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Comparison of Powerlifting Performance in Trained Males Using Traditional and Flexible DailyUndulating Periodization

Ryan James Colquhoun
University of South Florida, rcolquhoun@mail.usf.edu

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by

Ryan James Colquhoun

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Major Professor: William Campbell, Ph.D
Marcus Kilpatrick, Ph.D
Dominic D'Agostino, Ph.D

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ABSTRACT

Daily undulating periodization is a growing trend in the exercise science literature. Flexible daily undulating periodization allows for athletes to have some autonomy within a periodized training cycle and is a relatively new and unstudied concept. The comparison of a flexible and traditional daily undulating periodization program using trained males has not been examined in the literature. The purpose of this study was to compare the effects of Flexible and Traditional Daily Undulating Periodization models on powerlifting performance in trained males.

25 resistance-trained males (23±6 years; 79±22 kg) completed a 9-week resistance-training program and were randomly assigned to one of two groups: Flexible Daily Undulating Periodization (FDUP; N=14) or Daily Undulating Periodization (DUP; N=11). All subjects possessed a minimum of 6 months of resistance training experience & were required to squat 125% their bodyweight, bench press their bodyweight, and deadlift 150% their bodyweight. Dependent variables (DV) included bench press 1RM, squat 1RM, deadlift 1RM, Powerlifting total, and Wilk's Coefficient. Each DV was assessed at baseline and after the 9-week training program. The DUP group performed a hypertrophy workout on Monday, a power workout on Wednesday, and a strength workout on Friday. The FDUP group completed the exact same workouts in a given week, but were allowed to choose the order of the workouts. Data for each DV were analyzed via a 2x2 between-within factorial repeated measures ANOVA. The alpha criterion for significance was set at 0.05.

There were no significant differences in total volume or intensity between groups. There was a main effect for time ($p < 0.001$) for 1RM Squat (FDUP pre = 132 ± 34 kg, FDUP Post = 148 ± 33 kg; DUP pre = 147 ± 31 kg, DUP post = 165 ± 25 kg), 1RM Bench Press (FDUP pre = 96 ± 20 kg, FDUP post = 102 ± 19 kg; DUP pre = 147 ± 31 kg, DUP post = 165 ± 25 kg), 1RM Deadlift (FDUP pre = 166 ± 41 kg, FDUP post: 181 ± 37 kg; DUP pre = 174 ± 25 kg, DUP post = 188 ± 29 kg), Powerlifting Total (FDUP pre = 394 ± 90 kg, FDUP post = 431 ± 84; DUP pre = 439 ± 71 kg, DUP post = 480 ± 69 kg), and Wilk's Coefficient (FDUP pre = 147 ± 25 kg, FDUP post = 304 ± 51; DUP pre = 299 ± 41, DUP post = 325 ± 38). There were no interaction effects between the FDUP and DUP for any of the variables assessed.

9 weeks of Flexible DUP leads to comparable gains in powerlifting performance when compared to a Traditional DUP program in trained males. This may be attributed to the fact that both groups performed similar volumes of work throughout the study. Specifically, FDUP improved squat 1RM by 12%, bench press 1RM by 7%, deadlift 1RM by 9%, powerlifting total by 9%, & Wilk's coefficient by 9%. Similarly, DUP improved squat 1RM by 12%, bench press 1RM by 8%, deadlift 1RM by 8%, powerlifting total by 9%, & Wilk's coefficient by 9%.

Chapter 1: Introduction

Background

Resistance training has become increasingly popular in the literature throughout the past half century. Although the majority of the research still exists on aerobic activities, more information is now available regarding the potential benefits of anaerobic resistance training. The benefits include improvements in muscular strength, increases in muscle fiber size/hypertrophy/fat free mass, decreases in body fat, and potential improvements in connective tissue (Baechle & Earle, 2008). There is, however, a great debate on the periodization of resistance training and which form is best to produce optimal results. As stated by Bompa and Haff (2009), "Periodization is defined as the logical and systematic sequencing of training factors in an integrative fashion in order to optimize specific training outcomes at pre-determined time points" (Bompa & Haff, 2009). In short, periodization is the planned progression in a resistance training program and is based on many variables, mainly revolving Selye's (1950) General Adaptation Syndrome, which defines the mechanisms utilized by the body to adapt to stress.

While it is widely accepted that periodized resistance training programs produce significantly better results than non-periodized programs (Rhea, 2004), there have been relatively few studies comparing different models of periodization. Classical Linear Periodization (LP) has long been used as the base model when developing resistance training programs. Recently, however, many studies have demonstrated Daily Undulating Periodization

(DUP), a form of Non-Linear Periodization (NLP), to be superior in developing strength, hypertrophy, and power adaptations when compared to LP (Buford, Rossi, Smith, & Warren, 2007; Miranda, Simao, Rhea, Bunker, Prestes, Leite, et al., 2011; Prestes, Frollini, De Lima, Donatto, Foschini, De Cassia Marqueti, et al., 2009; Rhea, Ball, Phillips, & Burkett, 2002; Simao, Spineti, Freitas De Salles, Matta, Fernandes, Fleck, et al., 2012;). LP divides the resistance training program into different segments: microcycles, which can range from a single training session to 4 weeks of training sessions; macrocycles, which equal 3-4 microcycles; and mesocycles, which equal 3-4 macrocycles. LP progresses from high volume, low intensity in the early training cycles of the year to low volume, high intensity cycles later in the year. NLP does not follow the same model, as volume and intensity may fluctuate through the microcycles. On the contrary, DUP features a mixture of low, moderate, and high intensity, as well as low, moderate, and high volume throughout every cycle during training.

Problem Statement

The DUP model allows different intensities and volumes of training to be performed simultaneously within the same training week. As such, a DUP model allows for greater variation in regards to manipulating the training variables than a LP model. This, in theory, should lead to more compliance with resistance training programs and a higher degree of motivation in each training session. Autoregulated progressive resistance exercise (APRE), a form of Flexible Nonlinear Periodization (FNLP), has been a growing trend in the strength and conditioning community since its introduction in Supertraining (Siff, 2003). This concept allows for participants to regulate the amount of weight they do in their last 2 sets of the day based on how they feel and their performance on prior sets. In traditional programming, days are permanently programmed and the lifter either confines to the parameters of the training

session or skips the day entirely. With FNLP, the lifter has a choice. He or she will still complete the session, but based on the weights they are capable of doing that day. The volume will be maintained within the training week and ultimately the microcycle, but lifters using FNLP may be at an advantage because the training session performed can be selected based upon the lifter's self-perceived readiness on each individual training day. This should lead to optimal recovery and training motivation when compared with lifters using traditional programming. It also provides lifters using FNLP with a sense of "control" over the program design, even though they are still completing the same amount of volume as lifters using traditional programming.

Purpose of Study

This study was conducted to test a traditional model of DUP versus a Flexible DUP (FDUP) model. Research in the area of autoregulation is very limited, although it has shown great promise thus far. To the researcher's knowledge, there has not been a study comparing FDUP and DUP, in which the FDUP group chooses the order of workouts, while the DUP group will get a permanent order of workouts. Although the theory has been presented, it is relatively unknown whether integrating the use of flexibility into the DUP model will alter training variables such as maximal strength, powerlifting total, and Wilk's Coefficient. The aim of this study is to improve upon an already superior form of periodization and provide strength and conditioning coaches with another variation of periodization for their programs. The potential benefits of successfully integrating flexibility into DUP programs could prove to further increase gains in strength, power and hypertrophy in a shorter time frame and more efficient manner, as well as increased autonomy and adherence to resistance training program guidelines.

Study Variables

The study's independent variables include whether or not the participant gets to choose the workout that day (FDUP group) or has to follow the set order of workouts (DUP group), as well as the timing of the measures of the pre-test at week 1 and post-test at week 10. The dependent variables in this study are the measure of 1RM in the squat, bench press and deadlift, as well as powerlifting total, and Wilk's Coefficient.

Hypotheses

Ho_1 There will be no difference between the FDUP group and DUP group in relation to 1RM bench press.

H_{A1} There will be a difference between the FDUP group and DUP group in relation to 1RM bench press.

Ho_2 There will be no difference between the FDUP group and DUP group in relation to 1RM squat.

H_{A2} There will be a difference between the FDUP group and DUP group in relation to 1RM squat.

Ho_3 There will be no difference between the FDUP group and DUP group in relation to 1RM deadlift.

H_{A3} There will be a difference between the FDUP group and DUP group in relation to 1RM deadlift.

Ho_4 There will be no difference between the FDUP group and DUP group in relation to powerlifting total.

H_{A4} There will be a difference between the FDUP group and DUP group in relation to powerlifting total.

Ho_5 There will be no difference between the FDUP group and DUP group in relation to Wilk's Coefficient.

H_{A5} There will be a difference between the FDUP group and DUP group in relation to Wilk's Coefficient.

Operational Definitions

Squat: The first lift in a powerlifting competition. It involves the barbell being placed across the posterior deltoids, then bending the knees until the hip joint is below the knee joint and then returning to the standing position.

Bench Press: The second lift in a powerlifting competition. It involves the lifter lying flat on a bench, unracking the barbell, lower in to the middle of the sternum for a slight pause, and then returning the bar to the starting position.

Deadlift: The deadlift is the third lift in a powerlifting competition. The deadlift involves the participant picking up a barbell from the ground, allowing it to pass the knees, until the lifter is standing erect with the barbell in hand.

Powerlifting Total: The total kilograms or pounds of the heaviest squat, bench press, and deadlift added together. The powerlifting total determines who wins or loses in each weight class in a powerlifting contest.

Frequency: Defined as the amount of training sessions a lifter performs a workout in a week.

Intensity: The percentage of the lifter's 1-rep max being used.

Volume: The number of sets multiplied by the number of reps multiplied by the weight being lifted. This is calculated for each individual lift, workout, week, as well as the total throughout the entire program as a whole.

1-Rep Max (1RM): The maximum amount of weight a lifter can correctly lift with proper technique. This is equal with an RPE of 10. If the lifter is able to complete more than 1 repetition, it is not a true 1-Rep Max.

Flexible Non-Linear Periodization (FNLP): A form of periodization in which the load, volume and intensities vary throughout a given week or month. The lifter is allowed to choose which lift they would like to perform from a set program based on how they feel.

Flexible Progressive Resistance Exercise (APRE): A system of periodization in which the weights used are determined based on the results of the previous session. This system accounts for the fluctuation in a lifter's strength between 1RM tests and training sessions.

Flexible Daily Undulating Periodization (FDUP): A system of periodization in which sets,

reps, and loads vary throughout the week. Lifters are allowed to choose a workout from prescribed workouts for the week based on their energy levels, sleep, soreness, and willingness to train that day.

Daily Undulating Periodization (DUP): A form of FLNP in which the sets, reps, and loads vary throughout the different workouts within a given week to incorporate different training attributes (hypertrophy, power, strength, etc.) within the same week.

Linear Periodization (LP): A system of periodization in which the program starts with a high volume, low intensity and progresses towards low volume, high intensity.

Wilk's Coefficient: A method of comparing the powerlifting totals of different lifts in different weight class to determine the most skilled lifter overall.

Plus Set: A set performed for maximal reps to either volition or technical failure, in which the participant is unsure if they could complete an additional rep with proper technique.

Assumptions

It is assumed that participants will give accurate information regarding training status, health status on initial paperwork, diet, use of anabolic steroids, supplements, and other relevant factors. It is also assumed that participants give full effort on max tests and will not perform any extraneous workouts outside of the study. It is also assumed that researchers are properly able to correctly gauge proper squat depth, bench press and deadlift technique when 1RM tests are performed and researchers are able to accurately distinguish reps performed properly from reps that do not count.

Limitations

The study will be performed in a lab, which may limit its transfer to other settings. This study may have limited carryover to those who are not interested in increasing their 1RM in the bench press, deadlift, and squat, as the participants in this study will be resistance trained (trained male powerlifters). For this reason, the study may also have limited carryover to females, as well as untrained and unhealthy participants. In addition, no formal dietary tracking was completed in this study. Participants were told to maintain the same diet for the duration of the study.

Delimitations

Delimitations include inability to control for extraneous supplements outside of what is given in the lab. The subjects will also have no programmed cardiovascular activities, speed and agility, or any other activities outside of resistance training, warm-up, and cool down. Therefore, it may have limited carryover to athletes and those who use concurrent training. This study will utilize only those powerlifters who do not compete in gear, or supportive weightlifting attire which provides additional support to the lifter (not including weightlifting belt or knee sleeves. Therefore, it may have limited carryover to geared powerlifters. The study will be conducted over a 10 week period, as the study had to coincide with school semesters.

Significance

The significance of this study is to determine if adding a flexible component into DUP programs yields better results than traditional training in intermediate to advanced trainees. By the completion of this study, the goal is to have determined if a flexible component is a valid tool in the programming of powerlifts or a trend that will pass like many of its predecessors.

The study will also attempt to quantify whether or not athlete motivation and control over workout order in the FDUP plays a role in effort given on sets taken to maximal reps possible, and improvements on the powerlifts, when compared to the traditional DUP group.

Chapter 2: Review of Literature

Resistance Training and Adaptations

Resistance training has proven to be a great benefit to athletes and non-athletes alike. Adaptations to resistance training include neurological changes, as well as morphological and muscle fiber type changes (Baechle & Earle, 2008; Bompa & Haff, 2009; Fry, A.C., 2004). When designing resistance training programs, one must take into account many different variables, including the volume and intensity used, the duration of the rest periods, the frequency of exercise, the individual exercises, and the exercise order that will actually be used. According to Staron et al. (1994), strength gains can be attributed to both neural adaptations and hypertrophic gains in the skeletal muscle (Staron, R.S, Karapondo, D.L., Kraemer, W.J., Fry, A.C., Gordon, S.E., Falkel, J.E. et al., 1994). With those beginning resistance training programs, it has been stated that most adaptations are due to improvements in neural connections, more so than adaptations occurring within the actual musculature (Kraemer, W.J., Fleck, S.J., Evans, W.J., 1996). For this reason it has been stated that beginners use higher repetition sets (8-15) and lower intensity when beginning resistance training, as gains in strength will be mostly due to neural adaptations as opposed to hypertrophic adaptations (Baechle, T.R. & Earle, R.W., 2008). It is also suggested that beginner's resistance train 2-3 times a week until they reach intermediate status, which is defined as 6 months or greater of resistance training experience (Baechle & Earle, 2008).

Volume

As an athlete's resistance training experience progresses from beginner to intermediate (greater than 6 months of resistance training experience) and advanced (greater than 2 years resistance training experience), more factors must be taken into account to elicit strength gains. Although neural and hypertrophic gains still lead to increases in strength gains, programs must be more carefully planned and evaluated to elicit stronger adaptations or progress will plateau (Bompa & Haff, 2009). This is the reason the training program in this study employs a hypertrophy day, a power day, and a strength day. To elicit strength gains in more advanced individuals, more specific strength attributes must be trained in a well-developed program. Robbins et. al, (2012) demonstrated that volume has a significant impact on eliciting strength gains in the lower body musculature (Robbins, D.W., Marshal, P.W.M., and McEwen, M., 2012). In this investigation, subjects were placed into 3 groups where they completed either 1 set, 4 sets, or 8 sets of squats at 80% percent of 1RM throughout a 12 week program. The group that performed 8 sets of squats significantly increased their 1RM squat when compared to the 1 set and 4 set, although the 4 sets group increased significantly more than the 1 set group. This is consistent with the findings of Rhea et. al (2002) in which they found 3 sets of leg press and bench press to be superior to 1 set of leg press and bench press in eliciting strength gains in trained males (Rhea, M.R., Alvar, B.A., Ball, S.D., and L.N. Burkett, 2002). These studies show a positive correlation between volume and 1RM strength gains in trained individuals.

Intensity

Another valuable factor that greatly plays into the improvement of strength through resistance training is the intensity used. Intensity is defined as the percentage of 1RM used on a

given set. Resistance used can be classified into zones based on the intensity used ranging from supermaximal (greater than 100% of 1RM) to very light (30-50% of 1RM) (Bompa & Haff, 2009). Elite level athletes do not train at a given intensity throughout a training cycle. Instead, intensities are varied to develop different qualities needed for the athlete to be successful, such as muscular endurance, hypertrophy, power, etc. Based on the previous scientific literature, it appears gains maximal strength are best emphasized in individuals with at least 1 year of resistance training with at least 80% of the participant's 1RM or higher (Bompa & Haff, 2009; Zatiorsky, V.M., Kraemer, W.J., 2006), while other literature suggests maximal strength is best achieved using intensities of 85% of 1RM or higher (Baechle & Earle, 2008). Manipulations of volume and intensity lead to different adaptations, depending on the training goal, although Gonzalez-Badillo et. al (2006) suggests that intensity plays a larger role in strength gains than volume (Gonzalez-Badillo, J.J., Izquierdo, M., & Gorostiaga, E.M., 2006). For this reason, strength days throughout the study are set at intensities of 85% and higher.

Neural Adaptations & Rate of Force Development

As previously stated, gains in maximal strength are primarily due to neural factors. According to Behm (1995), neural adaptations that induce gains in strength include "alterations in recruitment, rate coding, synchronization of motor units, reflex potentiation, co-contraction of antagonists, and synergistic muscle activity" (Behm, D.G., 1995). Rate of Force Development (RFD) is also an important factor in the development of maximal strength. RFD can be defined as the amount of time it takes muscles to develop maximal force generating capacities. The Strength-Velocity curve explains the inverse relationship between the force generated during a lift and the velocity at which the barbell is moving (Zatiorsky, V.M., & Kraemer, W.J., 2008). The curve ranges from lifts that are very heavy and generate great

amounts of force, but slow velocities (a 1RM attempt) to lifts that are very light and generate great amounts of bar speed, but not a lot of force (30% of a 1RM). RFD can be developed at various points along the Strength-Velocity curve (Figure 2.1). Behm (1995) also stated that maximal muscular power was not adequately developed during traditional strength training programs (Behm, D.G., 1995). He proposed that power training be comprised of its own separate entity in which specific training was devoted to developing maximal power. Since power is defined as work divided by time, the most efficient way to develop power is to do as much work as possible in the shortest amount of time. Scientific literature suggests that maximal power can be developed between 30-80% of 1RM (Bompa & Haff, 2009), while Baechle and Earle (2008) state that maximal power can be developed between 75-90%. While many studies may agree with lower percentages of 1RM for maximal power output (Comrie, P., McCaulley, G.O., Triplett, N.T., & McBride, J.M. 2007 & Baker, D.G., Nance, S. & Moore, M.), this study will use sets of 1-3 repetitions using 75-90% of 1RM for the power day through the training cycle, a protocol resembling that of a similar study (Zourdos 2012). The reason for the higher percentage power day is to develop maximal force, at a load most similar to that of a maximal lift used in a powerlifting meet. While previously mentioned studies have shown higher levels of power to be developed at lower percentages of 1RM, these lower percentages may have limited carryover to powerlifting since the load used is so light (Dolan, C., Schau, K. A., Quiles, J. M., Klemp, A., Day, B., Garcia Merino, S.& Zourdos, M. C. 2014). A power day is included in the participants training program in order to develop maximal muscular power and Rate of Force Development, two important factors in the development of maximal strength.

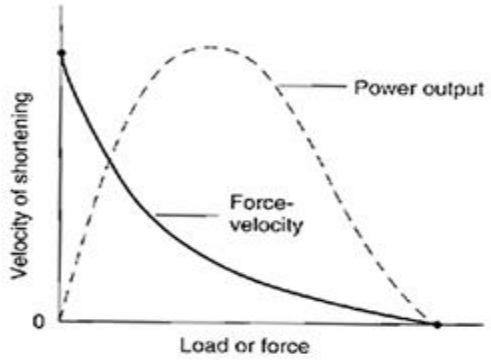

Figure 2.1. The strength-velocity curve. From Zatiorsky & Kraemer, 2006

Periodization

The organization of training variables into a planned model is a simplistic way of defining periodization. Periodization has been used as an effective method to developing resistance training program when compared to non-periodized programs (Baker, D.G., Wilson, G., and Carlyon, R., 1994; Rhea, 2004). Kiely (2012) found that in 13 out of 15 studies comparing results from periodized programs and non-periodized programs, the periodized programs had superior results (Kiely, J., 2012). Periodization is, simply put, the planned training of an athlete or group of athletes. A more complex definition, as stated by Bompa and Haff (2009) is "Periodization is defined as the logical and systematic sequencing of training factors in an integrative fashion in order to optimize specific training outcomes at pre-determined time points." Periodization itself is not a new concept. Its roots can be traced back to the ancient Greeks, who used different periods to organize the training of their athletes (Pedemont, J., 1986). The theory of modern periodization has roots that date back to 1950 with Hans Selye's published work on the General Adaptation Syndrome (Selye, 1950). With this ground breaking information, modern periodization was born through Russian Physiologist Leo Metveyev and Romanian Tudor Bompa, who are credited as the fathers of modern

periodization (Pedemonte, J., 1986). They were able to apply the General Adaptation Syndrome model and expand upon it in order to improve the recovery and performance of their athletes through resistance training. Though the basic concepts of periodization have remained, different philosophies have been developed on the optimal way to implement periodization into a resistance training program.

Linear Periodization

Linear Periodization (LP) is often defined as "Classical Periodization" and follows of a systematic order of progressing from lighter weights and a higher volume of work to heavier weights and a lower volume of work. As the volume decreases in LP, the intensity increases. For example, in LP the first microcycle would feature high volume, low intensity work (3 sets of 10 reps at 65%). The next microcycle would feature moderate volume, moderate intensity work (3 sets of 5 reps at 75%). The final microcycle would feature low volume, high intensity work (3 sets of 3 reps at 85%). LP follows this systematic approach and often uses the same workout throughout the week, before lowering the reps and raising the intensity in the next week or microcycle.

Reverse Linear Periodization

Reverse Linear Periodization (RLP) is derived from classical linear periodization, except reversed. Instead of starting with a higher volume of work and a lighter load, RLP starts with a heavier load and lower volumes of work and progresses towards lighter loads, with higher volumes of work. Prestes et al. (2009) found LP to be better suited than RLP when comparing improvements in body composition and gains in maximal strength in trained women (Prestes, J., De Lima, C., Frollini, A.B., Donato, F.F., & Conte, M., 2009).

Flexible Non-Linear Periodization

Flexible Non-Linear Periodization (FNLP) can be described as any periodization model in which a set order of workouts is not established throughout a microcycle. For example, an athlete may have 3 workouts to complete in a week. The coach will not assign a set order to these workouts, but will instead instruct the athlete to complete the 3 workouts throughout the week, depending on how the athlete is feeling that day. For example, if the athlete's first day is a Monday and they only slept for 4 hours and is drained from the weekend, the athlete can choose to pick the workout that they feel is easiest. They will complete the other 2 workouts based on how they feel on the other 2 training days of the microcycle. This provides the athlete with a sense of control over their workouts, while still allowing the coach to control the amount of work the athlete is doing throughout the microcycles, macrocycles, and mesocycles of a training year. McNamara et al. (2010) found FNLP to be superior to a non-linear periodization (NLP) group in a beginning weight training class (McNamara, J.M., & Stearn, D.J., 2010). Both groups completed 8 workouts using sets of 5 reps, 8 workouts using sets of 10 reps, and 8 workouts using sets of 20 reps. The NLP group was assigned the workout they would do on a given day, while the FNLP group was granted a choice of workout throughout the 12 weeks. The FNLP displayed significantly greater increases in maximal leg press strength when compared to the NLP group, even though both groups had completed the same amount of work in the same time period.

Daily Undulating Periodization

Daily Undulating Periodization (DUP) is a form of FNLP in which sets, reps, intensity, and volume vary throughout a training week or microcyle. For example, a 3 day training week may feature a light day (high volume, low intensity) on Monday (3 sets of 10 reps at 65%),

moderate day (moderate volume, moderate intensity) on Wednesday (3 sets of 5 reps at 75%), and a heavy day (low volume, high intensity) on Friday (3 sets of 3 at 85%). Research has found DUP to produce better results in body composition, hypertrophy, and maximal strength when compared with linear periodization (Buford, T.W. et al.. 2007; Miranda, F., 2011; Prestes, J. et al. 2009; Rhea, M.R. et al. 2002; Simao, R. et al., 2012). The rationale behind the greater improvements in maximal strength, hypertrophy, and body composition when compared to linear periodization is that by varying rep ranges, volumes, and intensities in a given training cycle, the athlete is able to develop a multitude of traits at one time, instead of individually. In the given example, the participants in the first microcycle of the LP group will only gain muscular hypertrophy by completing 3 sets of 10 reps at 65% of their 1RM. As described earlier, power and strength need to be developed above 75% and 80%, respectively. Therefore, this group is only developing hypertrophy throughout this microcycle, not power and strength. In the example given previously using the DUP model, the athlete in the given microcycle is training hypertrophy on Monday with 3 sets of 10 reps at 65%, is training power and hypertrophy on Wednesday with 3 sets of 5 at 75%, and power and strength on Friday with 3 sets of 3 at 85%. This gives the athlete the ability to work all 3 qualities of strength within a given microcycle year round, which will lead to more optimal gains in strength and hypertrophy when compared with a linear model. Additionally, the coach is provided with the ability to include an extra power day if the athlete seems to be lacking power and is at a sufficient level of hypertrophy, or add an extra hypertrophy day if the athlete is lacking hypertrophy and is already at a good level of power or strength. Giving the coach freedom to make choices based on the individual needs of different athletes is one of the greatest strengths of daily undulating periodization.

DUP in Powerlifters

Zourdos (2012) compared two groups of trained powerlifters using two different models of DUP on maximal strength in the squat, bench press, and deadlift. In addition to these three lifts, powerlifting total and Wilk's score were also measured in each group. One group completed a hypertrophy day on Monday, strength day on Wednesday, and a power day on Friday (HSP group) (Zourdos, M.C., 2012). The other group completed identical workouts, but the order of workouts within the week was changed. On Monday they completed a hypertrophy workout, on Wednesday they completed a power workout, and on Friday they completed a strength workout (HPS group). Zourdos found that both groups significantly increased all 5 variables, with the exception of the bench press in the HSP group. He also found that the HPS group increased more than the HSP in every category. Therefore, the proposed optimal order of the workouts is following the hypertrophy-power-strength model proposed by Zourdos.

Flexible Daily Undulating Periodization

Flexible Daily Undulating Periodization (FDUP) is a form of FNLP in which the athlete is allowed to pick which workout they do in a given week from a pool of workouts given to them by a coach. In FDUP, the weights are also adjusted based on the previous workout, instead of using percentages based on the athletes original 1RM. This allows the athlete's weights to progress individually throughout a microcycle and allows the athletes to progress at their own pace. This idea is presented in "The APRE" by Dr. Bryan Mann (Mann, 2013). Mann suggested that athlete's RM's increase at a greater rate than 1RM testing occurs. To account for this, Mann suggested using Autoregulated Progressive Resistance Exercise (APRE). This idea was originally presented by Mel Siff in his book Supertraining (2003). The idea behind APRE

is to attempt maximal reps on the last set of resistance training exercises at a given percentage or estimated rep max (RM). The weights of the next workout will be adjusted based on the number of repetitions completed in this last set. The athlete then compares this to a chart (Table 1 and adjusts their weight based accordingly. Dr. Mann suggests using a 3RM day, 6RM day, and 10RM day, with 3 sets of each exercise. The first set is 50% of the estimated RM for the specified number of reps, the second is 75% of the estimated RM for the specified number of reps, and the third is taken to maximal reps at 100% of estimated RM. The weights for the next workout are then adjusted based on the final set of 100% of the estimated RM. FDUP applies the same principles of APRE using progression and differing intensities throughout a given microcycle, but all working sets are completed at the same percentage of 1RM, as opposed to a 3RM, 6RM, or 10RM.

Auto-Regulated Progressive Resistance Exercise

During a 6 week study, Mann et al. (2010) found that the APRE protocol produced better results in maximal bench press strength, estimated 1RM squat, and 225 lbs. bench press test in division I college football players when compared with a traditional linear periodization model (Mann, B.J., Thyfault, J.P., Ivey, P.A., and Sayers, S.P., 2010). The APRE group changed weights based on their performance on the 6RM APRE protocol and adjusted weights according to Table 2.1 listed below. The LP group progressed from 70% 1RM to 85% 1RM over the 6-week training protocol.

Table 2.1. APRE Protocol for 6RM. *Adapted from Mann et al. (2010)

Repetitions Completed	Change in Resistance Used for Next Workout
0-2 reps	Decreased by 5 to 10 lbs.
3-4 reps	No change to a decrease of 5 lbs.
5-7 reps	No change
8-12 reps	Increase by 5 to 10 lbs.
>13 reps	Increase by 10 to 15 lbs.

Rationale for Study Protocol

The research demonstrates a significant increase in results when comparing DUP to LP programs, and APRE programs to LP programs. To the researcher's knowledge there has been no study combining the factors of APRE and DUP, and comparing that to other models of DUP. By combining factors of both APRE and DUP to develop FDUP, weights and order of workouts can be Flexible to offer the athlete more control over which workout they perform based on their energy levels, motivation, and other training factors. By taking into account all of these factors, as well as individually adjusting weights and intensities throughout the training cycle, gains in maximal strength and hypertrophy should be optimized using the FDUP model presented in the methods section below.

Chapter 3: Methods

Participants

The participants in this study were 25 trained, college-aged males between the ages of 18 to 50. To meet inclusion requirements for this study, participants' 1RM's had to be at least one and a quarter times' bodyweight in the squat, one times the participant's bodyweight in the bench press and one and a half times the participant's bodyweight in the deadlift. Also, it is the goal to recruit subjects who have been resistance training at least 3 days a week for at least 1 year.

Instrumentation

Prior to the study, the participants were given a basic medical clearance form, as well as a Physical Activity Readiness Questionnaire (PARQ). The subjects were also be asked to fill out a demographics survey providing their age, sex, race, training status, as well as a brief description of their previous supplementation, training programs, and injury history.

Equipment

The equipment used in the study included York Barbell Squat Racks, Texas Power Barbells, York Barbell weight plates, York Barbell Olympic lifting platforms, and dumbbells. Participants were also allowed to use knee sleeves, wrist wraps, and weight belts periodically throughout the study and on 1RM attempts.

Procedures

Pre-Testing

Subjects were instructed to cease all supplementation (except vitamin/mineral and protein supplementation) 6 weeks prior to the study. Both groups of subjects were provided with approximately 24 grams of protein post-workout during the study and were instructed to refrain from all other supplementation throughout the study. On Thursday of week 1, participants entered the lab for initial testing and familiarization with the warm-up. Subjects performed a dynamic warm-up before participating in any testing or lifting. In addition, subjects were informed of the testing and procedures for 1RM test in the squat, bench press, and deadlift. Subjects were asked to complete 3 sets of 3 reps with an estimated 10RM with proper form to familiarize themselves with the testing protocol for the 1RM tests that proceeded the Friday of the same week. Subjects were then informed to maintain the same diet throughout the entire study. On Friday of week 1, subjects entered the lab for 1RM testing on the squat, bench press, and deadlift. Prior to any testing, the subject's height and weight were taken. After completing the standardized warm-up, subjects received 3-5 warm-up attempts before attempting their first 1RM and received 3-5 minutes between each attempt, depending on personal preference. At the conclusion of the 1RM testing, participants were ranked based on powerlifting total relative to body weight and were then assigned into the DUP group or the FDUP group. Participants were matched according to weight lifted and then randomly placed into groups. Participants also served as a spotter for other participants on lifts in which a spot was needed.

Program Overview

Subjects in the DUP group were assigned a standardized order of workouts, with Workout 1 being on Monday (Hypertrophy Day), Workout 2 on Wednesday (Power Day), and Workout 3 on Friday (Strength Day). The FDUP group was provided with a choice in the order based on their motivation within that given training day. All subjects, regardless of group, completed the same 3 training sessions and amount of work within a given week. In workouts 1 and 3, subjects completed a plus set (as many reps as possible without failure) on their final set. Subjects were informed to complete as many reps as they can to an RPE of 9-9.5, in which they were unsure if they could possibly complete 1 additional repetition without failing. 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 (see table 3.1 below). In the last week (week 9), all participants completed the Green Day on Monday and the Red Day on Wednesday before maxing on Friday, to standardize the retesting procedure.

Table 3.1: Overview of Training Schedule for Both Groups

Day of the Week	Week 1	Weeks 2-9	Week 10
Monday	No Training	Green Day	Green Day
Tuesday	No Training	No Training	No Training
Wednesday	No Training	Red Day	Red Day
Thursday	Familiarization and Initial Testing	No Training	Initial Testing Retest
Friday	Initial 1RM testing	Blue Day	1RM Retest

*****FDUP group follows same schedule for the first week of training, but daily workouts are varied throughout the remaining 8-weeks of training.

Training Session Overview

Both groups completed the squat and bench press in each training session and the deadlift on the Blue and Red Days. On the Green Day, subjects also performed accessory work for the shoulders, biceps, and triceps. On the Red Day, the subjects performed pullups and abdominal accessory work and on the Blue Day, the subjects performed barbell rows and abdominal accessory work. The progression of the Green and Blue Day training sessions was based on the amount of reps completed on the plus set of the squat, bench press, and deadlift. The progression was based on the chart below (Table 3.2). The reps per set changed every 2-3 weeks, starting with sets of 8 (Green Day) and 3 (Blue Day) repetitions in weeks 2-4, sets of 6 (Green Day) and 2 (Blue Day) repetitions in Weeks 5-7, and sets of 5 (Green Day) and 1 (Blue Day) repetitions in weeks 8-9. The Red Day followed a linear periodization model, in which the load started at 80% in the beginning weeks, and progressed to 90% in the final week. The percentages for the weights used on the Red Day were based on a projected 1RM from the previous Friday's plus set. The 9 weeks ended with a taper leading up to retesting on the Friday of week 10. Both groups were programmed to have equal volume and intensity throughout the duration of the study. While the groups were given equal amounts of volume and intensity, the progression of load from week to week was based on the performance of the lifter from the previous week.

For practical purposes, the deadlift is only programmed twice a week, as this is the practice of many high-level lifters and coaches, as to not develop unnecessary fatigue. Participants were allowed to rest between 3 and 5 minutes between sets, based on personal preference. The entire program is outlined in table 3.3 below.

Table 3.2: Progression Chart	
5+ reps under goal	Drop 15 lbs. next workout
3-4 reps under goal	Drop 10 lbs. next workout
1-2 reps under goal	Drop 5 lbs. next workouts
0-1 reps above goal	Same weight next workout
2-3 reps above goal	Add 5 lbs. next workout
4-5 reps above goal	Add 10 lbs. next workout
6+ reps above goal	Add 15 lbs. next workout

*Based on the amount of reps completed in the last set of the prior workout
**Based on Projected 1RM

Study Rationale

The rationale behind this study is athlete autonomy. Although the athlete does not have complete control, they do have a say in their workouts and loads were progressed based on the athletes performance. The proposed design gives an athlete autonomy over their workout order, leading to the feeling that they have a choice in their programming. This choice, in theory, would lead to increased motivation and drive to complete the workout and the reps per set. The added flexibility and choice the FDUP group will receive, along with the additional motivation and desire, makes it reasonable to propose that these athletes will be able to push themselves more and get a few extra reps on the plus sets of the Hypertrophy and Strength days than the DUP group, leading to additional volume and a greater adaptation to the training stimulus over the 9-week training period.

Statistical Analysis

Data for each dependent variable was analyzed via a 2 x 2 between-within factorial ANOVA. Independent samples t-tests were used to determine if any baseline differences were observed. All analyses were completed using SPSS software and the alpha criterion for significance was set at 0.05.

Chapter 4: Results

Bench Press 1RM

Ho_1 stated that there will be no difference between the Flexible Daily Undulating Periodization Group (FDUP) and Traditional Daily Undulating Periodization Group (DUP) in 1-Repetition Max (1RM) Bench Press strength following nine weeks of resistance training. No statistically significant differences were found between groups in bench press 1RM (FDUP-Pre: 211.1 ± 44.2 lbs., FDUP-Post: 225.4 ± 41.5 lbs., DUP-Pre: 260.0 ± 45.9 lbs., DUP-Post: 279.6 ± 46.7 lbs., $p = 0.233$). Based on the findings, we fail to reject the null hypothesis. It is important to note that there was a significant main effect for time in relation to bench press 1RM ($p = <.001$), with the FDUP group increasing bench press maximal strength by 6.6% and the DUP group increasing bench press maximal strength by 7.7%. Also, there was a significant difference at baseline between the groups (FDUP: 211 ± 44.2, DUP: 260 ± 45.9 lbs., $p=0.008$). This was the only dependent variable in which a baseline difference existed.

Squat 1RM

Ho_2 stated that there will be no difference between the Flexible Daily Undulating Periodization Group (FDUP) and Traditional Daily Undulating Periodization Group (DUP) in 1-Repetition Max (1RM) Squat strength following nine weeks of resistance training. No statistically significant differences were found between groups in squat 1RM (FDUP-Pre: 291.8 ± 75.4 lbs., FDUP-Post: 326.1 ± 72.4 lbs., DUP-Pre: 324.6 ± 67.6 lbs., DUP-Post: 364.1 ± 55.9 lbs., p =

0.558). Based on the findings, we fail to reject the null hypothesis. It is important to note that there was a significant main effect for time in relation to squat 1RM (p = <.001), with the FDUP group increasing squat maximal strength by 11.6% and the DUP group increasing squat maximal strength by 12.0%.

Deadlift 1RM

Ho_3 stated that there will be no difference between the Flexible Daily Undulating Periodization Group (FDUP) and Traditional Daily Undulating Periodization Group (DUP) in 1-Repetition Max (1RM) Deadlift strength following nine weeks of resistance training. No statistically significant differences were found between groups in deadlift 1RM (FDUP-Pre: 366.4 ± 89.5 lbs., FDUP-Post: 398.9 ± 81.8 lbs., DUP-Pre: 384.1 ± 56.0 lbs., DUP-Post: 414.1 ± 64.3 lbs., p = 0.765). Based on the findings, we fail to reject the null hypothesis. It is important to note that there was a significant main effect for time in relation to deadlift 1RM (p = <.001), with the FDUP group increasing deadlift maximal strength by 9.0% and the DUP group increasing deadlift maximal strength by 7.8%.

Powerlifting Total

Ho_4 stated that there will be no difference between the Flexible Daily Undulating Periodization Group (FDUP) and Traditional Daily Undulating Periodization Group (DUP) in Powerlifting Total following nine weeks of resistance training. No statistically significant differences were found between groups in powerlifting total (FDUP-Pre: 869.3 ± 198.6 lbs., FDUP-Post: 950.4 ± 185.4 lbs., DUP-Pre: 968.6 ± 156.0 lbs., DUP-Post: 1057.7 ± 152.2 lbs., p = 0.630). Based on the findings, we fail to reject the null hypothesis. It is important to note that there was a significant main effect for time in relation to powerlifting total (p = <.001), with the FDUP

group increasing powerlifting total by 9.3% and the DUP group increasing powerlifting total by 9.2%.

Wilk's Coefficient

Ho_5 stated that there will be no difference between the Flexible Daily Undulating Periodization Group (FDUP) and Traditional Daily Undulating Periodization Group (DUP) in Wilk's Coefficient following nine weeks of resistance training. No statistically significant differences were found between groups in Wilk's Coefficient (FDUP-Pre: 278.7 ± 55.0, FDUP-Post: 303.5 ± 50.9, DUP-Pre: 299.2 ± 40.5, DUP-Post: 325.2 ± 37.9, p = 0.811). Based on the findings, we fail to reject the null hypothesis. It is important to note that there was a significant main effect for time in relation to powerlifting total (p = <.001), with the FDUP group increasing Wilk's Coefficient by 9.0% and the DUP group increasing Wilk's Coefficient by 8.7%. Table 4.1 below summarizes the raw data for each dependent variable assessed.

Table 4.1: Raw Data for Each Dependent Variable Assessed

Variable	Flexible Daily Undulating Periodization: Pre-Test	Flexible Daily Undulating Periodization: Post-Test	Traditional Daily Undulating Periodization: Pre-Test	Traditional Daily Undulating Periodization: Post-Test	P-value (Interaction Effect)
Bench Press 1RM	211.1 ± 44.2 lbs.	225.4 ± 41.5 lbs.	260.0 ± 45.9 lbs.	279.5 ± 46.7 lbs.	0.233
Squat 1RM	291.8 ± 75.4 lbs.	326.1 ± 72.4 lbs.	324.5 ± 67.6 lbs.	364.1 ± 55.9 lbs.	0.558
Deadlift 1RM	366.4 ± 89.5 lbs.	398.9 ± 81.8 lbs.	384.1 ± 56.0 lbs.	414.1 ± 64.3 lbs.	0.765
Powerlifting Total	869.3 ± 198.6 lbs.	950.4 ± 185.4 lbs.	968.6 ± 156.0 lbs.	1057.7 ± 152.2 lbs.	0.630
Wilk's Coefficient	278.7 ± 55.0	303.5 ± 50.9	299.2 ± 40.5	325.2 ± 37.9	0.811

Chapter 5: Discussion

Study Aims

The aim of the present study was to examine whether Flexible Daily Undulating Periodization (FDUP) would deliver superior strength gains in the powerlifts when compared to a traditional model of Daily Undulating Periodization (DUP). To the researcher's knowledge, this was the first study to examine the use of FDUP using the powerlifts in trained males. Other studies have used a flexible model of daily undulating periodization (McNamara, J.M., & Stearn, D.J., 2010), as well as different protocols of DUP using the powerlifts and trained males (Zourdos, MC 2012), but this was the first study to combine FDUP in trained males using the powerlifts.

Study Results

This study found significant changes over time in squat 1RM, bench press 1RM, deadlift 1RM, powerlifting total, and Wilk's Coefficient after 9 weeks of resistance training within groups. However, there were no significant differences between the groups in any of these variables. There were significant changes in the pre- and post-test 1RM bench press numbers between groups, but there was no interaction effect between groups on any variable. The resistance training program was designed to recruit high-threshold motor units and a high level of neural activity in order to increase maximal strength numbers. One possible explanation for the similar strength gains between groups would be the similar levels volume

and intensity. This would theoretically lead to similar neural and physiological adaptations. While neither volume nor intensity was exactly equal between groups, as weekly loads were adjusted based on plus sets of the prior week, both groups performed a similar amount of work in the 10-week program and there were no significant differences in volume between groups. The average reps per plus set was almost equal between groups (FDUP: 5.9 reps, DUP: 6.0 reps), which was a contributing factor to the similar progression of volume and intensity between groups. There was no significant difference in volume or intensity between groups. Another possible explanation could be that the subjects responded favorably to a well-designed, periodized and supervised resistance training program. Although these subjects were well trained, it is unlikely that they would have made comparable strength gains on their own. The program was designed to equate volume between groups, but allow participants to push themselves and "auto-regulate" progression based on the previous weeks performance.

Group Differences

While there were no significant differences found between groups, the DUP had a larger average increase in bench press 1RM (DUP: +19.5 lbs., FDUP: +14.3 lbs.), squat 1RM (DUP: +39.6 lbs., FDUP: 34.3 lbs.), and powerlifting total (DUP: +89.1 lbs., FDUP: +81.1 lbs.). While these changes are not statistically significant, the extra 5.2 lbs. in bench press strength, 5.3 lbs. in squat strength, and 8 lbs. in powerlifting total could potentially be the difference between podium positions in a powerlifting meet. It is particularly interesting that the DUP group had larger increases in strength, as they were the more trained group when compared to the FDUP group (DUP Squat 1RM Pre: 324.5 ± 67.6 lbs., DUP Bench Press 1RM Pre: 260.0 ± 45.9 lbs., DUP Deadlift 1RM Pre: 384.1 ± 56.0 lbs., DUP Powerlifting Total Pre: 968.6 ± 156.0 lbs. vs. FDUP Squat 1RM Pre: 291.8 ± 75.4 lbs., FDUP Bench Press 1RM Pre:

211.1 ± 44.2 lbs., FDUP Deadlift 1RM Pre: 366.4 ± 89.5 lbs., FDUP Powerlifting Total Pre: 869.3 ± 198.6 lbs.). In theory, the FDUP group should have more room for improvement since they were "less trained" than the DUP group, but this was not the case in this study. In conclusion, while there were no significant differences in strength gains between the FDUP and DUP groups, the DUP group did gain more strength in the squat, bench press, and powerlifting total, which may be of importance to some higher level lifters or those attempting to maximize their training adaptations

Comparison to Previous Studies

The findings of this study differed from that of a similar study conducted by McNamara and Stearn (2010). The authors had 16 untrained male and female subjects train twice per week for 12 weeks. The subject's completed a variety of free weight and machine exercises, and completed 8 workouts using a 10-repetition maximum, 8 workouts using a 15-repetition maximum, and 8-workouts using a 20 repetition maximum over the course of 12 weeks. Participants were assigned to a Flexible Non-Linear Groups (FNL) or a Non-Linear Group (NL). 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, while the NL group was given a set order (20RM, 15RM, 10RM repeated throughout the duration of the study). The authors found that the FNL group gained significantly more strength in leg press 1RM when compared to the NL group. No significant differences were found in chest press 1RM and long jump between the groups. While both studies showed an increase in strength in at least one variable, McNamara and Stearn found that a flexible model lead to superior strength gains, while our study showed equal strength gains between groups. This could be

attributed to the fact that participants in this current study had less choice, as they had to complete the same three workouts in a week, as opposed to a specific number of workouts over a 4 week period as in McNamara's study. The differences could also be attributed to the fact that participants in this study were trained males using only free weight exercises, where McNamara and Stearn used untrained male and female subjects using a combination of free weight and machine exercises.

In another similar study performed by Zourdos (2012), 18 male powerlifters completed 8 weeks of resistance training focused on improving 1RM strength in the powerlifts. The subjects were divided into two groups: HSP, which performed a Hypertrophy workout on Monday, a Strength workout on Wednesday, and a Power workout on Friday, and HPS, which performed a Hypertrophy workout on Monday, a Power workout on Wednesday, and a Strength workout on Friday. Both groups significantly increased squat and deadlift strength, powerlifting total, and Wilk's score from pre- to post-testing. 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. On the contrary, the present study showed an increase in all strength training variables over time. The results of these 2 studies lead the author to conclude that structuring workouts following the HPS order or allowing for a flexible approach leads to significantly greater strength gains in the powerlifts and Wilk's coefficient, when compared to a HSP design.

Mann et al. (2010) conducted a study using a similar autoregulated approach to the progression of load. The researchers divided 23 Division 1 football players into 2 groups: a linear periodization group (LP; N=11) and an Auto-Regulated Progressive Resistance Exercise (APRE) group (APRE; N=12). The LP group started with a high rep, low load scheme (3 sets of 8 reps at 70% of 1RM) at the beginning of the study, and finished with a low rep, high load

scheme (4 sets of 5 reps at 85% of 1RM). The APRE group's workout consisted of different Repetition Maximum (RM) Protocols, using a projected 10RM, 6RM, or 3RM. Each protocol consists of 4 sets. The 1st set is at 50% of the projected RM, the 2nd at 75% of the projected RM, and the 3rd with 100% of the RM, which is taken to muscular failure. The 4th set is also taken to muscular failure, but the load is determined based on the performance during the third set. The protocol used most for the APRE group was the 6RM protocol. The subjects were tested on 1RM Back Squat, 1RM Bench Press, and the 225-lb. Maximum Repetition Bench Press Test. The APRE group significantly increased 1RM Bench Press and 1RM Back Squat strength, as well as an improvement of around 3 repetitions on the 225-lb. Maximum Repetition Bench Press Test. The LP group slightly decreased strength in 1RM Bench Press and 225-lb. Maximum Repetition Bench Press Test, and showed significantly less improvement in 1RM Squat strength when compared to the APRE group (APRE 1RM Squat Improvement: 43.3 ± 44.7 lbs., LP 1RM Squat Improvements: 7.4 ± 34.9 lbs.). This study confirms that using an autoregulated approach to progressive overload leads to significantly increased strength gains in 1RM Back Squat and Bench Press, as the APRE group and both the FDUP and DUP groups in our study used a similar approach to progressing load. In addition, both studies used trained males. In contrast to the study by Mann, our study did not use Division 1 athletes, and participants in this study were not allowed to participate in outside activities like the participants in Mann's study. To our knowledge, this is the first study to combine autoregulated resistance training and powerlifting performance in trained males. There was also a difference in protocols used for each workout. Mann's APRE group completed 2 warm-up sets, followed by a set to failure on the 3rd set with an estimated repetition maximum (either 3RM, 6RM, or 10RM). The load for the 4th set was then adjusted based on performance of the third set. In our study, participants completed 3 sets with a given

load. On the 4th set, known as a plus set, participants completed as many reps as possible without reaching volitional or technical failure. Participants were informed to stop when they were unsure if they were able to get the next rep. The load for all 4 sets of the next week was then adjusted based on the performance of the plus set. In conclusion, the combination of our results and that of Mann (2010) provide solid evidence that autoregulating training load leads to strength increases in both 1RM Bench Press and Squat.

Participant Adherence

It is also important to point out the both the DUP and FDUP groups started with 16 participants. While both groups started with equal numbers, the FDUP group had all 16 subjects complete the study, but 2 participants had to be removed from data collection due to extraneous activity. The DUP group started with 16 participants and finished with 11, finishing with only 69% of the starting participants. In conclusion, it appears that whether participants follow a structured traditional DUP program or a flexible DUP program, 9-weeks of training at a frequency of 3 days per week leads to significant improvements in 1RM Squat, Bench Press, and Deadlift, as well as Powerlifting Total and Wilk's Coefficient.

Practical Applications

While there were no significant differences between the groups, it is important to note that the DUP group added an additional 5.2 lbs. in bench press strength, 5.3 lbs. in squat strength, and 8 lbs. in powerlifting total when compared to the FDUP group. This could potentially be the difference between podium positions in a powerlifting meet, which may be of potential benefit to some practitioners and athletes. Additionally, adding a flexible component may increase adherence when compared to a "traditional" resistance training program, which

could be of particular interest to personal trainers and strength and conditioning coaches. In conclusion, keeping “traditional” programming with set days may lead to marginal improvements (yet non-significant) over a flexible approach. However, a flexible approach may lead to more adherence to a resistance training program.

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APPENDICES

Appendix A: Pre-Activity Screening Questionnaire

Pre-Activity Screening Questionnaire (PASQ)

Section 1-Diagnosed Medical Conditions

Please mark either Y (Yes) or N (No) *for* each of the items below that you have had diagnosed by a physician.

Cardiovascular (Heart) Disease Pulmonary (Lung) Disease Metabolic Disease

Y□ N□ Heart attack **Y□ N□** Emphysema **Y□ N□** Liver disease

Y□ N□ Heart surgery **Y□ N□** Chronic bronchitis **Y□ N□** Diabetes

Y□ N□ Coronary angioplasty (PTCA) **Y□ N□** Interstitial lung disease **Y□ N□** Thyroid disorders

Y□ N□ Heart valve disease **Y□ N□** Cystic fibrosis **Y□ N□** Kidney disease

Y□ N□ Heart failure **Y□ N□** Asthma

Y□ N□ Heart transplantation □If Yes to asthma, is this a current condition **Y□ N□**

Y□ N□ Congenital heart disease

Y□ N□ Abnormal heart rhythm

Y□ N□ Pacemaker/implantable cardiac defibrillator

Y□ N□ Peripheral vascular disease (PVD or PAD): disease affecting blood vessels in arms, hands, legs, and feet

Y□ N□ Cerebrovascular disease (stroke or transient ischemic attack): disease affecting blood vessels in the brain ___

____

Y□ N□ Do you have any other medical conditions diagnosed by a physician (such as musculoskeletal problems,

recent surgery, seizures, pregnancy, cancer, etc.) that may limit your physical activity?

Y□ N□ Do you take any prescription medications?

Section 2- Signs or Symptoms

Please mark either Y (Yes) or N (No) for each item below that you have recently experienced.

Y□ N□ Pain, discomfort in the chest, neck, jaw or arms at rest or upon exertion

Y□ N□ Shortness of breath at rest or with mild exertion

Y□ N□ Dizziness or loss of consciousness during or shortly after exercise

Y□ N□ Shortness of breath occurring at rest or 2-5 hours after the onset of sleep

Y□ N□ Edema (swelling) in both ankles that is most evident at night or swelling in a limb

Y□ N□ An unpleasant awareness of forceful or rapid beating of the heart

Y□ N□ Pain in the legs or elsewhere while walking; often more severe when walking upstairs/uphill

Y□ N□ Known heart murmur

□If Yes to known heart murmur, is this a current condition **Y□ N□**

Y□ N□ Unusual fatigue or shortness of breath with usual activities

Section 3- CVD Risk Factors

Please mark Y (Yes) or N (No) for each the following:

Positive Risk Factors

Y□ N□ I am a man who is 45 years or older or a woman who is 55 years or older.

Y□ N□ I have a father or brother who had a heart attack, coronary (heart) by-pass surgery, or who died
suddenly before age 55 or I have a mother or sister who had a heart attack, coronary (heart) by-pass
surgery, or who died suddenly before age 65.
Y□ N□ I am a smoker or I have quit smoking in the last 6 months or am exposed to environmental tobacco smoke.
Y□ N□ In the last 3 months, I have **not** been physically active - meaning I have **not** participated in 30 min of
moderate intensity physical activity at least 3 days/week.
Y□ N□ I have a BMI greater than or equal to 30 (see BMI chart on page 2 to determine your BMI).

Please mark Y (Yes), N (No), or DK (Don't Know) for each the following:

Y□ N□ DK□ My blood pressure is greater than or equal to 140/90 mm Hg.
Y□ N□ DK□ My blood cholesterol level is greater than or equal to 200 mg/dL.
Y□ N□ DK□ My fasting blood glucose is greater than or equal to 100 mg/dL.
Negative Risk Factor
Y□ N□ DK□ My high-density lipoprotein (HDL) cholesterol level is greater than or equal to 60 mg/dL.

Section 4- ***Acknowledgment, Follow-up, and Signature***

**I acknowledge that I have read this questionnaire in its entirety and have responded accurately, completely, and to the best of my knowledge. Any
questions regarding the items on this questionnaire were answered to my satisfaction. Also, if my health status changes at any time, I understand
that I am responsible to inform this health/fitness facility of any such changes.**

_____
_____
(Participant's Name-Please Print) (Participant's Signature) (Date)

Body Mass Index Chart:
BMI= Weight (kg)/ height (m2)
Instructions:
1. Find the appropriate height in the left-hand column labeled **Height** (in inches).
2. Move across to a given body (in pounds)*.
3. Move up to the top of that column to find the corresponding **.**
NOTE:
− If your weight (for your height) is greater than the information provided in the chart below, your BMI is greater (>) than 30.
− If you'd like to have your BMI calculated, log onto the following website & enter in the appropriate information. http://www.nhlbisupport.com/bmi/bmicalc.htm
**Pounds have been rounded off*
Adapted and reprinted with permission from NHLBI Obesity Education Initiative Expert Panel. *Clinical Guidelines on the
Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*. National Institutes of
Health, September 1998: Publication No. 98-4803. Accessed via

http://www.nhlbi.nih.gov/guidelines/obesity/bmi_tbl.htm.

Height
(inches)
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76

Appendix B: Demographics Survey

Demographics Survey (Personal Information Sheet)

Personal Information

Name:

Address:

City: _____ State: _____ Zip Code: _____

Home Phone: (___) _____ Work Phone: (___) _____

Cell Phone: (___) _____

Email address: _____

Birth date: ___ /___ /____ Age: ____ Height: _____ Weight: _____

Exercise History/Activity Questionnaire

1. Describe your typical recreational activities:

2. Describe any exercise training that you routinely participate.

3. How many days per week do you exercise/participate in these activities?

4. How many hours per week do you train?

5. How long (years/months) have you been consistently training?

Appendix C: Informed Consent

Informed Consent to Participate in Research
Information to Consider Before Taking Part in This Research Study

IRB Study #00017283

You are being asked to take part in a research study. Research studies include only people who choose to take part. This document is called an informed consent form. Please read this information carefully and take your time making your decision. Ask the researcher or study staff to discuss this consent form with you, please ask him/her to explain any words or information you do not clearly understand. We encourage you to talk with your family and friends before you decide to take part in this research study. The nature of the study, risks, inconveniences, discomforts, and other important information about the study are listed below.

Please tell the study staff if you are taking part in another research study.

We are asking you to take part in a research study called: *Comparison of Powerlifting Performance in Trained Males Using Traditional and Flexible Daily Undulating Periodization*

The person who is in charge of this research study is Ryan Colquhoun**.** This person is called the Principal Investigator. However, other research staff may be involved and can act on behalf of the person in charge. Ryan Colquhoun is being guided in this research by Dr. Bill Campbell.

The research will be conducted at The University of South Florida in Tampa. It will be specifically located in the Performance and Nutrition Laboratory on the ground floor of the USF Recreation Center.

Purpose of the study

The purpose of this study is to examine the effects of two different forms of Periodization on strength gains in the powerlifts. The powerlifts include the squat, bench press, and deadlift. Periodization is the planning of resistance training over a period of time. This involves the manipulation of volume (the amount of work done), frequency (how often the lifts are performed), as well as intensity (the percentage of maximal effort given). The different

manipulation of these variables can potentially lead to different results. The goal of this study is to determine if two different forms of Periodization lead to different strength gains in the powerlifts. The two different forms of periodization that will be assessed in this study are known as the flexible model of daily undulating periodization and the traditional model of daily undulating periodization. The difference between these two models (flexible vs. traditional) is quite simple. In the traditional model, the participant engages in a resistance-training program three days per week with each workout being pre-planned for the week. In the flexible model, the participant engages in the same workouts, but gets to choose which workouts they want to engage in on a particular day. There has been a minimal amount of research published in this area. Ryan Colquhoun, who is an exercise science graduate student, will be conducting this study.

Should you take part in this study?

- This form tells you about this research study. After reading through this form and having the research explained to you by someone conducting this research, you can decide if you want to take part in it.
- You may have questions this form does not answer. If you do have questions, feel free to ask anyone on the research team or the person explaining the study, as you go along.
- Take your time to think about the information that is being provided to you.
- Talk it over with your regular doctor.

This form explains:

- Why this study is being done.
- What will happen during this study and what you will need to do.
- Whether there is any chance of benefits from being in this study.
- The risks involved in this study.
- How the information collected about you during this study will be used and with whom it may be shared.

Providing informed consent to participate in this research study is up to you. If you choose to be in the study, then you should sign the form. If you do not want to take part in this study, you should not sign this form.

Why are you being asked to take part?

We are asking you to take part in this research study because you are a part of a specific demographic that regularly strength trains using these exercises. We want to obtain information that may help people who weight train in this manner.

What will happen during this study?

<u>Study Procedures</u>

Your participation in this project will require your attendance at The University of South Florida Exercise & Performance Nutrition Laboratory over a period of 10 weeks. You will be performing one of two different resistance training programs (one using a flexible model of

periodization, the other using a traditional model) of which, each training session will last approximately 60 minutes: During the first week, we will measure your height and weight and also measure how strong you are in three different resistance exercises – the bench press, the squat, and the deadlift. For the next 8-weeks, you will be asked to workout three days per week for about an hour per workout. In the last week of the study (Friday of week 10), the research staff will repeat each of the assessments that were conducted during the first week of the study – height, weight, and your strength in the three different resistance exercises.

The study schedule is outlined in the chart below:

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1				**Familiarization of Testing Procedure**	**Pre-Testing**
2	Training Session 1		Training Session 2		Training Session 3
3	Training Session 4		Training Session 5		Training Session 6
4	Training Session 7		Training Session 8		Training Session 9
5	Training Session 10		Training Session 11		Training Session 12
6	Training Session 13		Training Session 14		Training Session 15
7	Training Session 16		Training Session 17		Training Session 18
8	Training Session 18		Training Session 19		Training Session 20
9	Training Session 21		Training Session 22		Training Session 23
10	Training Session 24		Training Session 25		**Post-Testing**

Prior to starting the resistance training workouts, you will first be scheduled to a familiarization session. In this session you will be familiarized with the exercise testing protocol, and the exercises used in the study. Your height and weight will also be taken and you will participate in the dynamic warm-up and perform 3 sets of 3 repetitions with 50% of your projected 1RM (1-repetition maximum) in the squat, bench press, and deadlift to familiarize you with the 1RM testing procedures. The following day, you will return to the lab for 1RM strength testing. The strength testing procedure will involve a short dynamic warm-up of 5-10 minutes preparing muscles for the squat, bench press, and deadlift measures. The 1RM strength test will then be used to determine base line strength. Prior to the squat, bench press, and deadlift 1RM tests, sub maximal loads will be used for multiple sets to ensure that you are warmed up. The squat will

involve the unloading of the weight from the rack and walking it out of the rack a few steps. Once the squat has been walked out, you will lower the weight through a full range of motion, where the thighs are slightly beyond parallel in relation to the floor. At that moment, the weight will be pressed until the knees are fully extended. Next, you will perform the bench press exercise. You will lay flat on the weight bench with feet flat on the ground and the shoulders, butt, and head touching the bench at all times throughout the lift. The bar is then lifted off the rack and held at full extension. The bar is lowered to the chest and then pressed until the arms are fully extended. The third and final lift is the deadlift. For performance of the deadlift, the barbell is to start on the floor. You will grip the bar and stand with the barbell, until fully locked out, standing fully erect. After you have stood up with the bar, you will lower the bar under control back to the floor. Typically, the first attempt of all three lifts is usually about 50% of your estimated 1RM load. You will be allowed to rest enough to feel recovered from the previous attempt prior to the next attempt (1-5 minutes typically). The load will be increased 5-15% between trials until the maximum amount of weight is moved for 1 repetition. This protocol is performed on all 1RM tests.

Once pre-training measurements are taken, you will be asked to not resistance train for the time between the pre-training testing and beginning of the training for the study which will be scheduled 2 days later. The last part of the familiarization session is going over the exercise protocol. The exercises used in this study will be the squat, bench press, deadlift, barbell row, and the pullup or lat pulldown. After completion of the baseline testing protocol, you will begin the respective training program for three times a week for nine weeks until completion. After the last training session is completed, post training measurements will be scheduled for the Friday of week 10 of the study. This session will follow the same procedure as the baseline testing measures. You will also be given a food-log prior to the study, at week five of the study, the last week of the study. You will be asked to write down everything you eat for a 3-day period at each of these time points. You will also be given whey protein isolate after each session as nutritional control measures. If you are allergic to whey protein, soy or milk, or any of the ingredients in the protein supplement you will not be able to participate in this study.

The study training sessions are outlined in the chart below:

Program Outline

	Week 2	Weeks 3/4	Weeks 5/6/7	Weeks 8/9	Week 10
Workout 1	**4x10+ 70%**	**4x10+****	**4x8+****	**4x6****	**2x6+****
Workout 2	**6x1 80%**	**6x1 80%**	**5x1 85%**	**4x1 90%**	**2x1 90%**
Workout 3	**4x3+ 85%**	**4x3+****	**4x2+****	**4x1+****	**Retest**

Total Number of Participants

About 30 individuals will take part in this study at USF.

Alternatives

You do not have to participate in this research study.

Benefits

The potential benefits of participating in this research study include:

1. Increased Muscle Hypertrophy
2. Increased Muscular Strength
3. A nine week instruction on performing specific exercises

Risks or Discomfort

The risks associated with this study include the following: overexertion, shortness of breath, dizziness, headache, nausea, and muscle soreness. You may also be at risk for muscle strains and sprains, as well as bruises and other possible injuries associated with overexertion, dropping weights on yoursefl, and/or walking into equipment such as barbells, squat racks, etc.

Compensation

You will receive no payment or other compensation for taking part in this study.

Cost

There will be no additional costs to you as a result of being in this study.

Privacy and Confidentiality

We will keep your study records private and confidential. Certain people may need to see your study records. By law, anyone who looks at your records must keep them completely confidential. The only people who will be allowed to see these records are:

- The research team, including the Principal Investigator, study coordinator, and all other research staff.
- Certain government and university people who need to know more about the study. For example, individuals who provide oversight on this study may need to look at your records. This is done to make sure that we are doing the study in the right way. They also need to make sure that we are protecting your rights and your safety.
- Any agency of the federal, state, or local government that regulates this research. This includes the Food and Drug Administration (FDA), Florida Department of Health, and the Department of Health and Human Services (DHHS) and the Office for Human Research Protection (OHRP).

- The USF Institutional Review Board (IRB) and its related staff who have oversight responsibilities for this study, staff in the USF Office of Research and Innovation, USF Division of Research Integrity and Compliance, and other USF offices who oversee this research.

We may publish what we learn from this study. If we do, we will not include your name. We will not publish anything that would let people know who you are.

Voluntary Participation / Withdrawal

You should only take part in this study if you want to volunteer. You should not feel that there is any pressure to take part in the study. You are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study.

New information about the study

During the course of this study, we may find more information that could be important to you. This includes information that, once learned, might cause you to change your mind about being in the study. We will notify you as soon as possible if such information becomes available.

What if you get sick or hurt while you are in the study?

If you need emergency care:

- Go to your nearest hospital or emergency room right away or call 911 for help. It is important that you tell the doctors at the hospital or emergency room that you are participating in a research study. If possible, take a copy of this informed consent form with you when you go. USF does not have an emergency room or provide emergency care.

If you do NOT need emergency care:

- Go to your regular doctor. It is important that you tell your regular doctor that you are participating in a research study. If possible, take a copy of this informed consent form with you when you go.
- The USF Medical Clinics may not be able to give the kind of help your needs.

Will I be compensated for research related injuries?

If you believe you have been harmed because of something that is done during the study, you should call Ryan Colquhoun at 954-661-1049 immediately. The University of South Florida will not pay for the cost of any care or treatment that might be necessary because you get hurt or sick while taking part in this study. The cost of such care or treatment will be your responsibility. In addition, the University of South Florida will not pay for any wages you may lose if harmed by this study. The University of South Florida is considered a state agency and therefore cannot usually be sued. However, if it can be shown that the researcher, or other USF employee, is negligent in doing his or her job in a way that harms you during the study, you may be able to sue. The money that you might recover from the State of Florida is limited in amount.

You can also call the USF Self Insurance Programs (SIP) at 1-813-974-8008 if you think:

You were harmed because he/she took part in this study.

Someone from the study did something wrong that caused you to be harmed, or did not do something they should have done.

Ask the SIP to look into what happened.

What happens if you decide not to take part in this study?

You should only take part in this study if you want to volunteer. You should not feel that there is any pressure to take part in the study to please the study doctor or the research staff. If you decide not to take part in the study you will not be in trouble or lose any rights you normally have.

You can decide after signing this informed consent document that you no longer want to take part in this study for any reason at any time. If you decide you want to stop taking part in the study, tell the study staff as soon as you can. We will tell you how to stop safely. We will tell you if there are any dangers if you stop suddenly. If you decide to stop, there are no known dangers to changing to your choice of resistance training, or no resistance training. Please contact Ryan Colquhoun at 954-661-1049 as soon as possible if you decide to stop. Even if you want you to stay in the study, there may be reasons we will need to withdraw you from the study. You may be taken out of this study if you develop intolerable sore muscles or joint pain, or if you are not coming for the study visits when scheduled. We will let you know the reason for withdrawing you from this study.

You should only take part in this study if you want to volunteer. You should not feel that there is any pressure to take part in the study. You are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study.

You can get the answers to your questions, concerns, or complaints.

If you have any questions, concerns or complaints about this study, call Ryan Colquhoun at 954-661-1049.

If you have questions about your rights, general questions, complaints, or issues as a person taking part in this study, call the USF IRB at (813) 974-5638.

Consent to Take Part in Research
And Authorization for the Collection, Use and Disclosure of Health Information

It is up to you to decide whether you want to take part in this study. If you want to take part, please read the statements below and sign the form if the statements are true. I freely give my consent to take part in this study and authorize that my health information as agreed above, be collected/disclosed in this study. I understand that by signing this form I am agreeing to take part in research. I have received a copy of this form to take with me.

_____ _____

Signature of Person Taking Part in Study Date

_____

Printed Name of Person Taking Part in Study

Statement of Person Obtaining Informed Consent and Research Authorization

I have carefully explained to the person taking part in the study what he or she can expect from their participation. I hereby certify that when this person signs this form, to the best of my knowledge, he/ she understands:

- What the study is about;
- What procedures/interventions/investigational drugs or devices will be used;
- What the potential benefits might be; and
- What the known risks might be.

I can confirm that this research subject speaks the language that was used to explain this research and is receiving an informed consent form in the appropriate language. Additionally, this subject reads well enough to understand this document or, if not, this person is able to hear and understand when the form is read to him or her. This subject does not have a medical/psychological problem that would compromise comprehension and therefore makes it hard to understand what is being explained and can, therefore, give legally effective informed consent. This subject is not under any type of anesthesia or analgesic that may cloud their judgment or make it hard to understand what is being explained and, therefore, can be considered competent to give informed consent.

_____

_____

Signature of Person Obtaining Informed Consent / Research Authorization Date

_____

Printed Name of Person Obtaining Informed Consent / Research Authorization

Appendix D: Sample Training Card

Green Day							
Name:							
Day of Week and Day							
Week	**Day of Week**		**Date**	**Week**	**Day of Week**		**Date**
1	N/A		N/A	**6**			
2				**7**			
3				**8**			
4				**9**			
5				**10**			
Body Weight				**Motivation**			
Week	**Weight**	**Week**	**Weight**	**Week**	**Motivation**	**Week**	**Motivation**
1	N/A	**6**		**1**	N/A	**6**	
2		**7**		**2**		**7**	
3		**8**		**3**		**8**	
4		**9**		**4**		**9**	
5		**10**		**5**		**10**	
A. Squat							
Week	**Sets x Reps**	**Weight**	**Last Set?**	**Week**	**Sets x Reps**	**Weight**	**Last Set?**
1	N/A			**6**	4x8+		
2	4x10+			**7**	4x8+		
3	4x10+			**8**	4x6+		
4	4x10+			**9**	4x6+		
5	4x8+			**10**	2x6+		
B. Bench Press							
Week	**Sets x Reps**	**Weight**	**Last Set?**	**Week**	**Sets x Reps**	**Weight**	**Last Set?**
1	N/A			**6**	4x8+		
2	4x10+			**7**	4x6+		
3	4x10+			**8**	4x6+		
4	4x10+			**9**	4x6+		
5	4x8+			**10**	2x6+		
C. BB Row							
Week	**Sets x Reps**	**Weight**	**Last Set?**	**Week**	**Sets x Reps**	**Weight**	**Last Set?**
1	N/A		N/A	**6**	4x10		N/A
2	4x15		N/A	**7**	4x10		N/A
3	4x15		N/A	**8**	4x10		N/A
4	4x15		N/A	**9**	4x10		N/A
5	4x15		N/A	**10**	2x10		N/A

Session Satisfaction				Session RPE			
Week	Satisfaction	Week	Satisfaction	Week	Session RPE	Week	Session RPE
1	N/A	6		1	N/A	6	
2		7		2		7	
3		8		3		8	
4		9		4		9	
5		10		5		10	

Appendix E: Study Charts

Motivation to Train				
1	2	3	4	5
Very Unmotivated	Unmotivated	Neutral	Motived	Very Motivated

Satisfaction with Training Session				
1	2	3	4	5
Very Unsatisfied	Unsatisfied	Neutral	Satisfied	Very Satisfied

Session RPE	
0	Rest
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal Effort

Appendix F: IRB Approval Letter

USF
UNIVERSITY OF
SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

7/8/2014

Ryan Colquhoun
Educational and Psychological Studies
4202 E. Fowler Avenue
EDU105
Tampa, FL 33620

RE: **Full Board Approval for Initial Review**
IRB#: Pro00017283
Title: Comparison of Powerlifting Performance in Trained Males Using Traditional and Flexible Daily Undulating Periodization

Study Approval Period: 6/17/2014 to 6/17/2015

Dear Mr. Colquhoun:

On 6/17/2014, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents outlined below.

Approved Item(s):
Protocol Document(s):
Demographics Survey
Health History Form
Thesis Proposal
Training Cards

Consent/Assent Document(s)*:
Informed Consent.pdf

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s).

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

Kelly Markey, Pharm.D., Vice-Chair
USF Institutional Review Board