Which periodization is better (traditional vs undulating) to induce changes in body composition and strength of healthy young adults?

¿Qué periodización es mejor (tradicional versus ondulada) para inducir cambios en la composición corporal y la fuerza de adultos jóvenes sanos?

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Abstract

The present study intends to investigate which type of programming is most effective for improving strength and body composition in untrained young men. A total of 41 men participated (22.5 ± 2.8 years old, 75.6 ± 5.5 kg, 175.3 ± 8.4 cm, 24.6 ± 1.8 kg · m-2) which were divided into two groups; Traditional periodization and Undulating periodization. A program of eight weeks of training including back and chest exercises were applied twice a week for the two groups. Both fat mass and fat-free mass were measured by Dual-energy X-ray absorptiometry, as well as the maximum repetition (RM) of the bench press and row by measuring the speed of execution with a linear encoder and the resting heart rate before and after the program. Data were analyzed using magnitude-based inference. Changes in athletes' scores were assessed by using effect sizes and 90% confidence intervals. The differences within the group in pre-training and post-training were evaluated using the standardized effect size. Improvements in 1RM row, resting heart rate and fat-free mass were observed not possible to determine which training periodization produces greater adaptations in both groups with a possible and probable inference.

Keywords: Dual-energy X-ray absorptiometry, lean body mass, bench press, rowing, health.

Resumen

El presente estudio pretende investigar qué tipo de programación es más efectiva para mejorar la fuerza y la composición corporal en hombres jóvenes. Participaron 41 hombres (22.5 ± 2.8 años, 7.,6 ± 5.5 kg, 175.3 ± 8.4 cm, 24.6 ± 1.8 kg · m-2) divididos en dos grupos; Periodización tradicional y Periodización ondulatoria. Se aplicó para los dos grupos un programa de ocho semanas de entrenamiento que incluía ejercicios de espalda y pecho, dos veces por semana. Se midió la masa grasa y la masa libre de grasa mediante el DEXA, el RM del press de banca y remo a través de la velocidad de ejecución, y la frecuencia cardiaca en reposo antes y después del programa. Los datos se analizaron mediante inferencia basada en la magnitud. Los cambios en las puntuaciones de los atletas se evaluaron utilizando tamaños del efecto e intervalos de confianza del 90%. Las diferencias dentro del grupo en pre-entrenamiento y post-entrenamiento se evaluaron utilizando el tamaño del efecto estandarizado. Se observaron mejoras en 1RM en remo, frecuencia cardiaca en reposo y masa libre de grasa. Los resultados muestran una posible y probable inferencia, no siendo posible determinar qué periodización del entrenamiento produce mayores adaptaciones.

Palabras clave: Absorciometría de rayos X de energía dual, masa corporal magra, prensa de banco, remo, salud.

Introduction

Muscle hypertrophy and strength enhancement are the main goals of strength training practiced by those within the fitness world (Schoenfeld, 2010, 2013). It is known that the physiological mechanisms for these adaptations to occur are different but at the same time complementary, therefore, the programming of strength training is an important factor for obtaining these results in the long term.

Programming consists in altering one or more elements during training over a period of time, in order to allow the program to remain challenging and effective (Baker, Wilson, & Carlyon, 1994). Simple manipulation of training variables such as volume and intensity can offer benefits like reducing overtraining and stimulating gains in performance (Schoenfel, Ogborn, & Krieger, 2017). However, there is a debate currently open about which periodization model gains better adaptations. At the moment, the two most used periodization models are: linear (LP) and undulating (UP) (Poliquin, 1988). Linear periodization is traditionally used in many sports. It is characterized by starting the cycle with a high volume of training and moderate intensity, which change their roles as the sessions develop, where at the end of the training cycle the intensity becomes high unlike the volume, which descends (Baker, Wilson, & Carlyon, 1994). Nonlinear or undulating periodization is based on the alternation of short periods of high training volume with other high-intensity periods (Izquierdo, et al., 2006). Undulating periodization is characterized by spending less time working on each aspect (hypertrophy, strength, and power), one or two weeks, but working on each one more frequently. Kraemer (1997) proved the possibility of undulating within a microcycle, thus being able to work all three aspects within the same week and even within the same session known as daily undulating periodization.

Attending the neuromuscular adaptation and the greater capacity to recruit fast contraction motor units, the undulating periodization generated better responses Monteiro, et al. (2009). This may be because of the constant change in the recruitment of motor units due to the different types of training over a short time frame. In the same line, Prestes et al. (2009) found that in trained individuals (minimum 1 year of experience) strength increases using a nonlinear periodization were between 30% and 40% higher compared to those who used conventional planning.

The daily undulating periodization showed better results in terms of muscle cross-sectional area over nine weeks of training Kok, Hamer, y Bishop (2009). However, undulating periodization could generate too much fatigue and can even reduce force Hartmann et al. (2009). Painter et al. (2012) found that daily undulating periodization trained every day to a maximum effort and even reached muscle failure during hypertrophy training. Therefore, it seems logical that there are unfavorable results in these conditions. In this sense, Simão et al. (2012) found higher enlarge increases for nonlinear periodization training. Zourdos et al. (2016) compared the two different programming models under different orders: phase of hypertrophy, strength, and power of the maximum strength concluding to reaching a greater total volume in a 6-month mesocycle, along with a greater magnitude of force gain in both squat and bench press. Finally, it is believed that undulating periodization is superior to traditional training Poliquin (1988) because linear periodization leads to stagnation and overtraining of the athlete which does not improve either their muscular structure or strength. Thereby, the aim of the present study was to analyze two types of training periodization programming (traditional vs. undulating periodization) to know which is the most effective for the improvement of strength and body composition in untrained young men.

Materials and Methods

Experimental Approach to the Problem

A quasi-experimental pre-and post-test group design using two training groups to examine the short-term (eight weeks) effects of two sessions per week when using traditional (TP) or undulating (UP) periodization. Before data collection, the subjects took part in a familiarization session for each test. One week after the familiarization, the dependent variables were tested, as described below. The subjects were tested by the same investigator, using the same protocol, at the same time of day at weeks 0 and 9, and at a similar ambient temperature (19 - 22 C°). In session 1, body composition (dual x-ray absorptiometry; DEXA; XR-46, Norland Corp., Fort Atkinson, WI) was measured. In session 2, completed 48 h after session 1, the individual 1RM strength was determined by means of a progressive loading during bench press (BP) and prone bench pull (PBP). For the completion of all experimental protocols, the subjects were instructed to remain fast for three hours and not to consume alcohol or caffeine within 12 h. They were also asked to avoid strenuous physical activities the day before each session. During the eight weeks training period, both training groups (UP and TP) performed training using a Technogym equipment (Technogym SpA, Cesena, Italy) twice a week. All subjects were asked to maintain their normal daily routines and eating habits, not to take nutritional supplements that might affect lean tissue mass, and to refrain from commencing new exercise programs during the study.

Sample

Forty-one males (22.5±2.8 years old, 75.6±5.5 kg, 175.3±8.4 cm, 24.6±1.8 kg·m-2) responded to an invitation to participate in the study. Inclusion criteria for participation included: a) All participants must not have participated in any strength training for at least three months; b) Must not perform any type of regular physical activity during the program; c) Not have any medical condition that could influence the training protocol; d) Do not use any anabolic androgenic steroid and/or other ergogenic substances. Prior to testing, subjects were informed about the design of the study and possible risks and discomforts related to the testing and training, after which they read and signed an informed consent document. Subjects were told that they were free to withdraw from the study at any time, without penalty. Each participant provided written informed consent before any testing began, based on the last version of the Helsinki Declaration. This study was approved by the Ethical Committee of the European University of Madrid (CIPI17/2019). To ensure the confidentiality of the players, all performance data were anonymized before analysis.

Procedures

Subjects performed two similar test sessions before and after the eight weeks training period. The first test session was conducted on two non-consecutive days during the week prior to the beginning of the training program. The second test session was conducted under the same conditions during the week after completion of the training program. Both test sessions were performed using the same procedures, and with the same technician, who was blind to the training-group affiliation following previous research protocol Heilbronn et al. (2020). All subjects were familiarized with the testing procedures one week before. Before each test session, the subjects performed a standard warm-up that included eight minutes of stationary cycling, followed by 10 min of dynamic stretching exercises. All tests were performed at the same location and under similar environmental conditions as in the training sessions.

Dual-energy X-ray absorptiometry

Total and regional fat and lean (body mass – [fat mass + bone mass]) masses were calculated by means of dual-energy X-ray absorptiometry (DXA) (Hologic Series Discovery QDR, Software Physician's Viewer, APEX System Software Version 3.1.2. Bedford, MA, USA). DXA equipment was calibrated using a lumbar spine phantom and following the Hologic guidelines. To ensure the reliability of the DEXA measurements, all pre- and post-training scans were conducted and analyzed by the same operator. Participants were scanned in supine position, with their body and limbs fully extended and inside the limits set by the scan lines. The x-ray scanner performed a series of transverse scans moving at 1-cm intervals from top to bottom of the whole body. Lean mass (g) and fat mass (g) were calculated from total and regional analysis of the whole-body scan. The lean mass of the limbs was assumed to be equivalent to the muscle mass. The test-retest reliability coefficient (*ICC*) for this device was very high ($R2$ = 0.99; p = 0.001) in both cases. DEXA measures were performed before any strength measures to minimize any effects of fluid shifts.

Dynamic measurement system

A dynamic measurement system (T-Force System, Ergotech, Murcia, Spain) automatically calculated the relevant kinematic parameters of every repetition, provided auditory velocity feedback and stored data on disk for analysis. This system consists of a linear velocity transducer interfaced to a personal computer by means of a 14-bit resolution analog-to-digital data acquisition board and custom software. Instantaneous velocity was sampled at a frequency of 1000 Hz and subsequently smoothed with a 4th order low-pass Butterworth filter with a cut-off frequency of 10 Hz. A digital filter with no phase shift was then applied to the data. Reliability (*ICC* = 1.00, *CV* = 0.57%) of this system has been recently reported elsewhere (Lorenzetti, Lamparter, y Lüthy, 2017; Garnacho-Castaño, López-Lastra, y Maté-Muñoz, 2015). Mean propulsive velocity (MPV) was calculated as the average velocity measured only through the propulsive phase, defined as that portion of the concentric action during which the measured acceleration (a) is greater than acceleration due to gravity (g), i.e., a ≥ -9.81 m·s −2. The final braking phase, on the other hand, corresponds to the remaining part of the concentric action, during which a < g. Since the effect of friction force was negligible in pilot testing, it was not taken into account in the calculations. The constant downward force exerted by the cable (~5 N) was not taken into consideration since it was minimal compared to the weights being lifted.

In each testing session, the individual 1 RM strength was determined by means of progressive loading. The warm-up consisted of five minutes of stationary cycling at a self-selected easy pace and upper-body joint mobilization exercises, followed by two sets of five repetitions for each exercise with fixed loads of 20 and 40 kg. A description of the BP testing protocol starts and finishes positions in the PBP, subjects were instructed to lie prone and place their chin on the padded edge of a high bench. The pulling phase began with both elbows in full extension, while the barbell was grasped with hands shoulder-width apart or slightly wider (4–5 cm). Participants were instructed to pull with maximum effort until the barbell struck the underside of the bench, after which it was again lowered to the starting position, they were not allowed to use their legs to hold onto the bench. There was a distance of 8 cm between the underside of the bench and the subjects' chest. Subjects were required to always perform the concentric action of both exercises in an explosive manner, at maximal voluntary velocity. A momentary pause, which lasted approximately 1.5 s, was interposed between the eccentric and concentric phases of each exercise to minimize the contribution of the rebound effect, and allow for more reproducible, consistent measurements. Only the concentric actions (pushing for BP and pulling for PBP) were analyzed in the present study. Both exercises were performed on the same Smith machine (Multipower Fitness Line, Peroga, Murcia, Spain)

For both exercises, the initial load was set at 20 kg for all subjects and was progressively increased in increments of 10 kg until the attained mean propulsive velocity (MPV) was lower than 0.5 $m·s^{-1}$ and 0.7 $m·s^{-1}$ for BP and PBP respectively. Thereafter, the load was individually adjusted using smaller increments (i.e., 5 to 2.5 kg). The heaviest load that each subject could properly lift while completing the full range of motion and without any external help was considered to be his 1RM. In the PBP, the barbell was required to touch the underside of the bench at the end of the concentric pulling phase. Trained spotters were present when high loads were lifted to ensure safety. Three attempts were executed for light (< 50% RM), two for medium (50–80% RM), and only one for the heaviest (> 80 % RM) loads. Inter-set rest intervals were three minutes for the light and medium loads and five minutes for the heaviest loads. Only the best repetition at each load was considered for subsequent analysis. The 1RM was calculated from the MPV attained against the heaviest load (kg) lifted in the progressive loading test using the following equations (Sánchez-Medina et. al., 2014): BP load = $11.2988 \times MPV^2 - 78.05 \times MPV + 113.04$; PBP load = $13.2596 \times MPV^2 - 93.867 \times MPV + 144.38$.

Table 1. Traditional Periodization. Sessions 1 and 2

	Sets × repetitions (cadences)	Rest between sets (min)	Intensity
Bench press	3×10 (1, 1, 3)	1-2	70% of RM
Press down	3×10 (1, 1, 3)	1-2	70% of RM
Bench press with dumbbells	3×10 (1, 1, 3)	1-2	70% of RM
Bench press declined	3×10 (1, 1, 3)	1-2	70% of RM
Row	3×10 (1, 1, 3)	1-2	70% of RM
Pull-up	3×10 (1, 1, 3)	1-2	70% of RM
Chest pulley	3×10 (1, 1, 3)	1-2	70% of RM
Row with dumbbells	3×10 (1, 1, 3)	1-2	70% of RM

Table 2. Undulating Periodization. Session 1 and 2

Exercise	**Sets × repetitions (cadences)**		**Rest between sets (min)**		**Intensity**	
	Session 1	*Session 2*	*Session 1*	*Session 2*	*Session 1*	*Session 2*
Bench press	3×8 (2, 1, 2)	3×10 + fail (1, 1, 3)	1-4	1-2	90% of RM	70% + 50% of RM
Press down	3×10 (0, 0, 1)	3×10+ fail (1, 1, 3)	1-2	1-2	50% of RM	70% + 50% of RM
Bench press with dumbbells	3×12 (1, 1, 3)	3×10 + fail (1, 1, 3)	1-2	1-2	70% of RM	70% + 50% of RM
Bench press declined	3×12 (1, 1, 3)	3×10 + fail (1, 1, 3)	1-2	1-2	70% of RM	70% + 50% of RM
Row	3×8 (2, 1, 2)	3×10 + fail (1, 1, 3)	1-4	1-2	90% of RM	70% + 50% of RM
Pull-up	3×10 (1, 0, 1)	3×10 + fail (1, 1, 3)	1-2	1-2	50% of RM	70% + 50% of RM
Chest pulley	3×12 (1, 1, 3)	3×10 + fail (1, 1, 3)	1-2	1-2	70% of RM	70% + 50% of RM
Row with dumbbells	3×12 (1, 1, 3)	3×10 + fail (1, 1, 3)	1-2	1-2	70% of RM	70% + 50% of RM

Diet logs

Subjects were instructed to maintain their accustomed dietary habits throughout the course of the study. To verify compliance with this instruction, dietary habits were assessed on two occasions (2 and 8 weeks). An experienced instructor obtained dietary records from the subjects without warning. On all occasions, dietary logs were recorded for three consecutive days, including one weekend day. The three days dietary records were analyzed for total caloric intake and for carbohydrate, fat, and protein composition using commercially available computer software (DietSource 3.0; Novartis, Barcelona, Spain), following previous research with similar protocols (Gallon et al., 2017). The two groups demonstrated a substantial similarity in diet habits: ≈ 61% carbohydrates, ≈ 20% proteins, ≈ 19% lipids.

Training Procedure Protocol

The subjects had to perform two workouts per week, and in each session, they performed four chest and four back exercises. The subjects that belonged to the TP group completed a total volume of 48 sets per week, 24 for each muscle group, at 70% of the RM at a cadence (1, 1, 3) with a rest between sets from one to two minutes. The individual load-velocity and load-power output relationships as well as 1 RM strength were determined by means of a progressive loading during bench press and seated pulley (Table 1). Undulating Periodization group, the volume of sets was matched to the traditional periodization, but the two weekly sessions followed a different methodology (undulating per session), working at different power levels, maximum strength and hypertrophy with different intensities, cadences and rests within the same session (Table 2).

Statistical Analysis

Statistical analysis of data was performed with SPSS 25.0 for iOX (IBM, Chicago, IL). Subjects' physical characteristics are reported as means ± standard deviation. The normal distribution and homogeneity parameters were checked with Shapiro-Wilk and Levene tests, respectively. A two-way repeated measures ANOVAs with GROUP (UP vs TP) and TIME (pre- to post-test) as factors was performed to analyze the training related effects. When significant interactions of both factors (GROUP × TIME) were found, independent t tests were computed on the pre- to post-trial change scores *(Δ%).* The calculation of Δ % used the pre- to post-test differences divided by the pre-test values and then multiplied by 100 and was carried out for each subject. Significance was accepted when $p < 0.05$. Effect sizes and confidence limits were reported to observe changes in scores athlete. The magnitude of the within-group changes was interpreted by using values of trivial (< 0.20), small (0.20 – < 0.60) and moderate (0.60 – < 1.20). The probability that these differences actually exist was then assessed via magnitude-based qualitative inferences (Batterham, & Hopkins, 2006; Hopkins et al., 2009). Qualitative inferences were based on quantitative chances of benefit (Baker, Wilson, & Carlyon, 1994). Probabilities that differences were higher than, lower than, or similar to the smallest worthwhile difference were evaluated qualitatively as possibly, 25% to 75%; likely, 75% to 95%, very likely, 95% to 99.5%; and most (extremely) likely, >99.5 %.

Results

Mean ± *SD* values for al l RM and body composition parameters pre- and post-training intervention are shown in Table 3, 4 and 5. No significant differences in any of these characteristics were found between UP and TP at the beginning of exercise training. No significant differences were observed in training compliance between UP and TP (95.6 ± 2.3 vs. 94.6 ± 2.9%, respectively).

Both press and row repetition maximum were statistically higher in the post-test than in the pre-test for the UP and TP group. However, the ANOVA did not display a GROUP × TIME interaction. For fat body mass and lean body mass, the ANOVA did not display either a TIME effect or a GROUP × TIME interaction; instead, upper lean body mass was statistically higher in the post-test than in the pre-test for the UP group. There was no difference in the change in upper lean body mass between UP and TP.

Table 3. Traditional Periodization (n = 21): mean ± SD values for all 1RM parameters pre- and post-training intervention

	Pre	**Post**	**Post – Pre**			
	M* *(SD)	***M* *(SD)***	***p***	***%Δ* *(SD)***	***ES* *(90% CL)***	***Inference***
RM Bench Press (kg)	63.8 (16.8)	68.4 (15.3)	0.005	8.53 (12.48)	*0.26 (0.16)*	***Small****
RM Prone Bench Pull (kg)	74.6 (21.4)	92.6 (27.8)	<0.0001	25.32 (20.98)	*0.81 (0.26)*	***Moderate*******
Fat body mass (g)	14024.7 (7934.3)	14800.6 (8037.7)	0.419	6.49 (11.85)	*0.09 (0.07)*	***Trivial******
Lean body mass (g)	60748.4 (7133.2)	61071.9 (7542.4)	0.896	0.54 (4.33)	*0.04 (0.14)*	***Trivial******
Upper lean body mass (g)	24046.8 (3151.0)	24491.6 (3423.4)	0.104	1.80 (3.82)	*0.14 (0.27)*	***Trivial******

Values are mean ± standard deviation, percent change ± standard deviation and standardized effect size; ±90% confidence limits. Abbreviations: *n*, sample size; *M*, mean; *SD*, standard deviation, %Δ, percent change; *ES*, effect size; 90% *CL*, 90% confidence limits; RM, repetition maximum. Qualitative inferences are *trivial* (< 0.20), *small* (0.20 – < 0.60) and *moderate* (0.60 – < 1.20): * possibly, 25 – < 75; ** likely, 75 – < 95%; *** very likely, 95 – < 99.5; **** most likely, > 99.5. Positive, neutral and negative descriptors qualitatively describe the change between post and pre values and its importance relative to the specific variable.

Table 4. Undulating Periodization (n = 20): mean ± SD values for all 1RM parameters pre- and post-training intervention

	Pre	**Post**	**Post – Pre**			
	M	***M***	***p***	***%Δ***	***ES***	***Inference***
	(SD)	***(SD)***		***(SD)***	***(90% CL)***	
RM Bench Press (kg)	62.1	67.8	0.001	10.23	*0.27*	***Small*****
	(20.1)	(21.8)		(11.34)	*(0.11)*	
RM Prone Bench Pull (kg)	71.6	86.9	<0.0001	21.22	*0.68*	***Moderate*******
	(21.8)	(29.8)		(18.17)	*(0.23)*	
Fat body mass (g)	13883.2	13728.3	0.357	-2.12	*0.02*	***Trivial*******
	(8111.5)	(8373.4)		(9.86)	*(0.06)*	
Lean body mass (g)	57069.2	57392.4	0.130	0.53	*0.04;*	***Trivial*******
	(8397.9)	(8293.1)		(2.29)	*(0.06)*	
Upper lean body mass (g)	22069.0	22718.5	0.017	3.14	*0.16*	***Trivial******
	(3423.4)	(3933.6)		(5.85)	*(0.32)*	

Values are mean ± standard deviation, percent change ± standard deviation and standardized effect size; ±90% confidence limits. Abbreviations: *n*, sample size; *M*, mean; *SD*, standard deviation, %Δ, percent change; *ES*, effect size; 90% *CL*, 90% confidence limits; RM, repetition maximum. Qualitative inferences are *trivial* (< 0.20), *small* (0.20 – < 0.60) and *moderate* (0.60 – < 1.20): * possibly, 25 – < 75; ** likely, 75 – < 95%; *** very likely, 95 – < 99.5; **** most likely, > 99.5. Positive, neutral and negative descriptors qualitatively describe the change between post and pre values and its importance relative to the specific variable.

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Table 5. Post#Pre change. Traditional and Undulating Periodization

			ES (90% CL)	Inference
RM Bench Press (kg)			0.04 (0.65)	Trivial*
RM Prone Bench Pull (kg)			0.20 (0.57)	Small*
Fat body mass (g)			0.14 (0.65)	Trivial*
Lean body mass (g)			0.56 (0.61)	Small**
Upper lean body mass (g)			0.35 (0.53)	Small**

Values are mean ± standard deviation, percent change ± standard deviation and standardized effect size; ±90% confidence limits. Abbreviations: *ES*, effect size; 90% CL, 90% confidence limits; RM, repetition maximum. Qualitative inferences are *trivial* (< 0.20), *small* (0.20 – < 0.60) and *moderate* (0.60 – < 1.20): * possibly, 25 – < 75; ** likely, 75 – < 95%; *** very likely, 95 – < 99.5; **** most likely, > 99.5. Positive, neutral and negative descriptors qualitatively describe the change between post and pre values and its importance relative to the specific variable.

Discussion

The aim of the present study was to analyse two type of training periodization programming (traditional vs. undulating periodization) to know which is the most effective for the improvement of strength and body composition in untrained young men. The findings indicated that eight-weeks of TP or UP improve upper body strength, and upper lean body mass only with TP. However, in the absence of statistically significant differences between groups, it is not possible to determine which training periodization produces greater adaptations.

Nevertheless, Baker et al. (1994), unlike what is shown in the present study were the first to compare strength between a linear and a nonlinear periodization model and concluded that an undulating model was more effective. Along the same line Rhea et al. (2002) compared a twelve-week

protocol the greatest increases in strength levels were achieved with the nonlinear protocol. Another similar study was conducted by Simao et al. (2012), concluded that in both programs there were gains in the two parameters evaluated, although better results were obtained in nonlinear programming. The variety of stimuli performed in the undulation may also favor physiological adaptations, through supercompensation. Another priority would be flexibility when applying the training load, as the stimulus varies at each moment.

Thereby, previous studies (Painter et al., 2012; Solberg et al., 2015) affirmed that there were no significant differences between the two models of periodization. Within the nonlinear models, no differences in force between a daily undulating model and a weekly one has been observed. The studies that evaluated hypertrophy using corporal values did not show any significant difference to be able to affirm that one type of periodization is more efficient than another. This corroborates with our results found in which the two types of periodization are effective. However, the studies analyzed had measured strength using the traditional RM method and for body composition anthropometry techniques were used. In the present study body composition was measured with DEXA and strength was obtained measuring the speed of execution.

In this sense, within the parameters of strength and body composition in advanced practitioners, found no significant differences in body composition or strength increases across neither of the three protocols (daily undulating, weekly undulating or a linear method) Buford et al. (2007). Although more studies would be needed to verify which type of periodization is more effective for advanced participants. On the other hand, Hoffman et al. (2003) showed better results in the traditional model compared with the undulating model. However, they compared the same group over two periods of time, meaning that improvements in the classical model could be attributed to an adaptation during the first period (first year, first season) which followed a linear model, and the second year the same group followed an undulating model. In our study there is a slight inclination towards the traditional periodization, but unlike the work of Hoffman et al. (2003), the comparison was made with two different groups which both trained and were measured in the same conditions.

Equalizing the volume for both linear periodization training and nonlinear training is very relevant, since this has not been done with all the studies found, meaning that some of the non-significant differences could be related to the amount of volume in one model or another. Another characteristic of the studies found is that those who correlate a linear model with greater effectiveness in training have the peculiarity that their participants are physically active, and the vast majority follow a specific strength training plan.

It should also be noted that not all studies used the same evaluation technique to measure body values, some were measured by skin folds, others by circumference, others by bioelectrical impedance and some even by ultrasound. Body values depend on more factors besides training, as in the case of hypertrophy, which also depends on other variables such as eating habits or sleep. In the present study, dietary indications were given so that the sample was the most homogenous as possible in that aspect.

As demonstrated, both periodization methods are able to obtain significant gains in strength and improvement of body composition. Obviously, the two compared models obtain greater effectiveness than a non-periodized model (Fleck, 2011). However, it can be said that both periodization models increased equally in the different variables such as strength and body composition. In general terms, there are no significant differences between using a linear or a nonlinear periodization. For practical purposes, it would be interesting to analyses which of the two causes less injury or greater motivation, since these two factors can influence the adherence to strength programs.

Conclusions

An important finding in this study was that for untrained subjects, the benefits will always be positive regardless of the type of periodization used, which is important for this population so that training organization does not cause physical problems or demotivation. In trained subjects, where adherence is already established, the most frequent problem is the stagnation of adaptations or an increase in injuries, for which, planning considering either models makes training more efficient. The undulating model may have an advantage over the linear model regarding the upper lean body mass, although there were no statistically significant differences between groups. This kind of periodization works with different load and volume ranges making the training less boring which may influence on the results of the training.

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