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REVIEW

Should resistance training programs aimed at muscular hypertrophy be periodized? A systematic review of periodized versus non-periodized approaches

Les entraînements en résistance pour hypertrophier le muscle doivent-ils être fractionnés ? Une revue systématique des approches fractionnées versus non fractionnées

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KEYWORDS
Cross-sectional area;
Growth;
Skeletal muscle

Summary
Objectives. — Our goal was to systematically review the current literature and interpret the findings regarding the effects of periodized (PER) versus non-periodized (NP) resistance training programs aimed at muscular hypertrophy.
News. — Controversy exists as to whether a (PER) approach to resistance training is superior to a (NP) approach for maximizing muscular hypertrophy, or vice-versa, or if no differences exist between the approaches.
Prospect and projects. — Following a search of the PubMed/MEDLINE, Scopus, and Web of Science electronic databases, 12 studies comprising a total of 31 treatment groups met pre-determined inclusion criteria.
Conclusion. — Based on the results of our review, we conclude that similar hypertrophic effects may be achieved using either a PER or a NP approach. Importantly, the findings are specific to short-term training interventions, as the average duration of programs across studies amounted

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to ~15 weeks; and to untrained individuals, as only two studies involved resistance-trained participants. A limitation of the reviewed literature also pertains to the small number of studies ($n = 3$) using direct measures of hypertrophy (i.e., magnetic resonance imaging or ultrasound). Further research is needed to fill in the gaps in the current literature.

MOTS CLÉS
Section transversale du muscle ;
Croissance ;
Muscle squelettique

Résumé Notre objectif était de réaliser une revue systématique de la littérature actuelle et d'interpréter les résultats concernant les effets hypertrophiants musculaires des entraînements en résistance fractionnés (FR) versus non-fractionnés (NF). En effet, il existe une controverse quant à savoir si une approche (FR) des entraînements en résistance est supérieure à une approche (NF) pour maximiser l'hypertrophie musculaire ou vice versa ou si aucune différence n'existe entre les approches.

Méthodologie. — À la suite d'une recherche dans les bases de données électroniques PubMed/MEDLINE, Scopus et Web of Science, 12 études comprenant 31 groupes de traitement répondent à des critères d'inclusion prédéterminés.

Résultats. — Sur la base de l'analyse de ces études, nous concluons que des effets hypertrophiques similaires peuvent être atteints en utilisant une approche FR ou NF. Il faut noter que ces résultats ne concernent que des entraînements à court terme (la durée moyenne des programmes étant d'environ 15 semaines) et des sujets préalablement non entraînés (à l'exception de deux études portant sur des sujets déjà entraînés en résistance). Une autre limitation de la littérature étudiée est qu'elle ne comprend qu'un faible nombre d'études ($n = 3$) qui utilisent des mesures directes de l'hypertrophie (imagerie par résonance magnétique ou échographie). D'autres recherches sont donc nécessaires pour combler les lacunes de la littérature actuelle.

1. Introduction

The inclusion of resistance training as a part of a well-designed exercise program is recommended by many public health organizations, including World Health Organization, American College of Sports Medicine, and American Heart Association. Resistance training offers multiple health benefits including improvements in physical performance, longer functional independence, and increases in cognitive abilities and self-esteem [1]. A common goal of individuals participating in resistance training is to increase muscle mass. The current body of literature provides empirical evidence regarding a majority of resistance training variables (i.e., intensity, volume, exercise selection, etc.) oriented towards achieving such a goal [2]. However, there is a paucity of evidence regarding how to manipulate these variables for optimal results. This strategy referred to as periodization is regarded as a fundamental component of the training process as it may provide a conceptual structure for devising a training plan [3].

A training program may be periodized (PER) using one or more conventional periodization models. These models include:

- linear periodization (LP), characterized by increases in training intensity and decreases in training volume over time, or, reverse linear (RL), characterized by decreases in intensity and increases in volume;
- daily undulating periodization (DUP) characterized by undulation in intensity and volume each training day, weekly undulating periodization (WUP) or the undulating model (UP), characterized by weekly or biweekly fluctuation in intensity and volume, respectively;
- the block periodization (BP) model that divides the training program into several blocks that focus on specific training goals.

Some authors [4] have proposed that the use of a DUP resistance training program provides greater benefits for achieving increases in muscle mass than the utilization of an LP resistance training program. However, it is currently unknown if a resistance training program aimed at muscular hypertrophy should be periodized using either of the above-discussed models or a non-periodized (NP) program with high levels of training volume and progressive overload is sufficient to elicit hypertrophic effects.

By synthesizing the available data and conducting a systematic review, it is possible to glean further insights into the topic and thus draw evidence-based conclusions for resistance training program design. In accordance, the objective of this paper is: to evaluate the effects of PER versus NP resistance training programs on measures of muscle hypertrophy by systematically reviewing the current body of literature and present practical information for individuals striving to optimize resistance training programs aimed at increases in muscle mass.

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2. Methods

2.1. Inclusion criteria

The guidelines from PRISMA were followed for the systematic literature search [5]. The criteria for inclusion were the following:

- an experimental trial published in an English-language refereed peer-review journal;
- the study included a comparison of any form of a PER resistance training program to an NP resistance training program using dynamic exercise with both concentric and eccentric muscle actions;
- the researchers used at least one method of assessing changes in muscle mass;
- the training intervention lasted a minimum of six weeks;
- the study involved human participants.

2.2. Search strategy

We performed searches in PubMed/MEDLINE, Scopus, and Web of Science electronic databases, from their earliest records up to November 14, 2016. The databases were searched using combinations of the following terms: ''periodization'', ''periodisation'', ''resistance training'', ''muscle hypertrophy'', ''muscular hypertrophy'', ''maximal strength'', ''muscle mass'', ''constant loading'', ''variable loading'', ''strength training'', ''bodybuilding'', ''cross-sectional area'', ''undulation training'', ''growth'', ''muscular strength'', ''fitness'', ''training load'', ''training variation'', ''physiological changes''. Forward citation tracking of the included studies was performed in Scopus.

2.3. Coding of the studies

All of the included studies were coded for the following variables:

- study characteristics, including author(s), title and year of publication;
- descriptive information of participants by group, including the number of participants in each group, sex, age and experience in resistance training;
- the duration of the study and the weekly training frequency;
- the characteristics of both the PER and the NP resistance training models;
- the method used for the assessment of muscle hypertrophy (skinfolds, ultrasound, MRI, dual energy X-ray absorptiometry [DEXA], air displacement plethysmography [BOD-POD], hydrostatic weighing and/or bioimpedance analysis [BIA]) and the region of the body measured for studies that used ultrasound or MRI.

2.4. Methodological quality

An assessment of the methodological quality of the included studies was performed using the PEDro scale [6]. The PEDro Scale is an 11-criteria scale for assessing the methodological quality of randomized controlled trials with the scale range from 0 to 10. Each satisfied item (besides item 1) contributes 1 point to the overall PEDro score. The scale was modified due to the specificity of the topic (i.e., exercise intervention) and the scale items regarding blinding (items 5, 6, and 7) were removed, so the maximum score was 7 points. The interpretation of the PEDro was performed as in the review by Grgic et al [7].

The search, coding and methodological quality appraisal was conducted independently by two authors (JG and BL). Disagreements between the reviewers were resolved by mutual consensus whereas the third author (PM) settled any inter-review disagreement.

3. Results

A total of 1483 studies were evaluated based on the results of the search. Initially, the titles of the articles were examined. Then, the abstracts were read. Finally, the entire article was perused. In total, 12 studies were included [8—19] with a total of 337 participants (258 males and 79 females) involved either in a PER or in a NP resistance training program. The search process is depicted by a flow diagram in Fig. 1.

Eight studies included only male participants, two studies involved only female participants, and two studies involved both sexes. Resistance training programs employing a DUP approach were used in eight studies, LP approach was used in four studies, WUP and UP were used in two studies while the BP approach was used in one study. The average duration of a training intervention across studies equaled 15.4 weeks, with a mean training frequency of 3 training days/week. Seven of the included studies equated the training volume between groups. The training intensity varied from studies with 30% of 1RM being the lowest and 90% of 1RM being the highest recorded intensity. Nine studies used a combination of both free-weight multi-joint and machine-based isolation exercises in the training programs. Two studies employed only machine-based exercises while only one study used only free-weight multi-joint exercises. High adherence (> 90% training sessions completed) was noted in the studies that reported adherence to the programs. Detailed characteristics of the included studies are presented in Table 1.

In general, few adverse effects were noted in the studies, with Conlon et al. [10] reporting two injuries during 1RM testing procedures and one overuse injury, and Schoenfeld et al. [18] reporting one minor joint-related injury during training. No meta-analysis was performed due to the heterogeneity of study designs. The pre- and post- mean ± standard deviation values with percent changes for lean body mass and muscle thickness along with the methods used for hypertrophy assessment may be observed in Table 2.

The values obtained for quality assessment using the PEDro scale are presented in Table 1. Five of the included studies were deemed as studies of moderate methodological quality; four studies were deemed as studies of excellent methodological quality, two as studies of good quality and only one study as a study of poor methodological quality. The average score across twelve included studies was 4.8 out of maximal 7 points.

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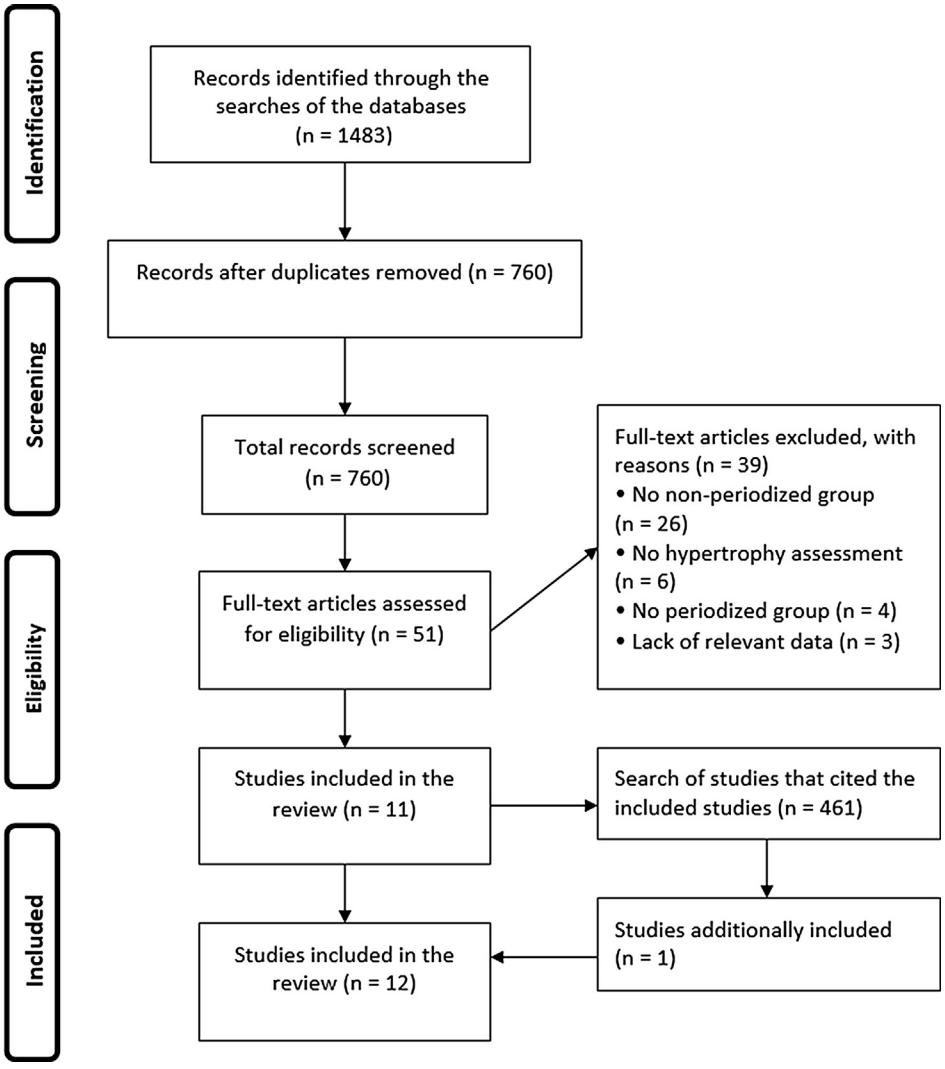

Figure 1 Flow diagram of the search process.

4. Discussion

The present review article is the first to have systematically evaluated the effects of these two training approaches on measures of muscular hypertrophy. By observing the results of each study included in this review, it may be suggested that both PER and NP approaches to resistance training can be used to achieve muscular hypertrophy and that similar hypertrophic effects may be achieved using either approach. However, as we elaborate in further text, there are limitations to the current body of evidence that warrant caution in drawing definitive conclusions on the topic.

4.1. DUP, WUP and UP versus NP resistance training programs

All of the studies that met inclusion criteria used at least one of the undulating models of periodization, with DUP being the most frequently used approach. The greatest differences in muscular hypertrophy between a DUP and an NP approach were observed in a study that did not equate the training volume between the groups [15]. Specifically, the group assigned to a DUP approach trained with a higher weekly frequency (four vs. three days/week) and with more sets per training session. Given the well-established dose-response relationship between training volume and hypertrophy [20], the findings of this study may be primarily attributed to the additional training volume of the DUP group. Previously, it has been shown that performing three sets vs. one set induces a greater myofibrillar protein synthesis [21] and mechanistic target of rapamycin [22] activation, and, thus, more significant hypertrophic effects. Not equating training volume between experimental groups is a limitation we observed in the literature, and this limits the comparison of the effectiveness between PER and NP resistance training programs.

Further, a limitation of the studies included in this review pertains to the methods used for assessing changes in muscle mass over time. Only three studies [11,18,19] used a direct measure of hypertrophy (i.e., ultrasound or MRI).

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Table 1 Characteristics of studies included in the review.

Study	Participants characteristics	Treatment groups	Duration; weekly training frequency	Volume equated?	Adherence to the programs	PEDro score
Ahmadizad et al. (2014)	Young overweight untrained men	Participants were assigned either to a non-exercising control group ($n = 8$), LP ($n = 8$), DUP ($n = 8$), or a NP ($n = 8$) resistance training programs	8 weeks; 3 days/week	Yes	Not reported	6
Baker et al. (1994)	Young untrained men	Participants were assigned either to a control group ($n = 9$) using a non-periodized approach, LP ($n = 8$) or a WUP ($n = 5$) resistance training programs	12 weeks; 3 days/week	Yes	Not reported	3
Conlon et al. (2016)	Elderly untrained men and woman	Participants were assigned either to a NP ($n = 10$), BP ($n = 13$) or a DUP ($n = 10$) resistance training programs all performing 6 different exercises	22 weeks; 3 days/week	Yes	NP = 95.6%; BP = 96.9%; DUP = 96.8%	4
Fink et al. (2016)	Young untrained men	Participants were assigned either to a high load (80% 1RM) NP group ($n = 7$), low load (30% 1RM) NP group ($n = 7$) or a WUP ($n = 7$) resistance training programs	8 weeks; 3 days/week	No	Not reported	6
Hunter et al. (2001)	Elderly untrained men and woman	Participants were assigned either to a non-exercising control ($n = 8$), high load (80% 1RM) NP ($n = 14$) or a DUP ($n = 14$) resistance training programs	25 weeks; 3 days/week	No	Average adherence rate over 90%	5
Kramer et al. (1997)	Young men (training status is unknown)	Participants were assigned either to a NP single-set to failure ($n = 16$), NP multiple set ($n = 13$) or a WUP ($n = 10$) resistance training programs performing	14 weeks; 3 days/week	No	> 90% for all groups	4
Kreamer et al. (2003)	Young untrained woman	Participants were assigned either to a non-exercising control group ($n = 8$), NP ($n = 10$) or a DUP ($n = 9$) resistance training programs	36 weeks; 3 days/week	Yes	100% for both groups	6
Marx et al. (2001)	Young untrained woman	Participants were assigned either to a non-exercising control group ($n = 10$), NP ($n = 12$) or a DUP ($n = 10$) resistance training programs performing	24 weeks; 3 days/week for the NP, 4 days/week for the DUP	No	100% for both groups	6
Monteiro et al. (2009)	Young trained men	Participants were assigned either to a NP ($n = 9$), LP ($n = 9$) or a DUP ($n = 9$) resistance training programs	12 weeks; 3 or 4 days/week	Yes	Not reported	5
Schoenfeld et al. (2016)	Young trained men	Participants were assigned either to an NP ($n = 9$) or a DUP ($n = 10$) resistance training programs	8 weeks; 3 days/week	No	NP = 93.9% DUP = 92.5%	4
Schiotz et al. (1998)	Young untrained men	Participants were assigned either to an NP ($n = 8$) or a WUP ($n = 6$) resistance training programs	10 weeks; 4 days/week	Yes	> 90% from both groups	4
Souza et al. (2014)	Young untrained men	Participants were assigned either to a non-exercising control group ($n = 5$), NP ($n = 9$), LP ($n = 9$) or a DUP ($n = 8$) resistance training programs	6 weeks; 2 days/week	Yes	Average adherence of 98%	4

LP: linear periodization; DUP: daily undulating periodization; NP: non-periodized; WUP: weekly undulating periodization; UP: undulating periodization; BP: block periodization; RM: repetition maximum; 1RM: 1 repetition maximum.

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Table 2 Relative changes in muscle mass in periodized versus the non-periodized strength training models.

Study	Periodization groups			Non-periodization groups			Method of hypertrophy assessment
	Pre-training	Post-training	Percent change (%)	Pre-training	Post-training	Percent change (%)	
Ahmadizad et al. (2014)	LP: 63.7 ± 5.7 DUP: 61.5 ± 6.8	LP: 64.9 ± 4.6 DUP: 62.7 ± 4.9	LP: 1.9 DUP: 2.0	62.1 ± 6.1	63.3 ± 3.5	1.9	Lean body mass using the BIA
Baker et al. (1994)	LP: 68.1 ± 7.2 UP: 63.3 ± 8.1	LP: 70.0 ± 7.6 UP: 65.4 ± 7.7	LP: 2.8 UP: 3.3	71.3 ± 5.6	73.6 ± 6.5	3.2	Lean body mass using skinfolds
Conlon et al. (2016)	BP: 44.9 ± 8.2 DUP: 50.1 ± 10.0	BP: 47.4 ± 8.4 DUP: 53.9 ± 12.4	BP: 5.6 DUP: 7.6	45.8 ± 13.2	49.1 ± 13.9	7.2	Lean body mass using DEXA
Fink et al. (2016)	10.3 ± 1.8	11.2 ± 1.9	8.7	NP high load: 9.7 ± 1.6 NP low load: 9.7 ± 1.1	NP high load: 10.6 ± 1.5 NP low load: 10.7 ± 0.9	NP high load: 9.3 NP low load: 10.3	MRI performed on the biceps brachii
Hunter et al. (2001)	44.8 ± 10.8	46.6 ± 11.3	4.0	53.2 ± 10.8	55.1 ± 11.6	3.6	Lean body mass using BOD-POD
Kramer et al. (1997)	68.9 ± 8.0	68.9 ± 7.7	0	NP single set: 67.5 ± 5.5 NP multiple set: 66.5 ± 7.5	NP single set: 67.9 ± 5.9 NP multiple set: 67.6 ± 7.2	NP single set: 0.6 NP multiple set: 1.7	Lean body mass using skinfolds
Kreamer et al. (2003)	46.5 ± 4.9	49.8 ± 4.9	7.1	46.1 ± 4.0	47.7 ± 4.8	3.5	Lean body mass using skinfolds
Marx et al. (2001)	42.3 ± 5.3	45.6 ± 6.3	7.8	41.3 ± 5.1	42.3 ± 5.0	2.4	Lean body mass using hydrostatic weighing
Monteiro et al. (2009)	LP: 69.5 ± 2.4 DUP: 70.3 ± 5.3	LP: 70.3 ± 2.8 DUP: 70.5 ± 5.4	LP: 1.1 DUP: 0.3	68.9 ± 4.4	66.8 ± 3.9	−3.0	Lean body mass using skinfolds
Schoenfeld et al. (2016)	EFT: 44.1 ± 3.0 TBT: 50.2 ± 4.1 VLT: 58.9 ± 3.6	EFT: 47.0 ± 2.4 TBT: 53.4 ± 3.6 VLT: 63.4 ± 4.3	EFT: 6.6 TBT: 6.4 VLT: 7.6	EFT: 46.1 ± 4.9 TBT: 50.5 ± 4.7 VLT: 55.9 ± 4.6	EFT: 48.4 ± 4.8 TBT: 52.6 ± 4.6 VLT: 60.7 ± 4.5	EFT: 5.0 TBT: 4.2 VLT: 8.6	Ultrasound performed on the biceps, triceps and vastus lateralis
Schiotz et al. (1998)	64.8 ± 4.2	65.5 ± 4.2	1.1	67.2 ± 3.0	67.5 ± 2.9	0.4	Lean body mass using skinfolds
Souza et al. (2014)	LP: 8689.4 ± 770.8 DUP: 8616.8 ± 1495.0	LP: 9099.2 ± 892.7 DUP: 9064.0 ± 1503.2	LP: 4.7 DUP: 5.2	8801.5 ± 983.2	9247.1 ± 972.3	5.1	MRI performed on the quadriceps muscle

LP: linear periodization; DUP: daily undulating periodization; NP: non-periodized; WUP: weekly undulating periodization; UP: undulating periodization; BP: block periodization; EFT: elbow flexor thickness; TBT: triceps brachii thickness; VLT: vastus lateralis thickness; BIA: bio-impedance analysis; BOD-POD: air displacement plethysmography; DEXA: dual energy X-ray absorptiometry; MRI: magnetic resonance imaging.

A closer scrutiny of the study by Schoenfeld et al. [18] indicates that a greater magnitude of effect was observed in the DUP group for two out of three sites used to assess changes in hypertrophy. Furthermore, studies from Fink et al. [11] and Souza et al. [19] found similar effects in untrained males for both the PER and NP approaches. However, the very low number of exercises used in these studies (one and two, respectively) restrict practical applications of their findings. Further empirical evidence is needed to examine the effectiveness of various undulating periodization models versus NP programs in trained individuals.

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4.2. LP versus NP resistance training programs

A variation of the traditional or the LP resistance training program was used in four studies meeting inclusion criteria. All of these studies used a volume-equated design between the training approaches (LP vs. NP) and found similar effects regarding changes in muscle mass. However, three out of four studies used untrained individuals to compare the two approaches. In fact, it can be hypothesized that maintaining the same basic routine may be beneficial during the early stages of training, as repetitive practice could enhance motor learning of movement patterns. Based on these findings, we speculate that no differences exist between LP and NP approaches to resistance training when applied to untrained individuals. It remains unclear whether similar findings would be observed over the long term, as the duration of the longest experimental treatment among the studies amounted to only 12 weeks. Advantages of using a LP approach in trained individuals is supported by the findings of Monteiro et al. [16], who reported that trained participants that used a NP method decreased their lean body mass over a 12-week period (even when equated for volume with other groups) while the LP group achieved slight increases in muscle mass (i.e., 0.8 kg). However, the NP group did not adjust for absolute load throughout the exercise intervention. When load is adjusted, even trained individuals have shown to achieve robust gains in muscle size and strength with an NP resistance training program [24]. Furthermore, a limitation to the study by Monteiro et al. [16] it is the use of skinfolds for assessing changes in muscle mass.

4.3. BP versus NP resistance training programs

The study by Conlon et al. [10] was the only one that compared the effects of a BP to an NP resistance training program, assessing for changes in muscle mass. In a cohort of older adults, the researchers observed no significant differences in muscle mass, physical function or physiological health outcomes between the BP and NP approaches. These findings suggest that, in previously untrained older adults, both approaches to resistance training can be equally effective regarding improvements in muscle mass. Similar outcomes were observed in the same population when the effects of a DUP and an NP approach to resistance training were compared in a study by Hunter et al [12]. Taken together, it may be suggested that periodization in resistance training is not essential for physiological adaptations in untrained older adults [5]. It is important to emphasize that Conlon et al. [10] recorded a high adherence rate to resistance training programs (NP = 95.6%; BP = 96.9%; DUP = 96.8%). As such, these findings have a great value due to the low participation rates reported among older adults [25]. However, it remains unclear whether these findings would be replicated in non-controlled settings. Further studies are needed to examine whether any differences regarding changes in muscle mass exist between BP and NP resistance training programs.

4.4. Methodological quality of the studies and limitations of the review

Most of the included studies were deemed to be of good methodological quality. The PEDro assessment was conducted without the items regarding blinding, as the participants and the trainer cannot be blinded, and, in most exercise intervention studies, the assessors are rarely blinded. However, it is important to note that two [10,19] studies, commendably, did report blinding of the researchers, thereby enhancing the methodological quality.

Several limitations of the available empirical evidence must be recognized. For one, nearly all of the reviewed studies involved untrained participants. Assessing the effectiveness of the periodization models regarding their impact on measures of muscular hypertrophy based on the studies involving only untrained participants may be unpredictable, as periodization may not be necessary to elicit hypertrophic responses in this population. Current evidence is insufficient to determine whether resistance-trained individuals benefit from PER vs. NP approaches. Furthermore, the relatively small number of studies included in the review makes it difficult to draw definitive conclusions. Finally, the variety of methods used for assessing changes in muscle mass warrants cautions in interpretation, as only three studies used a direct method of assessing muscular hypertrophy (i.e., ultrasound or MRI).

In conclusion, the results of our review suggest that the use of either a PER or an NP approach to resistance training may yield similar results regarding muscle hypertrophy. However, these findings primarily pertain to previously untrained individuals and can not necessarily be generalized to trained populations. Prescription of a specific resistance training model may be a matter of individual preference, and, in accordance, we suggest that fitness coaches and practitioners individualize resistance training programs aimed at muscular hypertrophy to secure success over a long term.

Disclosure of interest

The authors declare that they have no competing interest.

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