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PERIODIZATION MODELS IN THE RESEARCH OF THE MUSCLE STRENGTH IN ATHLETES, THEORETICAL-METHODOLOGICAL REDUCTIONS OR NON-CRITICAL POSITIVISM IN SPORT-SCIENTIFIC PERIODICS

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Abstract

Periodization is a theoretical and practical construct of sports training that relates to the programming of training activities in mutually dependent periods of time in order to induce specific physiological adaptations. During training and competition processes, it is used to achieve results at the specific competition. The theoretical and practical foundations of the periodization process can also be studied from the aspect of its impact on biomotor abilities. In this context, the general position for the study of periodization include research covering the impact of different periodization models on muscle strength (the subject of this paper). Based on an analysis of the content, meaning, methodological orientation, and conclusion within a selected number of published studies/papers, it cannot be ascertained whether periodized training models, in the muscle strength area, give better results than the non-periodized model, or which periodized model gives better results at all. The above-mentioned dilemmas regarding the subject of this work have also been confirmed in several review papers and meta-analyses. However, by examining the methodological and theoretical context of these studies, a number of dilemmas are evident, primarily those related to the sample of the subjects. Namely, none of the analyzed studies focused only on the athletes as a target group, but instead, the results of the research performed on athletes were analyzed in relation to a group of recreational or non-trained subjects. Also, there is a discrepancy in the terminology of the applied periodization models, which opens up the question regarding the existence of a clear theoretical concept and methodological-organizational construct that aims to achieve a competitive result. It can be assumend that a clear analysis of the original context of the phenomenon of periodization, harmonization of methodical and methodological steps in the process of learning, clear distinction towards existing definitions and terminology, resulted in the optimization of the learning process that will lead to recognition of the periodization model, which will result in optimization of the training-competitive preparations goals. Therefore, the problem of this paper derived from the theoretical and methodological inconsistency of the researchers in areas covering the influence of different periodization models on athletes' strength. The aim of the paper was to analyze and determine the facts of the methodological and theoretical construct of periodization, the conclusions of various studies, which can be said to - despite publication in important international journals - lead to confusion in the area of the conclusion about the influence of different periodization models on the strength of athletes. After examining more than 80 papers published in refereed journals, and by selection in relation to the theoretical-methodological context and the context of deductive conclusions, 10 studies have been selected, in which the influence of different periodization models on the strength of athletes, while performing exercises with arms and legs, were compared. The results indicate that the applied periodized models, especially the block model, showed a higher degree of sensitivity towards the development of athletes' strength, but several important questions were also raised regarding the validity of the conclusions on this subject. However, the outcome and the purpose of this research is to present a more comprehensible definition of the periodization phenomenon and its models, as well as to identify the effects of the experimental factor in the function of the biomotor response of the subjects to the training stimuli.

Keywords: PERIODIZATION / MUSCLE STRENGTH / COGNITIVE PARADIGM / METHODOLOGICAL INCONSISTENCY / SPORT-SCIENTIFIC PERIODICS

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INTRODUCTION

Periodization is a theoretical and practical construct that is based on the logical, methodological, methodical and systematic process of planning training activities as a unique whole that leads to biomotor and psychic benefits in order to achieve peak training-competitive form at the appropriate time points. In other words, it is programming of training interventions in mutually dependent periods of time in order to induce specific physiological adaptations in the function of achieving results (Haff & Triplett, 2015). In a broader context, the goal is to have an overall transformation of the performance attributes, that is, integrate optimization of all the potentials of the athlete's for the performance at a specific competition. Besides the fact that periodization creates preconditions to ensure that the sporting form is achieved at the major competition, its methodological and cognitive context can, and must be studied also from the position of the overall impact on the biomotor abilities (speed, strength, power, agility and endurance) (Bompa & Haff, 2009). So, in a narrow context, periodization refers to the structuring of the training stages in order to bring the psychomotor abilities to the desired level, according to which this paper is referring to.

Periodization - Challenges and Concerns of Research Protocols

To date, sports practice and exercising have created a great number of variations of the training organization process that have grown into models - theoretical and practical constructs - and which, in relation to the subject of this paper, can be divided into non-periodized and periodized. The problems of unfinished training-competitive practice are compounded by the use of different terminology (semantic uncertainty) which, unfortunately, is more noticeable in scientific journals in relation to work in immediate practice. In short, research processes are implemented on the basis of insufficiently defined criteria for the classification of processes that accompany periodization. After analyzing the published papers, it remains unclear whether the periodization process is an essential or formal criterion for biomotor adaptation, i.e. are the supercompensation process and the setting of deload training periods the through the changes of some training load variables the only effects that ensures the integration of cumulative training effects in the construction of the competitive result?

In the process of scientific uncovering of the periodized training phenomenon and its effects, a non-periodized (NP) experimental factor is used. The methodological settings of this experimental factor (exercise) are set in relation to uniform, linear and random variant of periodization (Strohacker, Fazzino, Breslin, & Xu, 2015). However, in a comprehensive and up-to-date research design, only random and uniform variants should be classified in this experimental exercise group, which includes tracking unsystematic changes in their volume and/or intensity, or constant values of volume and intensity during the training period. In relation to muscle strength, this should be indicated by the number of repetitions and the percentage of one repetition maximum (1RM). For convenient purpose of such an approach the experimental design should be sought in the absence of any biomotor cycles in the process of training adaptations, so therefore, periodization cannot be discussed in its original theoretical and practical meaning.

Bearing in mind that periodization implies load variation in order to facilitate the integration of planned exercises and fatigue caused by training in terms of progressive flow adaptation (DeWeese, Gray, Sams, Scruggs, & Serrano, 2013), in this context - in the experimental design - linear variant of training load should also be classified into non-periodized model, since variation of load is not only implied by the change in the value of some load variables (where one increases and the other decreases), but above all the variation of the total amount of load that leads to cumulative training-competitive effects. It is true that linear variants (progressive and reverse) accompany changes in volume and intensity during periods of training which occurs in cycles (usually in 2, 3 or 4 weeks), but it is also true that these variants are not followed by the deload period, thus eliminating wave-like loading in the true sense of the word, which is one of the prerequisites for the creation of the middle cycles of training - mesocycles. But, given the frequent use of the experimental factor through the linear training load, for the purposes of this paper it will be considered like a periodized model. Additional confusion is created in the analyzed papers when certain authors named this model a traditional one (Ullrich, Pelzer, & Pfeiffer, 2018; Ullrich, Pelzer, Oliveira, and Pfeiffer, 2016), or traditionally linearly periodized (Hoffman, Ratamess, Klatt, Faigenbaum, Ross, Tranchina, ... & Kraemer, 2009), although these models do not have deload periods (which is the fundamental characteristic of the traditional model). On the other hand, there are also cases where authors define periodization models as a non-periodized, linear and nonlinear,

although the analysis of all three observed models showed that they had periods of increased load (3 weeks) and deload (1 week) (Monteiro, Aoki, Evangelista, Alveno, Monteiro, da CruzPiçarro, & Ugrinowitsch, 2009), which would define them as variants of the traditional model.

In addition to the models without cyclical changes in the load variables, there are some periodized models in which these cycles exist in a certain sense. These models are characterized by changes in load variables, where different variations occur in relation to the purpose, frequency and magnitude of these changes. For the purposes of this paper, the following periodization models and their variations will be considered as periodized models:

- Linear Periodization Model (LP);
- Traditional Periodization Model (TP);
- Block Periodization Model (BP).
- Undulating Periodization Model (UP);

The LP primarily refers to its progressive variant (the intensity is progressively increasing) characterized by a high volume and low intensity work at the beginning of the training program. Over time, load variables are changing, volume decreases gradually, while intensity increases. The second variant of the training program that involves low-volume and high-intensity work at the beginning of the program, where over time the volume gradually increases as the intensity decreases, is also considered the LP. This variant is called the reverse linear periodization model and is suitable for the development of muscular endurance and maximum strength (Clemente-Suárez, Fernandes, Arroyo-Toledo, Figueiredo, González-Ravé, and Vilas-Boas, 2015), where it is important to monitor and analyze the residual effects of power parameters.

The TP is characterized by wave-like progression, i.e. periods of overload[1] intercepted by deload periods, where the exercise at the beginning of the program coincides with the phase of general preparation. It is characterized by high volume and low intensity of training load, which later (the phase of specific preparation) changes and directs to low volume and high intensity (Kraemer & Ratamess, 2004). It is similar to LP, but unlike it, there are periods of deload (it forms the foundation for the existence of mesocycles) and is therefore termed TP (Strohacker et al., 2015). In practice, there is no confusion about this training program and its terminology. It is a widespread and applicable periodization model that came from a clearly defined theory to which this model belongs.

The BP is a training program that's implemented in blocks (Accumulation-Transformation-Realization) in which the focus is on specific goals. The middle cycles of training (blocks) are specific characteristic of the BP as a separate concept of periodization (Issurin, 2009), and for this reason, there is no confusion about the classification and terminology in this model either.

The UP is characterized by more frequent change in the load variables than in the TP, but without changing the total amount of load (deload periods) during the training program. In relation to their frequency, there are several variants of this model. The daily undulating variant (DUP) is the most frequent, characterized by different volumes and intensities within each individual training session or week. Weekly undulating variant (WUP) is characterized by changes in volume and intensity on a weekly or a two-week (2WUP) level. Also, it is possible to combine some variants of the undulating models - a daily and weekly variant - where each training session in a week involves a different program, but every week is different from the previous week. In practice (wrong) it is classified as one of the already existing variants of the UP. In the design of some research, in their very experimental factor, there is a clear difference between the 2WUP and the LP, which changes the load on every two weeks (Tammam & Hashem, 2016). Namely, the correctness in the setting of the experimental factor arises from a more sensitive approach to the effects of LP that take place in one direction of the relationship of the load variables (e.g. the volume is constantly decreasing and the intensity is constantly increasing), while in the 2WUP this relationship also changes every 2 weeks, but not always in the same direction. Non-linear periodization model (NLP) is practically one of the variants of the undulating approach to training loads. Although it is often distinguished as a separate (problem of terminology), for the purposes of this analysis, it will be defined as UP (Hoffman et al., 2009; Kraemer, Häkkinen, Triplett-McBride, Fry, Koziris, Ratamess, ... & Gordon, 2003). Flexible non-linear periodization model (FNLP) is another

[1] Overload refers to assigning a training regime of greater load than the athlete is accustomed to (Baechle & Earle, 2008). Primarily in terms of stimulating load - or a combination of retaining and stimulating load; load that is not inadequate, i.e. it is not overreaching that leads to overtraining.

variant of the UP. It is characterized by the adaptability of the training activities based on the readiness of the athlete and by the outward appearance of the periodized work is very similar to the DUP. Therefore, for the purpose of easier understanding of their impact, all these periodization models of training load will be treated as variants of UP, which they are in their essence.

Bearing in mind that periodization implies the effect of training, based on its phases and periods of its impact, it is obvious that periodization cannot be linear or undulating (Bompa & Buzzichelli, 2018). It can be noticed that only TP and BP can be considered as a periodized models in the true sense of the word in terms of changing the total amount of load, as well as the existence of medium cycles. In this context, these two models have no confusion about terminology. The great inconsistency in the terminology that leads to the error in the setting of the experimental factor and the conclusion based on the results of the research models arises precisely because the models are called according to the shape or outward appearance of the periodized work. In contrast, the essence of research projects should be the structure or internal appearance of the variation of training load and recovery. In particular, in case of the uniform and random (non-periodized) models, and also in the LP and UP (for this research they are classified into periodized models, although they are practically non-periodized), the essence - even the name - is in the external appearance, while in TP and BP this is certainly the internal structure and variation of the training load and recovery. However, in this paper, only random and uniform models will be considered as non-periodized models, while TP and BP, as well as LP and UP, will be considered as periodized models.

Strength and power in the theory of sports training

The professional and scientific community has been debating for a long time about the most appropriate way to improve strength and power. To this end, they were investigating the influence of various periodization models on different motor abilities and characteristics of subjects with different chronological and training age, as well as the degree of training. Although the prevailing opinion is that the application of periodized models is better when aiming at developing strength, power and muscular endurance with respect to non-periodized model (Fleck, 1999; Herrick& Stone, 1996; Kramer, Stone, O'bryant, Conley, Johnson, Nieman, ... & Hoke, 1997; O'bryant, Byrd, & Stone, 1988; Rhea & Alderman, 2004; Stone, Potteiger, Pierce, Proulx, O'bryant, Johnson, & Stone, 2000; Williams, Tolusso, Fedewa, & Esco, 2017), certain studies suggest that the benefits of periodization with the goal of developing muscular strength and hypertrophy are largely based on assumptions, and have little solid evidence that periodization is a superior exercising plan (Mattocks, Dankel, Buckner, Jessee, Counts, Mouser, ... & Loenneke, 2016). It is also concluded that when the total volume and intensity of the load are equalized, then there is no difference in the application of the non-periodized and the periodized model (Baker, Wilson, & Carlyon, 1994), i.e. that the periodized model does not always lead to significant improvements compared to the non-periodized model (Grgic, Lazinica , Mikulic, & Schoenfeld, 2018; Hoffman et al., 2009; Souza, Ugrinowitsch, Tricoli, Roschel, Lowery, Aihara, ... & Wilson, 2014). In other words, it is not necessarily disputed that periodized models are superior (the existence of a methodological explanation to vary training variables in order to optimize outcomes), but in view of the above-mentioned limitations of the experimental factor, it is obvious that, based on previous research, it is not possible to draw relevant and valid conclusions related to this topic (Nunes, Ribeiro, Schoenfeld, & Cyrino, 2018). The inconsistency in the conclusions is also found in studies in which different variants of periodized training were compared, primarily the linear and the undulating periodization model, and in which it was concluded that there was no difference between the mentioned exercising models (or periodization?) (Buford, Rossi, Smith, & Warren, 2007; Harries, Lubans, & Callister, 2015; Grgic, Mikulic, Podnar & Pedisic, 2017). It is not possible to conclude from the analysis whether the researchers, with the design of their research, tend to determine if there is a difference in the effects between the traditional and the undulating periodization model on the observed biomotor abilities, primarily on the muscle strength. It is not possible to determine which periodized program model of the experimental factor is more effective, since the conclusions of some previous studies, to which the authors call, showed that the undulating model is better for the development of strength (assessed through 1RM), but not for power, muscular endurance, isometric strength, and muscle hypertrophy (Caldas, Guimarães-Ferreira, Duncan, Leopoldo, Leopoldo, & Lunz, 2016).

The lack of a unified opinion on the theoretical and practical context of periodization leads to inconsistent conclusions about the effectiveness of different periodization models, which are most likely and primarily based on errors in the methodology used in various researches. Namely, after reviewing the

research, covered by meta-analyses and by additional insight into the realized training programs within them, a presence of certain inconsistency was observed in the names of the periodization models. For this reason, if the models are to be compared essentially, and not by the names assigned by their authors, it could be assumed that more concrete conclusions would be obtained (differently defined periodization models, specificity of training loads, different amount of some load variables). The next, not so insignificant factor that determines possible errors in the conclusion by the experimental factor is the small sample and the small homogeneity of the subjects in terms of different criteria (gender, age, lifestyle, degree of training, training history). Bearing in mind the specificity of the training and the impact of changing the exercise methods on adaptation, as well as the different duration of experimental factors, it is assumed that with different groups of subjects the response of the organism will be different as well. In particular, if it is assumed that in sports practice the traditional periodization model is more utilized than some other models, as confirmed in one study that has addressed with this topic (Junior & Drigo, 2017), it will be in an unequal position in relation to models which were not previously applied to the observed athletes. It is therefore very difficult to make a unique conclusion about the size of the impact of a particular periodization model in relation to the other. The suggestion is that future studies should control the application of the principle regarding exercise effects specificity, as well as other variables by which the sporting form is built. It would be possible to correctly determine whether the systematic load variation is important for maximizing the observed motor abilities. This is supported by the conclusions of almost all analyzed studies, which is the need for further research (Miranda, Simão, Rhea, Bunker, Prestes, Leite, ... & Novaes, 2011; Moraes, Fleck, Dias, & Simão, 2013; Rhea & Alderman, 2004 Silva, Vilação-Alves, de Souza, dos Santos, & Figueiredo, 2016; Storer, Dolezal, Berenc, Timmins, & Cooper, 2014). The question is whether the final testimony of empirical efforts for the need of future research is caused either by, the expression of methodological inconsistency, insufficient theoretical and practical enlightenment of the researchers, the insufficient structure of research teams in terms of covering all areas of sports science, or insufficiently throughout research problem? If the answer is the last one of the just mentioned concerns, this raises the question of the relevance of the research, and therefore the process of concluding by the subject and the problem!

These deficiencies could be partially solved by looking at the essential characteristics of the exercise program (no matter how the researchers defined it), but also by the specific homogenization of the sample, that is, by examining the impact of different periodization models on subjects which are homogenized according to some criteria.

The problem of this research came from the observed theoretical and methodological inconsistency of the researchers in the area of the study design, and the discussion on the influence of different periodization models on the strength of athletes. The subject of the paper includes published studies that focused on the impact of the application of different periodization models on the strength of trained athletes. The aim of the paper was to analyze and determine the facts of the methodological and theoretical construct of periodization, as well as to understand the conclusions of various researches, for which one can say that - in addition to their publications in important international journals – they lead to confusion in the area of conclusion about the influence of different periodization models on the strength of athletes. The research tasks were: searching electronic databases, reviewing and organizing the collected research, defining the basic characteristics of the training programs, and theoretical and analysis of the meaning of the studies design and their results.

METHOD

Sample of studies

Only those studies that compared the impact of the influence of different periodization models to the strength of athletes were taken into consideration. Electronic search of papers was carried out in the following databases: PubMed, ScienceDirect, SCIndex and Google Scholar. The search was carried out by a combination of key words related to periodization, strength training, and athletes. The search was limited to the following terms in English: “periodization”, “strength”, “power”, “resistance”, “sport”, “athletes”, “training”, “exercise”, “effects”, “volume”, “intensity”, “load”, “comparison”, “influence”, and “performance”. 84 papers published in scientific journals classified on the SCI list in the period from 2003 to 2018 have been collected and reviewed.

Selection of variables - discrimination of analyzed research studies

In the research studies, within the specificity of different sports in which athletes train and compete, different motor abilities, muscular stress and adaptation characteristics (isometric force, strength, power, explosive power, and hypertrophy) were assessed. Also, in the process of arriving at conclusions on the subject of design, various tests were applied and the flow of research studies was accompanied by various data collection techniques. Bearing in mind that the suggestion about the need for new research is in almost all analyzed studies, for this research a selection was made of studies that contain clear data of variables and were presented in such a way that they can be unambiguously compared. In other words, a step forward in understanding the meaning of analyzed studies has been made, with the aim of correcting methodological and terminological reductions of previous researches. In accordance with the subject of this paper, researches has been selected in which load variables are clearly defined, as well as variables that describe the strength of the subjects - maximum isometric force and/or 1RM. Also, in selecting the experimental influence of the selected exercises, the criterion was that the exercises were relatively simple and widespread in the strength training of athletes. In this regard, for the assessment of the effects of the experimental factors on the muscles of the arm, bench press was selected, while for the leg muscles, two multi-joint exercises were selected: squats (different knee angles) and the legs press, as well as two single-joint exercises: leg extension and leg curl.

Classification criteria

After analyzing more than 80 papers published in refereed journals, selecting them in relation to the theoretical-methodological context and the context of deductive conclusions, 10 of them have been singled out in which the influence of different periodization models (through training with jumps, free weights or weight machines) on the strength of athletes, through arms and/or legs exercises was compared. These papers were controlled randomized and non-randomized studies with only athletes as subjects. In them, the application of different periodization models lasted for at least 4 weeks, without discussion - for now - about the fundamental question: can the analyzed exercise models in this case be called periodization models at all? Also, the results of only those studies in which the training program was clearly defined during the experimental period (objectivity, verifiability) were taken into account.

Out of 84 analyzed, the aforementioned criteria was only met by 10 published researches: Manchado et al. (Manchado, Cortell-Tormo, & Tortosa-Martínez, 2018), Ullrich et al. (2018), Tammam and Hashem (Tammam & Hashem, 2016), Ullrich et al. (2016), Franchini et al. (Franchini, Branco, Agostinho, Calmet, & Candau, 2015), Bartolomei et al. (Bartolomei, Hoffman, Merni, & Stout, 2014), Painter et al. (Painter, Haff, Ramsey, McBride, Triplett, Sands, ... & Stone, 2012), Hoffman et al. (2009), Hoffman et al. (Hoffman, Wendell, Cooper, & Kang, 2003), as well as Kraemer et al. (2003). In them, a total of 229 subjects (168 men and 61 women) completed the research. The influence of different periodization models was assessed, most often through the 1RM test, and in some cases also through the maximum voluntary isometric contraction. Different periodization models monitored by tests which were simple exercises performed on isokinetic machines, weight machines or with free weights, and they were: bench press (in 8 studies), squat (5), half squat (3; one in isometric contraction), leg press (1), leg extension (3; two times in isometric contraction), as well as leg curls (2; one time in isometric contraction). However, in the theoretical sense, most papers showed reductions, because only 4 analyzed papers included names of the applied periodization models, and therefore the planned outcomes of the training were in accordance with the attached training program. In other words, theoretical reductions lead to methodological reductions, and hence to the disputability of the results and conclusions of the research, whose subject is to monitor the effects of the periodized exercising. This is due to the use of inaccurate names, or variants of some models, or even periodization models. Discussion chapter presents concrete training programs as well as the reasons for classifying applied periodization variants, i.e. models into another variant, i.e. model.

RESULTS

The results of this study indicate that from five observed models (non-periodized, linear, traditional, block, undulating), the block periodization model proved to be potentially the best solution for development of the athletes' strength. Namely, in a study of Bartolomei et al. (2014), as well as Manchado et al. (2018), block model was compared with the traditional model and proved to be a better solution for strengthening the arms, while for the legs there was no difference. On the other hand, in

research by Painter et al. (2012) the block model was compared with the undulating model and proved to be a better solution for strengthening the leg muscles. As for the linear and the undulating model, four studies have found that both models have an effect in terms of improving abilities (Franchini et al., 2015; Tammam & Hashem, 2016; Ullrich et al., 2018; Ullrich et al., 2016), while in one of them, the undulating model has also proven to be a significantly better solution (Tammam & Hashem, 2016). Two studies have compared the undulating model and non-periodized model. In one, there is no difference, and the conclusion is that both models equally improve the abilities of both arms and legs (Kraemer et al., 2003), while in the other, non-periodized model gives better results in the legs, while in the arms none of the models show improvements (Hoffman et al. al., 2003). In one study, the undulating, non-linear, and the linear model were compared, and the conclusion is that all observed models influence the improvement of legs and arms strength (Hoffman et al., 2009). Significant differences were not noticed between the observed models. Table 1 shows an overview of all 10 selected studies.

Table 1. An overview of the impact of different periodization models on the strength in athletes.

Study	Subjects, duration, sport	Observed variables	Comparing periodization models (and the name of the model before reduction)	Conclusion
Manchado et al. (2018)	• N=11, woman • Handball • 16 weeks, 2 x per week	• 1RM bench press • 1RM half squat	BP vs TP	BP proved to be a better solution for the development of the strength of the arms, while there is no difference in the legs.
Ullrich et al. (2018)	• N=22, 12 men & 10 women • Different sports • 6 weeks, 3 x per week	• Isometric leg extension 70º / 90º / 110º	LP vs UP (TP vs DUP)	Both models are equally effective to increase the leg extensors strength. Jumps (CMJ) with different loads (0%, 15%, 30% of body weight) were used as a power development tool.
Tammam & Hashem (2016)	• N=16, men • Volleyball • 12 weeks, 4 x per week	• 1RM bench press • 1RM half squat • 1RM leg curl • 1RM leg extension	LP vs UP	After 12 weeks, significant progress was observed with both models. Also, UP is significantly more effective in all observed variables compared to LP, except for leg curl.
Ullrich et al. (2016)	• N=11, 5 men & 6 women • Judo • 4 weeks, 3 x per week	• 1RM bench press • 1RM squat • Isometric leg extension 70º • Isometric leg curl 30º	LP vs UP (TP vs DUP)	After a short period of time, both models showed improvements in maximum muscle strength both in legs and arms.
Franchini et al. (2015)	• N=13, men • Judo • 8 weeks, 5 x per week	• 1RM bench press • 1RM squat	LP vs UP	Similar effects of improving the ability were observed after the application of both models.
Bartolomei et al. (2014)	• N=24, men • Throwing events, Rugby, and American football • 15 weeks, 4 x per week	• 1RM bench press • Isometric half squat	BP vs TP	BP proved to be a better solution for the development of the upper extremities' strength, while there is no difference in the lower.
Painter et al. (2012)	• N=26, 19 men & 7 women • Track athletes • 10 weeks, 3 x per week	• 1RM squat	BP vs UP (BP vs DUP)	BP compared to UP showed a greater impact on improving the maximum strength.
Hoffman et al. (2009)	• N=51, men • American football • 15 weeks, 4 x per week	• 1RM bench press • 1RM squat	NP vs LP vs UP (NP vs PL/TPL vs NLP)	With the application of all three models, bench press and squat are significantly improved. There is no difference between the models.
Hoffman et al. (2003)	• N=28, men • Soccer • 12 weeks, 2 x per week	• 1RM bench press • 1RM squat	NP vs UP (LP vs NLP)	During the season, significant progress was observed with the application of the NP only in squat. No observed model has made significant progress in bench press.
Kraemer et al. (2003)	• N=27, woman • Tennis • 9 months, 3 x per week	• 1RM bench press • 1RM leg press	UP vs NP (NLP vs NP vs Control)	Using both models, after 9 months, bench press and squat are significantly improved.

Legend: BP - Block Periodization Model; TP - traditional periodization model; LP - linear periodization model; UP - Undulating periodization model; NP - non-periodized model; NLP – non-linear periodization in the original paper; PL / TPL - linear periodization / traditional linear periodization in the original paper; NLP - nonlinear periodization model in the original paper; Control - the control group in the original paper; DUP - daily undulating model of periodization in its original paper.

DISCUSSION

Before discussing the reasons for theoretical reductions, as well as results of the study (after reductions), it is necessary to make certain observations relates the validity of the results of the analyzed research. There are a few:

1. Variation of the training load during the duration of the experiment protocol. Already in the first classification of non-periodized and periodized models of the training plan, the first theoretical and methodological dilemmas come to light. Namely, the question arises as to whether there were deload periods as a postulate and the essence of the very concept of periodization, i.e. whether is methodologically correct to distinguish the linear and the undulating periodization model (which are classified in periodized models for this research, although they are practically non-periodized) from the really non-periodized model (uniform and random variant), or it is correct to observe them as traditional and block model (which are periodized in the true sense of the word; by all criteria)?

2. Designs of analyzed studies do not declare the periodization model that was used by athletes prior to experimental factors. In this context, it could be assumed that the change in the training program itself will cause a different degree of biomotor, energy and coordination adaptations, and if it has been utilized for some time, it can be expected that continuation of exercise by the same model will have a reduced response (accommodation). Consequently, the conclusions go to the detriment of those models that are most often applied, i.e. if it is assumed that the traditional periodization model is the most utilized in sports practice, it is obvious that this model of periodized training will prove to be less efficient than it may be.

3. Unclearly defined factors which can influence the efficiency of the periodization model (declared or real). These are primarily specificity of the load and the total amount of work, but also the period of the season, as well as the career stages in which experimental exercise (factor) was applied. Also, the duration of the experimental factor is another of the administered criteria which, by its unprocessed duration, certainly influences the sensitivity of the process, and thus the very process of learning. Similar observations have been made by other authors, i.e. in conclusion, according to this analysis, it is important to point out that the results of the experiments were not analyzed and tested in relation to the hypotheses that were set, therefore the analyzes were mostly one-dimensional, and other methodological inconsistencies were noted too, above all, the integrality of the reaction of the subjects to the training stimuli (Afonso, Nikolaidis, Sousa, & Mesquita, 2017). According to Afonso at al., the concepts of periodization are also debatable, but also the authors need to use variation of load variables as a synonym for periodization. In such a context of experimental design an essential methodological problem arises, and it is that the declared periodization models are not periodization models, because under the periodization of biomotor abilities it implies that “the goals, contents, and methods of strength training programs change during the phase of the training plan, which is most often tied to the training year” (Bompa, 2009). Practically, for the shorter periods of the training cycle, the term “periodization” should not be used, but the use of the term “training adaptation in relation to the method and content of training” might be more appropriate here. In the mentioned context, even more obvious inadequate use of the term “periodization” is if we observe periodization in a broader context - as a strategy for training activities that leads to overall transformation and an integral optimization of all the athlete’s potentials for the performance at the specific competition.

4. Application of a constant amount of training load in the linear (change in volume followed by change in intensity) and non-periodized (uniform variant) training model (constant values of volume and intensity). Bearing in mind that the authors emphasize (Kraemer et al., 2003; Hoffman et al., 2009) that the load in non-periodized model was tailored at every training session, i.e. it is suggested that the last anticipated repetition be performed with the same maximum effort, it is obvious that the load in the absolute values was increasing during the application of experimental factor. Consequently, it still has some changes from the internal aspect of adaptation, and in some sense, it is not completely uniform. Accordingly, in certain specific situations it has an internal structure similar to the linear model (the volume of repetition to “failure”, with the subjective feeling of the subject). Bearing this in mind, but also that neither linear nor uniform model have deload periods, it would be reasonable to consider them as variants of a non-periodized model.

Examples of design and theoretical starting point - the reasons for reduction

In the research of Manchado et al. (2018), a traditional and a block periodization model were compared, where the handball players of one season were trained according to the traditional model during the preparatory period, while in the following season they trained according to the block model during the preparatory period. With both models, the entire training program with the intent of developing strength (but also with the intent of developing endurance) was applied through 3 phases (mesocycles - MSC) for the traditional model: general preparation (GP), specific preparation (SP) and competition (C); i.e. for block model through phases: accumulation (A), transformation (T) and realization (R). The first phases in both models (GP & A) involve work on strength development. During 4 weeks of the traditional model, program consisted of work in 3 sets of 10 repetitions at 60% of 1RM (in 1st week), 3 sets of 10 reps at 65% of 1RM (2nd week), 3 sets of 9 reps at 70% of 1RM (3rd week), and 3 sets of 8 reps at 75% of 1RM (4th week), while for the block model for all 5 weeks (one week longer!) program involved a smaller repetition rate - from 1 to 4 - but with intensity between 80% and 95% of 1RM. During the second phase, in both observed models (SP & T), the focus was on power developing. In the traditional model, the program consisted of work with 5 to 6 reps at 75% to 85% of 1RM during the first three weeks, and during the last week, 50% to 60% of 1RM (deload). On the other hand, the block model involved in all 5 weeks (again one week longer!) performing exercises with maximum velocity at 75% to 80% of 1RM. The third phase (C & R) involved the development of the specific strength required for handball, during 8 weeks at the traditional, and 6 weeks (two weeks shorter!) at the block model. Bearing in mind that there are certain changes in total amount of load, it can be considered that the shown models are named with appropriate names. On the other hand, although both models last the same, the problem is in the unequal duration of the phases during which a certain experimental factor was operating. Even the authors themselves state that during the first phase, both training programs were carried out using the same exercises in the same weekly training session and that the difference was only in the intensity and volume.

In the research of Ullrich et al. (2018), the traditional model involved increasing intensity every 2 weeks - 1st and 2nd week 6 sets of 7 jumps with 0% of body weight (1st type of workout); 3rd and 4th week 6 sets of 5 jumps with 15% of body weight (2nd type of workout); 5th and 6th week 6 sets of 3 jumps with 30% of body weight (3rd type of workout) - which is a characteristic of the linear model because there is no deload period, and the volume decreases and the intensity increase. For this reason, for the purposes of this paper, it was observed as a linear model. On the other hand, the daily undulating model involved different order of training sessions with different workloads (1st, 2nd, and 3rd, type of the workout), so it was observed as an undulating model.

In the research of Tammam & Hashem (2016), the names of the periodization models are in line with the terminology used in this paper. Namely, for the linear (progressive) model, the exercise program from 1st to 3rd week consisted of work in 3 sets of 10RM (10-repetition maximum), from 4th to 6th week 3 sets of 8RM, from 7th to 9th week 3 sets of 6RM, and from 10th to 12th week 3 sets of 4RM. In the biweekly non-linear model (in original paper), training program involved work in 1st and 2nd week in 3 sets of 10RM, in 3rd and 4th week in 3 sets of 8RM, 5th and 6th week 3 sets of 4RM, in 7th and 8th week 3 sets of 10RM, in 9th and 10th week 3 sets of 6RM, and in 11th and 12th week 3 sets of 4RM, which characterizes the properly mentioned periodization model, so in this paper it was observed as an variant of undulating model.

In another research by Ullrich et al. (2016), inconsistency in the model names was observed. Namely, the traditional model involved a way of exercising where after 4 training sessions the intensity of exercise was decreasing. Specifically for squat, in the first 4 training sessions (T1, T2, T3, T4), the exercise program involved work in 3 sets of 1 to 2 repetitions from 80% to 90% of 1RM (strength zone); from T5 to T8 in 3 sets of 1 to 4 reps from 65% to 75% of 1RM (power zone); from T9 to T12 in 3 sets of 3 to 6 reps from 50% to 60% of 1RM (speed zone). For bench press and leg curl exercises the program was similar just with a different number of repetitions at the same intensities of 1RM (and zones). At first glance, it can be seen that it is the linear (reverse) model rather than a traditional one as stated. Although for all exercises (and even for the three selected in this paper), a slight deload was observed in certain training sessions in the form of a reduction of one repetition compared to previous training session (for squat at T4, T8, and T12, 1 repetition), and this type of work seemingly could be defined as a traditional model, but this has not been done because the deload is such that it is carried out within the same microcycle (MC), i.e. there is no deload period (there is only one training session with reduced load, not the entire MC).

In the research of Franchini et al. (2015), the linear (reverse) model was compared with the undulating model. In the liner model, the training program during the first 2 weeks involved work in 4 sets of 3 to 5 reps (1st type of workout), during the next 3 weeks in 4 sets of 6 to 8 reps at 80% of 1RM (2nd type of workout), and 15 to 20 reps during the last 3 weeks (3rd type of workout). In the undulating model, the training program also involved 3 training sessions per week, with each one of them being one of the three different types of workouts. In the coming weeks, only their order within the week is changed, except in the 5th and 7th week. During those weeks, workout with 3 to 5 reps, was replaced by the workout with 6 to 8 reps at 80% from 1RM (Monday and Friday in 5th week) and with 15 to 20 reps (Monday and Friday in 7th week). The authors used terminology in both models in accordance with the terminology used in this paper.

In the research of Bartolomei et al. (2014), the traditional model and the block model were compared. In the traditional model, the exercise program consisted of 3 MSC lasting 5 weeks (apparently authors - not only in the above-mentioned work - instead of the term microcycle, use the term "week"!) with 2 training sessions per week for which the experimental factor was applied (the program involved 4 training sessions per week for strength development, but there were only 2 exercises for those observed in this paper). In all 3 MSC the order of the weeks was the same - 1st week 5 sets of 8 to 10 reps from 65% to 75% of 1RM; 2nd week 5 sets of 5 to 6 reps from 75% to 85% of 1RM; 3rd week 5 sets of 3 to 4 reps from 85% to 95% of 1RM; 4th week from 50% to 60% of 1RM; 5th week work with small load magnitude and through only 2 training sessions (deload). Practically, the program implied repeating a linear progressive model with last deload week, where the absolute load magnitudes (in kg) were tailored to meet the individual needs of the subject (increasing the absolute load magnitude to keep the intensity remaining in the predicted range). With the block model, the training program involved the same number of MSC as in the traditional model, as well as weeks and training sessions. The training program in the 1st MSC involved work on muscular hypertrophy (accumulation) with an intensity from 65% to 75% of 1RM through 6 to 10 reps, then work on strength (transformation) during 2nd MSC, with an intensity from 80% to 95% of 1RM through 1 to 6 reps, and finally the 3rd MSC training program involved work on the power (realization), with an intensity from 50% to 65% of 1RM through the maximum speed of performing. Bearing in mind that in the block model at the end of each MSC, a deload week is predicted, it is obvious that both models can be classified as named by the authors - the traditional model and the block model.

In the research of Painter et al. (2012), the block model and the (daily) undulating periodization model were compared. In the block model, through 3 blocks (for developing endurance, strength and power) volume and intensity were manipulated both within a week and during weeks, while in the (daily) undulating model change was performed only within a week (1st training session 3 sets of 8 to 12 reps; 2nd training session 3 sets of 5 to 7 reps; 3rd training session 3 sets of 3 to 5 reps) where the same contents of the week are repeated over the entire period. If the weeks are analyzed (like MC) it can be noticed that in the first 4 weeks, the initial weekly load increases, while in the last one decrease. Next, the same pattern was repeated in the next 4 weeks. Although in the tables of the original paper is stated that it is the traditional model, it is obvious that the term "traditional" was used with the meaning "common", and for this reason, it was also observed in this paper as a block model.

In the research of Hoffman et al. (2009), the names of the periodization models are not fully in line with the terminology used in this paper. During 4 training sessions per week for developing strength, bench press and squat were performed on 2 training sessions alternately. In the non-periodized model, training plan consisted of 4 sets (5 sets in the last 4 weeks) of 6 to 8 reps throughout the entire period. This name corresponds to the terminology used in this paper. In the traditional periodized linear model (as the authors call it) during the first 4 weeks the exercising involved 4 sets of 9 to 12 reps, over the next 6 weeks in 4 sets of 6 to 8 reps, and during the last 4 weeks in 5 sets of 3 to 5 reps. Obviously, this is a linear model, not the traditional one. Also, in the non-linear model during the first 4 weeks, the work involved 4 sets of 3 to 5 reps at the first and 9 to 12 reps at the second training session of the week (for the squat inversely). During the next 6 weeks work involved the same 4 sets of 3 to 5 reps at the first and 9 to 12 repetitions in the second training session of the week (for the squat inversely), but with a different order of other exercises. During the last 4 weeks work involved 5 sets of 3 to 5 reps at the first and 9 to 12 reps at the second training session of the week (for the squat inversely). All these characterize the properly mentioned periodization model, so in this paper it was observed as an variant of undulating model.

In another research by Hoffman et al. (2003), the names of the periodization models are inconsistent with the terminology used in this paper. Namely, 4 exercises – power clean, squat, push press, bench press - were applied 2 times per week for 12 weeks. The linear model involved exercising during the week on two identical training sessions, with 80% of the 1RM and in a volume of 3 sets of 3 to 5 reps for power clean, 6 to 8 reps for squat, 4 to 6 reps for push press, and 6 to 8 reps for bench press. This name does not correspond to the terminology used in this paper, because the same program is involved throughout all 12 weeks. For this reason, this is a uniform non-linear model rather than a linear one, since it is obvious that - observed for each exercise separately - there is no variation of the external load variables. In the non-linear model, the same exercises were applied twice a week, but with different load magnitudes. Once a week with an intensity of 70% of 1RM and in a volume of 3 sets of 4 to 6 reps for power clean, from 8 to 10 reps for squat, from 4 to 6 reps for push press, and from 8 to 10 reps for bench press. The second training session in the week was conducted according to a program that involved a 90% intensity of 1RM with a volume of 3 sets of 2 to 4 reps for all exercises. All these characterize the properly mentioned periodization model, so in this paper it was observed as an variant of undulating model.

In the research of Kremer et al. (2003), in the non-periodized model, it was exercised with such load magnitudes throughout the entire period that it was possible to perform 8 to 10 reps in 3 sets, while in the non-linear model the intensity was changed at each training session within a week (Mondays 3 sets of 4 to 6 reps; Tuesdays 3 sets of 8 to 10 reps, and Fridays 3 sets of 12 to 15 reps). For this reason, in this paper, a non-linear model is observed as a (daily) undulating model. At this point, it is important to note that the load magnitude in both models was defined by the external characteristics, but they increased in absolute values during the period of the experimental factor.

If we look at the publishing time of the analyzed studies in which the name of the applied periodization model has been changed (due to discrepancies with the attached training programs), it can be concluded that in recent years, the authors have somehow recognized the problems pointed out in this paper, so the need for correction of terminological inconsistencies was reduced. However, in order to completely discredit the discourse of the results and conclusions of the researches, whose subject is to monitor the effects of the periodized work, it is necessary to precisely define the theoretical as well as the methodological framework of the research that will be objective, purposeful and reliable.

Besides the necessity of respecting the observations mentioned at the beginning of the chapter Discussion (second and third observation), one of the first steps towards a clearer definition of the mentioned frameworks, surely could be a simplification of the model classification according to the basic criterion - the existence or absence of the deload period, i.e. the variability of the training load (first observation). Namely, although the different variants of the programmed exercise involve relatively similar variations of the load variables (primarily volume and intensity), they in their essence differ by whether the total load over time changes or does not change. In this context, although they contain segments that can be identical to the linear or the undulating model (as well as the uniform model), the traditional and the block model are classified as periodized models. On the other hand, the linear and the undulating model are characterized by a constant inverse interdependence of the load variables, by which they maintain a relatively similar load volume throughout the entire duration of the programmed exercise. In this context, it is possible to make a large number of variations (linear, reversed linear, undulating on a daily or weekly level, etc.) or even omit them (uniform model), but the essence will remain the same – the load variables are never reduced simultaneously, thus the reduction of one, is followed by the increase of another. As a result, the load is adding up to the load, which is possible only in relatively short periods of time. Bearing in mind that periodization as a concept - among other things - involves longer periods of time, as well as varying of the total training load during those periods, it is obvious that the mentioned models differ essentially from one another.

The justification for this attempt to classify the models - into periodized and non-periodized - in addition to the above mentioned theoretical explanation, to some extent, could also include the results of this study. Namely, the block model is the only model that, no research has shown to be a worse solution for improving the observed abilities than some other models. Only where it didn't produce better effects - but equal – is in comparison to the traditional model, specifically for leg muscles. On the other hand, by observing other models (linear, undulating, non-periodized) it is obvious that all these types of work improve abilities, but it is not possible to determine with certainty which is the optimal solution (perhaps because there is no difference between them). Finally, in a single study, the block model was compared with the undulating model (periodized with non-periodized), where the block proved to be a better

solution. In this last statement lie the reason and the justification for classifying only on two classes of the model - periodized and non-periodized. Also, the traditional model was not compared to any other model, other than the block model (only in two studies), therefore this is also a fact that needs to be kept in mind. In any case, this issue is also in need of further research - primarily comparing the influence of the traditional with the other models - but certainly with a different theoretical starting point from the one found so far in the works that dealt with this topic.

CONCLUSION

Block periodization model is potentially the best solution for developing the strength of athletes. This conclusion was imposed after a multilateral analysis of a large number of published papers in categorized scientific journals, whose subject and problem can be related to the key words of this paper (periodization / muscular strength / cognitive paradigm / methodological reduction / scientific periodic). When it comes to the strength of the legs, an equally good solution is the application of the traditional periodization model. On the other hand, the block model proved to be significantly better than the undulating model, which opens the possibility that, indirectly, other affirmative conclusions can be drawn about the significance of this model (as well as the periodized models in general) on the development of observed motor abilities of athletes. Also, the use of other models (non-periodized in its essential form, in which there are no variations of the total load in the observed period) improves the strength of athletes, but it is not possible to determine which model of periodized work is an optimal solution.

On the other hand, after theoretical, purpose and meaning analysis, as well as applied methodological framework, it is obvious that the scientific journals and publications need to clearly define the periodization model/models that will be used, or in other words they need to provide an answer to this question before the setting of the experimental protocol.

First of all, the concepts of periodization and using variation (in short term) of load variables as a synonym for periodization are debatable. Further, there are the criteria for classifying the model in terms of the existence or absence of a deload period (change in the total amount of load). The validity of the conclusions can certainly be influenced by the periodization models used by athletes before being exposed to experimental factors; in this case the potentially favored models are the ones that have not been applied so far, because the continuation of the work by the same periodization model may have a reduced response (accommodation). Other factors may also influence the effectiveness of the periodization model, therefore they need to be defined more clearly - specificity of the load, the amount of work, the period of the season or stage of the athlete's career, the integrality of the reaction to the total training stimuli and the duration of the experimental factor.

Editors of scientific journals and editors of sections, as well as reviewers, must pay attention to the theoretical frameworks of studies in order to produce a methodological framework of research that will be objective, purposeful, reliable... On the path of knowledge and conclusions about the adaptation process of organic systems in response to the specificity of the research protocol design, it is necessary for the authors to set up a protocol that is sensitive to the problem and the goal of the research. In other words, it must be without theoretical reductions leading to methodological inconsistencies and to low applicability in practical work in programmed physical activity and sports.

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