete the Red Day (power workout) on Friday. A layout of the training schedule is shown in Table 1.

In workouts 1 and 3, participants completed a plus set (a set in which they are told to complete as many reps as possible without failure) on their final set. These sets were used as performance markers to individualize progression on a weekly basis. Participants were instructed to complete as many reps as they could without failing, completing the set when they were unsure whether they could complete 1 additional repetition without failing. In the last week (week 9), all participants completed the Green Day on Monday and the Red Day on Wednesday before undergoing maximal strength assessments on Friday, to standardize the retesting procedure between groups.

The progression was based on the chart below (Table 2), which was performed in a similar fashion to Mann et al. (9). The reps per set changed every 2–3 weeks, starting with sets of 8 repetitions (hypertrophy day) and 3 repetitions (strength day) in weeks 2–4, sets of 6 repetitions (hypertrophy day) and 2 repetitions (strength day) in weeks 5–7, and sets of 5 repetitions (hypertrophy day) and 1 repetition (strength day) in weeks 8–9. The "power day" (red day) followed an LP model, in which the load started at 80% in the beginning weeks, and progressed to 90% in the final week. The percentages for the load used were based on a projected 1RM from the previous Friday's plus set using the Epley formula for predicting 1RM (5). The 9 weeks ended with a taper leading up to retesting of maximal strength on the Friday of week 10 (Table 1). Both

Table 5. Prechanges to postchanges in resistance training performance and body composition.*

	Flexible daily, undulating periodization				Traditional daily, undulating periodization			
	Baseline (mean ± *SD*)	Post (mean ± *SD*)	% Change	Effect size	Baseline (mean ± *SD*)	Post (mean ± *SD*)	% Change	Effect size
Bench press 1RM (kg)	95.8 ± 20.1	102.3 ± 18.8†	6.8	0.33	118 ± 20.8	126.8 ± 21.2†	7.5	0.42
Squat 1RM (kg)	132.4 ± 34.2	148.0 ± 32.8†	11.8	0.46	147.2 ± 30.7	165.2 ± 25.4†	12.2	0.64
Deadlift 1RM (kg)	166.2 ± 40.6	181 ± 37.1†	8.9	0.38	174.3 ± 25.4	187.9 ± 29.2†	7.8	0.50
Powerlifting total (kg)	394.4 ± 90.1	431.2 ± 84.1†	9.3	0.42	439.5 ± 70.8	479.9 ± 69.1†	9.2	0.58
Wilks Coefficient	278.7 ± 55	303.5 ± 50.9†	8.9	0.47	299.2 ± 55	325.2 ± 37.9†	8.7	0.56
Fat-free mass (kg)	67.1 ± 8.5	67.9 ± 7.7‡	1.2	0.10	71.4 ± 5.9	72.2 ± 5.4‡	1.1	0.14
Fat mass (kg)	8.7 ± 3.7	8.5 ± 3.3	−2.3	0.06	11.4 ± 5.6	11.1 ± 5.1	−2.6	0.06
Body fat (%)	11.3 ± 4	11.0 ± 3.5	−0.3	0.08	13.4 ± 5.3	13.0 ± 5	−3.0	0.08

*1RM = 1 repetition maximum.
†Significant within-group change as compared with baseline ($p \leq 0.001$).
‡Significant within-group change as compared with baseline ($p \leq 0.05$).

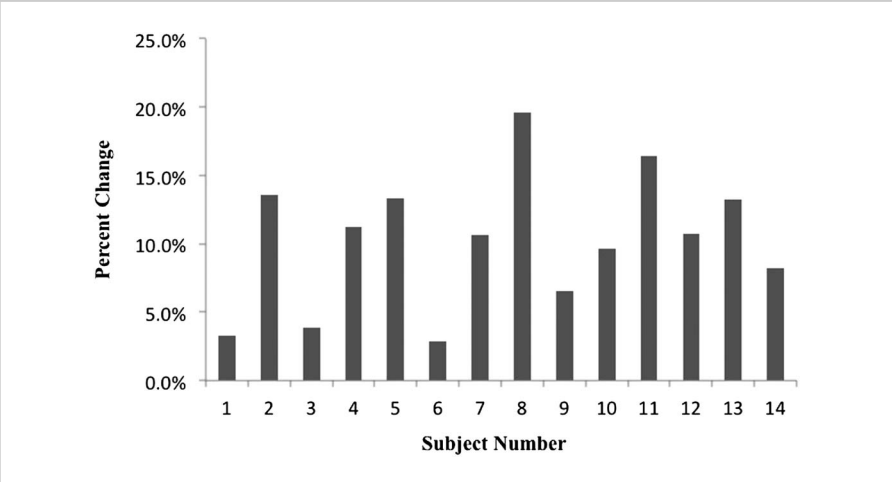

Figure 3. Individual subject plots for powerlifting total in flexible daily undulating periodization group.

groups were programmed to have equal volume and intensity throughout the duration of the study, as volume seems to be the main source of adaptation in strength training (19,21). Although the groups were given equal amounts of sets and reps, the progression of load varied from week to week was based on the performance of the lifter from the previous week, therefore individual volumes and intensities were subject to variation.

Participants performed the squat and bench press in every training session, and the deadlift only on the power and strength days. After completing the main lifts for each training session, participants completed additional accessory work. The deadlift was programmed twice a week for the purpose of not developing unnecessary fatigue. Also, from an anecdotal and practical standpoint, this is the practice of many high-level lifters and coaches. Participants were allowed to rest between 2 and 5 minutes between sets, based on personal preference. The entire program is outlined in Table 3. In addition, both groups were provided with approximately 24 grams of protein (Dymatize Elite Whey Protein; Dymatize Enterprises, LLC, Dallas, TX) after workout.

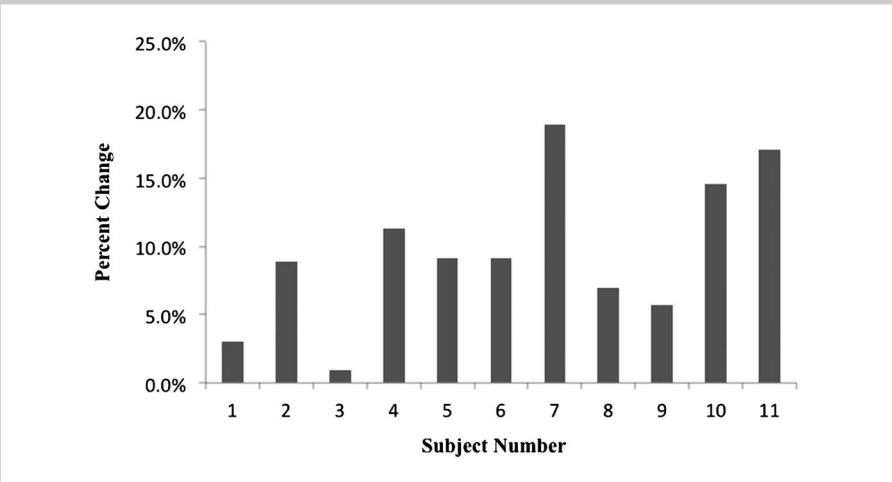

Figure 4. Individual subject plots for powerlifting total in daily undulating periodization group.

Statistical Analyses

Descriptive statistics (mean ± *SD*) for the different variables were calculated. The distribution of each strength and body composition variable was examined with the Shapiro-Wilk test (17,22). Data for each dependent variable were analyzed through a 2 × 2 between-within factorial analysis of variance. Independent samples *t*-tests were used to determine whether any baseline differences existed. Cohen's *d* was calculated using the mean difference divided by the pooled *SD*s (4). All analyses were completed using SPSS (Version 22; IBM, Armonk, NY, USA) software, and the alpha criterion for significance was set at 0.05.

Results

For both training groups, a Shapiro-Wilks test ($p > 0.05$) and a visual inspection of their histograms, normal Q-Q plots, and box plots showed that the maximal strength and body composition data variables were normally distributed. With the exception of baseline squat in the FDUP group (skewness z score = 2.2), the standardized (z scores) skewness and kurtosis coefficients for both training groups were within the range of ±1.96 (27). There were no differences between the groups in lifting volume or intensity (Figure 2 and Table 4). There was a significant difference at baseline between groups in the bench press 1RM ($p = 0.008$). This was the only dependent variable in which a baseline difference existed.

There were no group × time interaction effects observed for the squat ($p = 0.558$), bench press ($p = 0.233$), deadlift ($p = 0.765$), powerlifting total ($p = 0.630$), and Wilks Coefficient

Table 6. Comparison of psychological variables between groups.

	Flexible daily undulating periodization (mean ± *SD*)	Daily undulating periodization (mean ± *SD*)	*p*
Motivation to train	3.5 ± 0.6	3.8 ± 0.5	0.289
Satisfaction with training session	3.9 ± 0.7	4.1 ± 0.5	0.495
Session RPE	6.8 ± 1.6	6.3 ± 1.7	0.478

($p = 0.811$). There was a main effect for time for all strength-related measures ($p < 0.001$). Table 5 highlights the changes over time for both treatment groups. With the exception of bench press ($p = 0.008$), there were no main effects for group for any of the strength-related measures. The main group effect observed for bench press is explained by the differences that existed at baseline between the groups, and not due to the superiority of one treatment as compared with the other, as evidenced by the similar increases in bench press strength for both treatment groups (Table 5). Individual subject plots for improvements in powerlifting total are shown in Figures 3 and 4.

For body composition, there were no group × time interaction effects observed for any body composition variables (FFM, FM, or BF%). There was a significant main effect for time for FFM ($p = 0.003$), but not for FM ($p = 0.413$) or BF% ($p = 0.223$). Table 5 summarizes the raw data for each dependent variable assessed in relation to resistance training performance and body composition, as well as the calculated effect sizes. With respect to the psychological variables collected, no statistically significant differences were observed between groups for motivation to train ($p = 0.391$), satisfaction with training session ($p = 0.702$), or session RPE ($p = 0.369$) (Table 6).

Discussion

The primary finding of the present investigation was a significant increase in squat 1RM, bench press 1RM, deadlift 1RM, powerlifting total, and Wilks Coefficient after 9 weeks of resistance training in both the FDUP and traditional DUP groups. However, there were no significant differences between the groups in any of these variables. The resistance training program was designed to recruit high-threshold motor units and a high level of neural activity to increase maximal strength. Intensity was individually adjusted on a weekly basis based on the performance of plus sets. The average number of repetitions per plus set was nearly equal between groups (FDUP: 5.9 reps, DUP: 6.0 reps), which lead to similar weekly progression and likely explains the comparable amount of work and training adaptations observed in both training groups. Similarly, it is possible that the participants responded favorably to a well-designed, periodized, and supervised resistance training program. Although these participants were well trained, it is unlikely that they would have made comparable strength gains on their own. The program was designed to equate volume and intensity between groups, but allow participants to push themselves and autoregulate progression based on the previous week's performance.

The findings of this study differed from that of a similar study conducted by McNamara and Stearne (10). The investigators instructed 16 untrained male and female participants to train twice per week for 12 weeks, for a total of 24 resistance exercise workouts. The untrained participants completed a variety of free weight and machine exercises, and completed 8 workouts using a 10RM, 8 workouts using a 15RM, and 8 workouts using a 20RM over the course of 12 weeks. Participants were assigned to a flexible nonlinear (FNL) groups or a nonlinear (NL) group. Both groups completed the same repetition schemes and total lifting volume over the course of each 4-week block and over the entire duration of the 12-week study. However, the FNL group was allowed to choose what repetition scheme they used each session, whereas the NL group was given a set order (20RM, 15RM, and 10RM repeated throughout the duration of the study). The authors found that the FNL group gained significantly more strength in leg press 1RM (~42% improvement) when compared with the NL group (~11% improvement). No significant differences were found in chest press 1RM and long jump between the groups. Although both this study and the present one showed an increase in strength in at least 1 variable, McNamara and Stearne found that a flexible model leads to superior strength gains, while the current study showed equal strength gains between groups. These contradicting results could be attributed to the fact that participants in the current study had less choice, as they had to complete the same 2 workouts within the same week, as opposed to a specific number of workouts over a 4-week period as in the McNamara investigation (10). In addition, the differences in the adaptations could also be attributed to the fact that participants in the present study were trained men using only free weight exercises, where McNamara and Stearne used untrained male and female participants using a combination of free weight and machine exercises (10).

In another similar study performed by Zourdos et al. (28), 18 high-level male powerlifters completed 8 weeks of resistance training focused on improving 1RM strength in the powerlifts. The participants were divided into two groups: HSP (hypertrophy-strength-power), which performed

a hypertrophy workout on Monday, a strength workout on Wednesday, and a power workout on Friday, and HPS (hypertrophy-power-strength), which performed a hypertrophy workout on Monday, a power workout on Wednesday, and a strength workout on Friday. Both groups equally and significantly increased squat and deadlift strength, powerlifting total, and Wilks score from pretesting to posttesting. However, there were significant differences in the bench press 1RM over time, as the HPS group significantly increased 1RM bench press and the HSP group did not. In contrast, the present study showed an increase in all strength training variables over time with no particular lift improving to a greater extent in one group as compared with the other group. Because of the lack of agreement of the literature in this area of DUP programming, future research is needed to provide additional clarity.

While the effect size data from the current study suggest a greater adaptation from a traditional DUP model, it is interesting to point out that while both the DUP and FDUP groups started with 16 participants, the FDUP group had all 16 participants complete the study, but 2 participants had to be removed from data collection because of extraneous activity (engaging in planned physical activities not associated with the resistance training program provided in the current investigation). The DUP group finished with 11 participants, which was 69% of the participants who started the study. In terms of training adherence, participants in the FDUP group only missed 4 sessions total (attending 99% of scheduled training sessions), whereas participants in the DUP group missed 8 total sessions (attending 98% of all scheduled training sessions). In addition, both groups missed similar amounts of reps throughout the training cycle (DUP: 8 vs. FDUP: 9). Although there was no difference in motivation to train, session RPE, or satisfaction with training session between groups, it is also interesting to point out that 79% of the participants from the FDUP group attended every training session, while 73% of the participants in the DUP group attended every session. Therefore, using a flexible model may be more appropriate for program adherence and attendance of training sessions. Although this added adherence did not lead to additional short-term adaptation (i.e., 9 weeks), future research should examine whether increased adherence through a flexible model leads to additional strength gains over a longer time frame.

Practical Applications

Practitioners and coaches can use a flexible model of DUP to achieve comparable gains in maximal strength and body composition in resistance-trained men, when compared with a traditional DUP program. Although strength gains may favor a DUP model in the short term, the use of a flexible model may be more appropriate for those practitioners looking to maximize participant attendance and program adherence, while still achieving improvements in body composition and maximal strength.

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