Original article

Split versus full-body strength training workouts in untrained people. A randomised study

Pablo Prieto González[1], Eneko Larumbe Zabala[2], Mehdi Ben Brahim[1]

[1]Prince Sultan University, Arabia Saudí. [2]Texas Tech University Health Sciences Center. Lubbock, Texas, USA.

Received: 07/11/2018
Accepted: 29/04/2019

Summary

Introduction: There are numerous scientific studies in which the components of resistance training load have been analyzed, as well as many variables that condition the development of muscular strength. However, only a few studies compared the effectiveness of full body workouts and split body routines. The purpose of the present investigation was to determine which of them is more effective in increasing both muscular strength levels and kinanthropometric parameters.

Methods: 28 male university students without previous experience in strength training were finally included in the present study. They were randomly assigned to two different training groups: Full body workout group (GECC) and split body routine group (GERD). Intra- and inter-group differences in percentage changes (pre-post) were assessed using non-parametric tests.

Results: After the completion of an 8-week intervention period, significant improvements in body fat percentage (p = 0.028), levels of muscular strength on the upper body (p=0.008) and on the lower body (p=0.043) were observed in the GECC. Similarly, significant improvements in body fat percentage (p=0.006), lean body mass (p=0.011) and upper body (p=0.031) and lower body levels of muscular strength (p=0.048) were reported in the GERD. However, no significant differences between groups were found neither in the strength tests performed, nor in the Kineanthropometric parameters evaluated.

Conclusion: Both split and full body routines are useful to improve strength levels and kinanthropometric parameters in college students with no previous experience in strength training. However, neither of the two structures is significantly more effective than the other one when it comes to improving the above-mentioned parameters.

Key words:
Training. Strength. Split body routine. Full body workout.

Entrenamiento de fuerza mediante rutinas divididas versus rutinas de cuerpo completo en personas desentrenadas. Un estudio aleatorizado

Resumen

Introducción: Existen numerosas investigaciones científicas en las que se han analizado los componentes de la carga del entrenamiento de fuerza, y las numerosas variables que condicionan el desarrollo de esta capacidad. En cambio, son pocos los estudios en los que se ha contrastado la eficacia de los entrenamientos de cuerpo completo frente a las rutinas divididas. El objetivo del presente estudio fue determinar cuál de los dos es más eficaz a la hora de mejorar los parámetros de fuerza y cineantropométricos.

Material y métodos: 28 estudiantes universitarios de sexo masculino sin experiencia previa en el entrenamiento de fuerza fueron finalmente incluidos en este estudio y asignados aleatoriamente a dos grupos de entrenamiento de fuerza diferentes: Entrenamiento de cuerpo completo (GECC) y entrenamiento con rutina dividida (GERD). Se compararon los porcentajes de cambio (pre-post) intra e intergrupo mediante pruebas no paramétricas.

Resultados: Finalizada la intervención de ocho semanas, el GECC mejoró de forma significativa el porcentaje de grasa (p=0,028), y la fuerza en el tren superior (p=0,008), e inferior (p=0,043). En el GERD se produjeron mejoras significativas en el porcentaje de grasa (p=0,006), en el tejido magro (p=0,011), y en la fuerza en el tren superior (p=0,031), e inferior (p=0,048). Sin embargo, no existieron diferencias significativas entre ambos grupos en ninguna de las mejoras alcanzadas en los parámetros de fuerza y cineantropométricos evaluados.

Conclusión: Tanto las rutinas divididas como las de cuerpo completo permiten mejorar los niveles de fuerza y los parámetros cineantropométricos en estudiantes universitarios sin experiencia previa en el entrenamiento de fuerza. Sin embargo, ninguna de las dos estructuras de entrenamiento es significativamente más eficaz que la otra a la hora de mejorar los mencionados parámetros.

Palabras clave:
Entrenamiento. Fuerza. Rutina dividida. Rutina de cuerpo completo.

Correspondence: Pablo Prieto González
E-mail: pabloccjb@gmail.com

Introduction

Strength training is very important in the field of physical activity. In elite sport, increases in strength have a positive impact on the performance of athletes by improving their motor skills. They also reduce the risk of injury[1]. At a recreational and functional level, strength training helps improve the health and quality of life, while decreasing the risk of certain diseases and medical conditions[2-4]. Such benefits have been verified by numerous studies, which have also established the proper dose of strength training each population group needs in order to achieve adaptations which result in improved athletic performance or, where applicable, health[5].

Adequate handling of the components of the training load and appropriate management of certain variables (contraction regime, selection and order of exercises, speed of execution and weekly training frequency) determine the strength adaptations which each subject can achieve. There is a considerable degree of consensus regarding these parameters in the scientific literature[6,7]. This makes it possible to prescribe effective training programmes.

That said, there is one relevant aspect on which consensus is yet to be reached[8] and that is the structuring of the sessions themselves. This point, which has not been researched in any depth, conditions variables such as the number of exercises per muscle group performed in each session, the number of weekly sessions that stimulate a particular muscle group and the recovery time for each muscle group between one training session and the next.

Kraemer & Ratamess[9] and Heredia *et al*[10] inform us that there are three ways of structuring strength training sessions:

- *Full-body workouts:* exercises which stimulate the body's main muscle groups in the same training session. Normally, one exercise is carried out for each major muscle group.
- *Upper-/lower-body split workouts:* the muscles of the upper body are stimulated in one session and those of the lower body in the next.
- *Muscle-group split workouts:* exercises aimed at strengthening specific muscle groups are performed in each session.

Bodybuilders, and generally those seeking a certain degree of hypertrophy, tend to use split workouts. Fitness enthusiasts, athletes and weightlifters prefer workouts which address the entire body[11].

Various studies have demonstrated that both split and full-body routines are effective at improving strength levels. It has not, however, been established which of these is most useful in achieving certain adjustments. Choosing a specific training structure often responds to such factors as the personal objectives of each subject, the number of weekly training sessions devoted to strength training, the length of those sessions and personal preferences[10]. Within this context, the purpose of this study was to verify which of the two ways of structuring strength training workouts was more effective at improving strength levels and kinanthropometric parameters, full-body workouts or split workouts.

Materials and methods

Participants

The initial sample consisted of 39 subjects, all male. They belonged to Prince Sultan University in Riyadh (Saudi Arabia) and were enrolled in the "Beginner Weight Training" module. This meant that it was possible to fully monitor the intervention process, which was carried out in the fitness room at the university. 11 subjects were excluded from the research for failing to keep to the training programme, because they did not complete 85% of the sessions. The final sample, therefore, consisted of 28 subjects. None of them did physical activity in a structured manner and they had no previous experience of strength training. Neither did they have any injuries or diseases which would prevent them from carrying out the tests and activities involved normally. Participation in the study was voluntary and all the subjects were suitably informed of the benefits and risks of taking part. The research project observed the ethical principles of the Declaration of Helsinki and was approved by the Institutional Review Board of the Committee for Bioethics at Prince Sultan University.

Kinanthropometric measurements

A Seca digital column scale (Hamburg, Germany) was used to measure weight, height and BMI. The weight was recorded to the nearest 0.1 kg and height to an accuracy of 0.1 cm. The measurements were taken by the same researcher with the subjects barefoot. The body fat percentage was obtained using the following equation12: % fat = [(Σ of the abdominal, suprailiac, subscapular, triceps, quadriceps and medial calf folds) x 0.143] + 4.56. The caliper used to measure the folds of fat was an FG1056 Harpenden Skinfold Caliper (Sussex, UK). Lean mass was calculated with the following formula: lean mass = total mass (kg) - fat mass (kg).

Measuring strength

Before carrying out the tests, the participants in the study did the following warm-up:

Stage I: Activation: Five minutes of aerobic exercise.

Stage II: Joint muscle mobility: Mobilisation of the main joints in cephalocaudal order.

Stage III: Specific warm-up. A series of five repetitions of the following exercises at 50% estimated 1RM: Squat, bench press, hand grips.

Then the following tests were performed:

Lower-body strength: Lower-body strength was measured using a Takei Strength dynamometer T.K.K. 5402 Back D (Japan). The protocol was as follows: the participants placed their feet on the platform with their knees slightly bent (130º-140º). The bar was held with a backhand grip on the right hand and a forehand grip on the left hand. In this position, keeping the back straight, the subjects tried to straighten their knees, applying as much force as possible. Each subject had two tries13.

Bench press: As the study participants had no previous experience in strength training, 1RM was measured indirectly using the Epley formula[14,15]: 1RM = Weight lifted in the test x [1+ (0.003 x No. of repetitions to failure)]. This test was used to measure upper body strength. The muscles involved in this exercise are the pectoralis major (agonist) and the anterior fascicle of the deltoid and elbow extensors (which act as synergists). The test was performed using 80% of the estimated 1RM for each subject, using a Hammer Strength bench, an Olympic bar and Olympic plates. The participants adopted a supine position on the bench with head and hips neutral. The bar was held across the shoulders. The participants were told that they had to do as many repetitions as possible with a full range of motion, i.e. starting with the elbows fully stretched, they had to lower the bar until it made contact with the chest and then lift it back to the starting position. Each subject had one try and only repetitions performed correctly were recorded[16,17].

Hand-grip strength (kg): Hand strength or grip was measured using a Takei Grip Strength Dynamometer T.K.K. 5401 Grip-D (Japan). The measuring protocol was as follows: the participants, in standing position and with arms outstretched along the body, held the dynamometer with their dominant hand in such a way that the screen was visible to the researcher at all times. They were then told to apply the greatest force they could trying to grip their thumb and the rest of their fingers together without moving their arm. The score obtained was recorded to an accuracy of 0.1 kg. Each subject had two tries[13].

Intervention and design

A randomised test was conducted to compare the changes between before (pre) and after (post) the two conditions: full-body workout (FBW group) and split workout (SW group). Before starting the procedure, the subjects were asked not to alter their diets during the study. Over the two weeks prior to application of the intervention design, all the participants did identical strength training twice a week to familiarise them with the exercises (Table 1). They were then randomly assigned to one of the two experimental groups: FBW group [n = 12; age = 21.17 (1.70)] and SW group [n = 16; age = 21.12 (1.36)]. The eight-week intervention period, in which the participants did strength training workouts twice a week, then began (Table 1). The training sessions were conducted each week between 9:30 a.m. and 10:30 a.m. on Monday and Wednesday.

During the intervention, the training methods used and the weekly training load were identical for both groups. On Monday, however, the SW group only performed exercises to stimulate the muscles of the upper body and on Wednesday they did exercises to strengthen the upper body, while the FBW group did full-body workouts in all the sessions over the period. The strength exercises carried out by both groups were the same each week (Table 1). The training intensity was increased every two weeks to prevent stagnation.

The training programme used was designed and supervised by a sports training specialist. The recommendations of the American College of Sports Medicine for beginner strength training was followed. In short, three sets of between 6 and 12 repetitions were completed per exercise with a rest lasting from 60 seconds to two minutes. Free-weight exercises and exercises with weight machines were included. In each workout, the exercises to strengthen the larger muscle groups preceded those for the smaller muscle groups and the multi-joint exercises preceded the single-joint ones[18].

Table 1. Training methods and strength exercises used with the FBW group and SW group during the familiarisation and intervention periods.

	Training methods used by the two groups (FBW and SW)	Strength exercises used by the FBW group	Strength exercises used by the SW group
Familiarisation period	I: 56%; S: 3; Rep: 14: R: 1'; EL: Two repetitions not done.	Vertical press, seated cable row, ab crunch on machine, back extension on machine, leg extension on machine, seated leg curl, seated calf raise on machine, shoulder press	Vertical press, seated cable row, ab crunch on machine, back extension on machine, leg extension on machine, seated leg curl, seated calf raise on machine, shoulder pres
Intervention period: 1st and 2nd weeks	I: 62%; S: 3; Rep: 12: R: 1'; EL: Maximum number of repetitions possible per set	*Monday:* Bench press, behind the neck jerk, seated cable row, dumbbell fly, reverse fly, dumbbell side lateral raise, triceps extension with pulley, triceps kickbacks, dumbbell curl, Scott bench biceps curl. *Wednesday:* Leg press, quadriceps extension on machine, seated leg curl, lying leg curl, ab crunch with machine, pelvic lift, back extension on machine, back extension on roman chair, seated calf raise on machine, standing calf raise on machine.	*Monday:* Bench press, seated cable row, quadriceps extension on machine, seated leg curl, ab crunch with machine, back extension on machine, seated calf raise on machine, dumbbell side lateral raise, triceps extension with pulley, dumbbell curl. *Wednesday:* Leg press, behind the neck jerk, lying leg curl, dumbbell fly, pelvic lift, back extension on roman chair, standing calf raise on machine, reverse fly, triceps kickbacks, Scott bench biceps curl.
Intervention period: 3rd and 4th weeks	I: 62%-67%-72%; S: 3; Rep: 12-10-8; R: 1'30"; EL: Maximum number of repetitions possible per set		
Intervention period: 5th and 6th weeks	I: 72%; S: 3; Rep: 8: R: 2'; EL: Maximum number of repetitions possible per set		
Intervention period: 7th and 8th weeks	I: 78%-72%-78%; S: 3; Rep: 6-8-8; R: 2'; EL: Maximum number of repetitions possible per set		

I: Intensity; S: Sets; Rep: Repetitions; R: Rest; EL: Exertion levelperiod.

Statistical analysis

The data are presented with calculation of the arithmetic mean and standard deviation for all the variables. The distributions of the data were checked using the Shapiro-Francia test and the D'Agostino K-squared test. Since the groups were of different sizes and some variables showed irregular variances and non-normal distributions, non-parametric tests were used. The intragroup differences between pre-test and post-test were calculated using the Wilcoxon signed-rank test for related samples. In order to estimate a measurement of the practical effect adjusted by the previous values for each subject, the percentage changes were calculated between pre-test and post-test using the formula: 100 (post-test – pre-test) / pre-test. 95% confidence intervals (CI) were calculated for the percentage changes and those which did not cross zero were considered statistically significant. The percentage changes seen in the two groups were then compared using the Wilcoxon-Mann-Whitney test. The significance level was set at 0.05. All the calculations were made using Stata 13.1 (Stata Corp, College Station, Texas, USA).

Results

As can be seen in Table 2, the FBW group saw a reduction in body fat percentage (p = 0.028), indicating a loss of 5.07% (95% CI = 0.19 to 9.95). Looking at the strength variables, a statistically significant increase was observed in this group in the bench press exercise (p=0.008), representing an average improvement of 23.9% (95% CI = 5.29 to 42.52). Although significant differences were also observed in lower-body strength between pre-test and post-test (p = 0.043), the effect size exhibited great variability and did not confirm improvement in relative values: 24.34% (95% CI = -3.51 to 52.19). Significant differences were not observed in this group for the other variables analysed.

The SW group, however, not only experienced a slightly higher reduction in body fat percentage (p = 0.006), indicating a loss of 6.76% (95% CI = 2.75 to 10.77), it also saw a significant increase in lean body mass (p = 0.011), with a percentage change of 1.94% (95% CI = 0.68 to 3.21). Looking at the strength variables, there were also significant differences between pre-test and post-test in the SW group both on the bench press (p = 0.031) and with the back dynamometer (p = 0.048). The improvement seen on the bench press was 9.22% (95% CI = 1.41 to 17.04) and on the back dynamometer it was 23.33% (95% CI = -3.85 to 50.5). As with the FBW group, no significant differences were observed in the SW group on the other tests performed.

As for intergroup differences, no statistically significant differences were found in the relative improvements achieved by each group for any of the variables analysed and the effect sizes were also seen to be small (Table 2).

Discussion

The results verify that the two training structures lead to improvements in strength levels and body composition. Both the FBW group and the SW group significantly improved their performance on the back dynamometer and the bench press. They did not, however, achieve any significant improvement on the hand grip dynamometer. We understand that this responds to the specificity of training principle, since the intervention process did not involve any exercises to strengthen the forearm muscles (Table 1). As for kinanthropometric variables, only the SW group showed significant increases in its lean mass percentage. The body fat percentage of both groups, however, fell significantly. The results of this study, therefore, are consistent with previous research in

Table 2. Comparison of results between the FBW group and SW group

	FBW group (n=12)				SW group (n=16)				p	d
	Pre	Post	p	% [CI 95%]	Pre	Post	p	% [CI 95%]		
Height (cm)	176.6 (4.6)	176.6 (4.6)	–	–	178 (6.7)	178 (6.7)	–	–	–	–
Weight (kg)	80.1 (24.1)	79.6 (23.1)	0.340	-0.23 [-1.67, 1.2]	82.6 (27.6)	82.9 (27.9)	0.283	0.29 [-0.51, 1.1]	0.378	-0.31
BMI (kg/m2)	25.7 (7.3)	25.6 (6.9)	0.705	0.15 [-1.52, 1.81]	25.9 (7.9)	26 (8)	0.278	0.31 [-0.46, 1.08]	0.642	-0.17
Lean mass (kg)	63.6 (12.8)	64.5 (13)	0.103	1.42 [-0.12, 2.96]	65.3 (14.8)	66.8 (16.2)	0.011	1.94 [0.68, 3.21]	0.781	-0.10
Fat (%)	18.6 (7.6)	17.4 (6.5)	0.028	-5.07 [-9.95, -0.19]	18.6 (8)	17.3 (7.5)	0.006	-6.76 [-10.77, -2.75]	0.403	0.34
Hand-grip strength (kg)	39.2 (7.5)	40.4 (8.4)	0.519	3.91 [-7.14, 14.97]	37.4 (9.5)	38.2 (7.3)	0.522	6.85 [-7.34, 21.03]	0.889	0.05
Lower-body strength (kg)	108.6 (26.8)	130.2 (36.2)	0.043	24.34 [-3.51, 52.19]	109 (35.8)	124.4 (31.5)	0.048	23.33 [-3.85, 50.5]	0.889	0.05
Bench press (kg)	51.6 (16.1)	61.2 (14.1)	0.008	23.9 [5.29, 42.52]	59.5 (26.9)	63.7 (24.8)	0.031	9.22 [1.41, 17.04]	0.242	0.51

The pre- and post-test data show the mean (standard deviation). The pre- and post-test percentage changes are presented with a confidence interval of 95%

which strength training led to improvements in body composition, both in subjects with experience in strength training[19] and the untrained[20].

Meanwhile, no significant differences were observed between the two groups in either the kinanthropometric parameters analysed or the strength tests carried out. As for strength levels, these results are consistent with those obtained in the research conducted by Calder *et al*.[21] with young women and Campbell *et al.*[22] with older people. In both studies, the subjects had no previous experience in strength training and it was possible to verify that the two types of workout led to similar increases in strength. Schoenfeld *et al*.[23], in a study conducted with university students with previous experience in strength workouts, also found that the two ways of structuring training sessions led to similar improvements in strength levels. They also noted that full-body workouts were more effective than split workouts in increasing muscle mass. In our study, however, the split workout resulted in a greater increase of lean tissue, although it is also true that the body fat percentages of both the FBW and SW groups fell significantly. This discrepancy should be analysed in subsequent research.

Be that as it may, according to the results of the present study and the three studies which analysed the subject before it[21-23], it can be argued that neither of the two ways of organising strength training sessions is clearly better than the other, irrespective of the subjects' age, sex or level of physical activity. We understand that this is because both types of workout have pros and cons. The advantages of split workouts are[21]: a) the training sessions do not have to be too long; b) the fatigue accumulated from the earlier exercises in the session does not prevent the exercises at the end of it from being carried out at the desired intensity; c) they result in greater muscle stress, because the number of sets per muscle group in each workout is high, in turn increasing acute hormonal secretions, cellular inflammation and muscle ischemia; d) they are less fatiguing. By contrast, the advantages of full-body routines are: a) they allow you to work each muscle group at least twice a week, leading to greater strength gains through hypertrophy[24]; b) the release of anabolic hormones is directly related to the amount of muscles used in workouts[25,26].

Certain factors which condition the suitability of each type of workout do, however, need to be borne in mind: individuals who wish to do more than three strength training sessions a week should not do full-body workouts. This is because the recovery time between moderate-intensity training sessions should be no less than 48 hours and at least 72 hours for intense workouts[27,10]. Nor is it advisable to do a very high number of exercises or sets per session, since it has been shown that shorter strength workouts are more effective in improving levels of hypertrophy and obtaining neuromuscular adaptations[28]. The main advantage of full-body workouts is that they are more suitable if you want to combine strength training with other physical ability or motor skill training. Dedicating fewer days per week to building strength means that other training stimuli can be applied on the recovery days[21]. Conversely, with split workouts, the subjects or athletes can do more than three strength training sessions per week because just a small number of muscle groups are stimulated in each session. The importance of respecting the functional unit training principle, however, need also be remembered[29]. This means that the number of muscle groups working in each training session should not be too limited because human beings are made up of a set of interrelated systems that work together in synchronisation.

Regarding the limitations of the study, it would have been desirable to conduct the research with three experimental groups instead of two, with one group doing full-body workouts, another doing upper/lower-body split workouts and the third doing split workouts based on muscle groups. However, this was not possible because workout splits focusing on muscle groups best involve people with some degree of experience in strength training and this was not the case with the subjects who were recruited to take part in this study. Moreover, their schedules meant that it was not possible for them to do three sessions per week.

Conclusion

Both split workout and full-body workouts over an eight-week period are useful for improving strength levels in university students without previous experience of strength training. Both types of workout help reduce the body fat percentage, the split system being more effective for increasing lean tissue. Neither of the approaches, however, is significantly more effective than the other when it comes to increasing strength levels or improving kinanthropometric parameters. .

Conflict of interest

The authors declare that they are not subject to any type of conflict of interest.

Bibliography

1. Suchomel TJ, Nimphius S, Bellon CR, Stone MH. The importance of muscular strength: training considerations. *Sport Med*. 2018;48:765-85.
2. Silva NL, Oliveira RB, Fleck SJ, Leon AC, Farinatti P. Influence of strength training variables on strength gains in adults over 55 years-old: a meta-analysis of dose-response relationships. *J Sci Med Sport*. 2014;17:337-44.
3. Kraschnewski JL, Sciamanna CN, Pogera JM, Rovniak LS, Lehman EB, Cooper AB, *et al.* Is strength training associated with mortality benefits? A 15 year cohort study of US older adults. *Prev Med.* 2016;87:121-7.
4. Ambrose KR, Golightly YM. Physical exercise as non-pharmacological treatment of chronic pain: Why and when. *Best Pract Res Clin Rheumatol.* 2015;29:120-30.
5. Fisher J, Steele J, Bruce-Low S, Smith D. Evidence-based resistance training recommendations. *Med Sport*. 2011;15:147-62.
6. Ratamess N, Alvar BA, Evetoch TK, Housh TJ, Kibler WB, Kraemer WJ. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc.* 2009;41:687-708.
7. Schoenfeld BJ. The mechanisms of muscle hypertrophy and their application to resistance training. *J Strength Cond Res.* 2010;24:2857-72.
8. Fleck SJ. Periodized strength training: a critical review. *J. Strength Cond. Res.* 1999;13:82-9.
9. Heredia JR, Chulvi Medrano I, Isidro Donate F, Soro J, Costa MR. Determinación de la carga de entrenamiento para la mejora de la fuerza orientada a la salud (Fitness muscular). *PubliCE Standard.* 2007;21:17.
10. Kraemer WJ, Ratamess NA. Fundamentals of resistance training: progression and exercise prescription. *Med Sci Sports Exerc.* 2004;36:674-88.

11. Fleck SJ, Kraemer WJ. Designing resistance training programs. 4th Edition. Champaign. *Human Kinetics;* 2014. p. 225.
12. González Gallego J, Sánchez Collado P, Mataix Verdú J. *Nutrición en el deporte y ayudas ergogénicas y dopaje.* Madrid. Editorial Díaz de Santos; 2006. p. 273.
13. Santana Pérez FJ, de Burgos Carmona M, Fernández Rodríguez EF. Efecto del método Pilates sobre la flexibilidad y la fuerza y resistencia muscular. *EFDeportes.com*, Revista Digital. 2010;148.
14. Cummings B, Finn KJ. Estimation of a one repetition maximum bench press for untrained women. *J. Strength Cond. Res*. 1998;12:262-5.
15. Ware JS, Clemens CT, Mayhew JL, Johnston TJ. Muscular endurance repetitions to predict bench press and squat strength in college football players. *J. Strength Cond. Res.* 1995;9:99-103.
16. Chulvi Medrano I, Díaz Cantalejo A. Eficacia y seguridad del press de banca. Revisión. *Rev int med cienc act fís deporte*. 2008;32:338-52.
17. Travis TN, Brown V, Caulfield S, Doscher M, McHenry P, Statler T, *et al.* NSCA Strength and conditioning professional standards and guidelines. *Strength Cond J.* 2017;39:1-24.
18. American College of Sports Medicine. American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc.* 2009;41:687-708.
19. Orquín Castrillón FJ, Torres-Luque G, Poncede León F. Efectos de un programa de entrenamiento de fuerza sobre la composición corporal y la fuerza máxima en jóvenes entrenados. *Apunts. Medicina de l'Esport.* 2009;44:156-62
20. Lee H, Kim IG, Sung C, Kim JS. The Effect of 12-Week Resistance Training on muscular strength and body composition in untrained young women: Implications of exercise frequency. *J Exerc Physiol Online*. 2017;20:88-95.
21. Calder AW, Chilibeck PD, Webber CE, Sale DG. Comparison of whole and split weight training routines in young women. *Can J Appl Physiol.* 1994;19;185-99.
22. Campbell WW, Trappe TA, Jozsi AC, Kruskall LJ, Wolfe RR, Evans WJ. Dietary protein adequacy and lower body versus whole body resistive training in older humans. *J Physiol*. 2002;542:631-42.
23. Schoenfeld BJ, Ratamess NA, Peterson MD, Contreras B, Tiryaki-Sonmez G. Influence of resistance training frequency on muscular adaptations in well-trained Men. *J Strength Cond Res.* 2015;29:1821-9.
24. Schoenfeld BJ, Ogborn D, Krieger JW. Effects of resistance training frequency on measures of muscle hypertrophy: A systematic review and meta-analysis. *Sports Med.* 2016;46:1689-97.
25. Kraemer WJ. Endocrine responses to resistance exercise. *Med Sci Sports Exerc*. 1988;20:152-7.
26. Kraemer WJ, Ratamess NA. Hormonal responses and adaptations to resistance exercise and training. *Sports Med.* 2005;35:339-61.
27. McLester JR, Bishop PA, Smith J, Wyers L, Dale B, Kozusko J, *et al*. A series of studies-a practical protocol for testing muscular endurance recovery. *J Strength Cond Res.* 2003;17:259-73.
28. Häkkinen K, Kallinen M. Distribution of strength training volume into one or two daily sessions and neuromuscular adaptations in female athletes. *Electromyogr Clin Neurophysiol.* 1994;34:117-24.
29. Granell JC, Cervera VR. *Teoría y planificación del entrenamiento deportivo*. Badalona. Paidotribo; 2006. p. 16