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The Hatfield-System vs. Weekly Undulating Periodized Strength Training

Das Hatfield-System vs. wöchentlich-wellenförmig periodisiertes Krafttraining

REVIEW

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Summary

- **Periodization of strength training** or planned changes in training volume and intensity are aimed at optimizing the development of strength (i.e. maximum power, strength endurance, speed power) and muscle mass.
- **Types of periodized resistance training:** Linear (classic) periodization (LP), nonlinear (undulating) periodization (weekly (WUP) and daily (DUP)), block periodization (BP), and a holistic version developed by Frederick Hatfield (HAT). The most important differences between these types are specific changes in the volume, intensity and frequency of training. In particular, the WUP and the HAT seem to elicit similar effects and benefits, but differences may result from different program structures (i.e., HAT: holistic/all-in-one, WUP: weekly changes). Practice shows that problems may arise especially in team sports or in sports that are periodically repeated (e.g., tennis, ball games) in terms of practical implementation planning of targeted strength training due to the weekly sports-specific loads. In this regard, it was speculated that HAT might represent a more viable way to increase strength performance and muscle mass through its easy-to-use approach compared to WUP.
- **This article** is intended to compare effects of WUP and HAT based on available scientific data, to provide practical decision support for sport physicians, coaches, and therapists who are supervising athletes at a higher level of performance.

KEY WORDS:
Resistance Training, Maximum Power, Power Endurance, Program Design, Hypertrophy

Zusammenfassung

- **Eine Periodisierung des Krafttrainings,** die geplante Änderungen von Umfang, Intensität und Frequenz des Trainings, dient der optimalen Entwicklung von Kraft (Maximalkraft, Kraftausdauer, Schnellkraft) und der Muskelmasse.
- **Die verschiedenen Arten des periodisierten Krafttrainings:** Die lineare (klassische) Periodisierung (LP), die nichtlineare (wellenförmige) Periodisierung (wöchentlich (WUP) und täglich (DUP), die Blockperiodisierung (BP) und eine ganzheitlichere Version, die von Frederick Hatfield entwickelt wurde (HAT). Die wichtigsten Unterschiede zwischen diesen Typen sind die Änderungen des Trainingsvolumens, der Trainingsintensität und der Frequenz von Änderungen. Speziell die wöchentliche wellenförmige Periodisierung (WUP) und das Hatfield-System (HAT) zeigen hierbei ähnliche Wirkungen, jedoch scheinen besonders aus praktischer Sicht, aufgrund ihrer unterschiedlichen Programmstrukturen (HAT: holistisch/all-in-one, WUP: wöchentlich veränderte Inhalte) Anwendungsunterschiede zu bestehen. Die Praxis zeigt, dass sich insbesondere bei Mannschaftssportarten oder bei Sportarten, die oftmals mehrfach periodisiert sind (z. B. Tennis, Ballspiele), häufig Probleme hinsichtlich der praktischen Durchführungsplanung eines gezielten Krafttrainings ergeben. Es wird vermutet, dass HAT im Vergleich zu WUP eine möglicherweise geeignetere Methode zur Kraftverbesserung und zum Muskelaufbau darstellen könnte.
- **Dieser Artikel** präsentiert einen Vergleich zwischen WUP und HAT, basierend auf verfügbaren wissenschaftlichen Daten, und soll eine praktische Entscheidungshilfe speziell für Sportärzte/-innen, Trainer/-innen und Therapeuten/-innen darstellen, welche Sportler/-innen auf höherem Leistungsniveau betreuen.

SCHLÜSSELWÖRTER:
Widerstandstraining, Maximalkraft, Kraftausdauer, Programmdesign, Hypertrophie

Introduction

Periodization in strength training has been applied since the 1950's and has become more and more important. Primary goals related to strength training are increases in the areas of maximum strength and muscle mass, strength endurance and speed. There are many comparative studies on periodized and non-periodized programs indicating that periodized programs result in greater strength gain than non-periodized programs (16, 36, 37, 38, 40, 42, 43).

Especially in team sports and in sports which are multiple periodized (e.g. tennis, ball games, etc.) and due to the dramatic increase in the number of competitions of world class athletes (28), problems may arise with regard to the practical implementation of a targeted strength training due to the weekly sport-specific loads. Because coaches may primarily focus on tactics and technique or generally on the competitive performance, the time resources to ›

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improve strength abilities are often limited (28, 51, 54). Therefore, high efficiency with maximum effects often represents the main goal when implementing a strength training program, which is only possible to a limited extent. For example, it is important to take care about the realization of undulating periodization models. After an initial adaptation phase, usually a specific and time-consuming transition phase is necessary if one want to continue with a focus-oriented training regarding maximum strength and/or muscle mass, strength endurance, and/or speed of movement. Thus, time may represent a limiting factor. Thus, the question arises for which target group of athletes which type of periodization would be appropriate to avoid the usually necessary specific and time-consuming transition phase and to minimize the risk of adverse effects. This question is here discussed by means of weekly undulating periodization (WUP) and the Hatfield-system (HAT).

The WUP was deliberately chosen as a comparative model. WUP does not show significant differences in strength and muscle mass gains in most comparative studies with other periodization models (5, 16, 24) and is recommended for the use of team sports (25). HAT was already successfully applied in bodybuilding for the build-up of muscle mass in the early 80's, although it was often criticized for its "all-in-one" structure, as it was completely contrary with all other periodization models used at that time. HAT, however, was not recognized until 2000 as a useful tool for training in team sports. However, no comparative studies were existing. The probably first study comparing HAT and WUP effects in strength-training experienced athletes was conducted in 2017 (1, 2). Although Hatfield suggested physiological considerations for the structural assembly of his training system (26), the connections between the physiological mechanisms and the training stimuli still remain elusive (50).

Comparison of Two Periodization Models (WUP und HAT)

Weekly Undulating Periodization (WUP)

Low training volume with high intensity but also high training volume with low intensity are characteristics of the linear periodization model (LP) and the nonlinear (undulating) periodization (weekly (WUP) and daily (DUP)) as well (5, 16, 24). As training progresses, both volume and intensity change in order to gain strength (i.e. maximum power, strength endurance, speed power) and muscle mass. The WUP enables variation in intensity and volume within each 7 to 10-day mesocycles by rotating different protocols to train various components of the neuromuscular system (14). There are more frequent changes in stimuli compared to the LP because LP is generally characterized by five individual mesocycles of four to six weeks duration (16). WUP is designed to train various adaptation aspects of the neuromuscular system within the same microcycle by training the various components of muscle size and strength within one week (14). Several potential advantages of the WUP approach may be assumed, although no definitive conclusions can be made because several studies compared LP and WUP programs demonstrating significant differences within groups but not between groups (9, 24). Lorenz (35) suggested that the weekly fluctuations in training loads may elicit more favorable neuromuscular adaptations compared to the LP approach. Finally, due to the concurrent nature of the training, detraining effects that occur in a LP approach might be avoided. For example, the plateau effect can be more easily prevented because this type of periodization is better balanced and also allows for a period of deloading. A deload means a reduction in weight for an exercise or a decrease in training volume by reducing the amount of training sets in order to reduce the training stress (21, 39).

Several training parameters (i.e., maximum strength, muscle mass, strength endurance and speed) may be addressed at the same time in the WUP model and therefore, athletes can focus on different goals each week. In general, the WUP model is considered not being suitable for beginners because typically heavy loads are implemented during the first week of the workouts. Thus, the beginner needs rather to perform a basic program for 4 to 6 weeks using lighter weights, allowing the individual to gain toleration to the resistance training program and continuing afterwards with an undulating progression of varying volumes and intensities (30). Furthermore, a WUP training program may elicit a higher degree of effectiveness in older subjects (e.g., >60 years) compared to younger individuals (33). According to Haff (23), in younger athletes only the range of the number of repetitions should be increased with WUP. The initial load for an intramuscular coordination training, a high-intensity strength training intended to increase the maximum force, should be in the range of 4-6 repetition maximum (RM). For older people, however, this is less suitable as the use of intensity techniques or performing sets to the point of muscle failure, in order not too much stress joints and to avoid potential injury (16).

The Hatfield-system (HAT)

Hatfield (26) developed his conceptual periodization program in the form of a "holistic training model", which is based on the Specific Adaptation to Imposed Demand (SAID) principle. Hatfield assumed that this "all in one" system would allow different components of a muscle cell to respond and adapt to various stimuli which are generated by high and low number of repetitions (reps) performed with different speed (fast and slow execution) and with different repeat intervals. Thus, Hatfield's approach was aimed at processing as many specific cell elements as possible in one training session in order to stimulate all these components (e.g., myofibrils, mitochondria, sarcoplasm and capillaries). In this context he raised his important "rule in the holistic approach" to training: Cell components that contribute most to muscle size should also be trained the most (26). Through this "all-in-one" training system (developed by Hatfield in 1984), high numbers of reps (i.e., 20–25) were intended to improve strength endurance by increasing the number of mitochondria in muscle cells and generating new capillaries. Moderate reps (i.e., 12–15) were thought to enhance cell plasma and to achieve muscle growth. Low reps (i.e., 4–6) with a heavy load should stimulate the myofibrils of muscle fibers and improve maximum power (26). An important advantage of this model may be due to the fact that the usually specific and time-consuming transition phase is not necessary afterwards (1, 2). Coaches therefore have the opportunity to continue then with the training of maximum strength, strength endurance, speed power and gain of muscle mass. Hatfield suggested the following execution types of reps: (a) explosive with short breaks between reps, (b) moderate with short breaks between reps, and (c) slow without break and with constant tension (26). To be mentioned, the HAT is also not suitable for beginners because heavy loads are usually implemented in the first week of workouts.

Comparison Between WUP and HAT and Differences

Characteristics of WUP and HAT in a mesocycle (3 weeks) are shown in table 1. In the example of WUP, the amount and intensity in week 1 are adjusted to the training goal of increasing ›

Table 1

Comparison of both models (HAT and WUP) in a mesocycle for one exercise (1, 2, 26). WUP=Weekly Undulating Periodization; HAT=Hatfield-system; RM=repetition maximum; Reps=repetitions.

		HAT				WUP			
WEEK	**SETS**	**REPS**	**METHOD**	**REST**	**GOAL**	**REPS**	**METHOD**	**REST**	**GOAL**
1	1+2	4-6 RM	Explosively (concentric: 0.75-1.0 seconds), with pausing between each repetition (maximum: 2 seconds).	5	Maximum power + muscle mass + speed power	4-6 RM	Speed of 1 rep: concentric phase: 1 second/eccentric phase: 2 seconds. No rest pauses through the entire set.	5	Maximum power + muscle mass
	3+4	12-15 RM	Moderate speed (concentric: 1-1.5 seconds), with a relaxation pause between each repetition (maximum: 2 seconds).	4	Muscle mass	4-6 RM	Same as in set 1+2	5	Maximum power + muscle mass
	5+6	20-25 RM	Perform each rep in a slow (concentric: 1.5-2 seconds), sustained fashion (i.e., keep continuous tension on the muscle throughout the concentric and eccentric phases of the movement). No rest pauses through the entire set	3	Strength endurance	4-6 RM	Same as in set 1+2	5	Maximum power + muscle mass
2	1+2	4-6 RM	Explosively (concentric: 0.75-1.0 seconds), with pausing between each repetition (maximum: 2 seconds).	5	Maximum power + muscle mass + speed power	12-15 RM	Speed of 1 rep: concentric phase: 1 second/eccentric phase: 2 seconds. No rest pauses through the entire set.	4	Muscle mass
	3+4	12-15 RM	Moderate speed (concentric: 1-1.5 seconds), with a relaxation pause between each repetition (maximum: 2 seconds).	4	Muscle mass	12-15 RM	Same as in set 1+2	4	Muscle mass
	5+6	20-25 RM	Perform each rep in a slow (concentric: 1.5-2 seconds), sustained fashion (i.e., keep continuous tension on the muscle throughout the concentric and eccentric phases of the movement). No rest pauses through the entire set	3	Strength endurance	12-15 RM	Same as in set 1+2	4	Muscle mass
3	1+2	4-6 RM	Explosively (concentric: 0.75-1.0 seconds), with pausing between each repetition (maximum: 2 seconds).	5	Maximum power + muscle mass + speed power	20-25 RM	Speed of 1 rep: concentric phase: 1 second/eccentric phase: 2 seconds. No rest pauses through the entire set.	3	Strength endurance
	3+4	12-15 RM	Moderate speed (concentric: 1-1.5 seconds), with a relaxation pause between each repetition (maximum: 2 seconds).	4	Muscle mass	20-25 RM	Same as in set 1+2	3	Strength endurance
	5+6	20-25 RM	Perform each rep in a slow (concentric: 1.5-2 seconds), sustained fashion (i.e., keep continuous tension on the muscle throughout the concentric and eccentric phases of the movement). No rest pauses through the entire set	3	Strength endurance	20-25 RM	Same as in set 1+2	3	Strength endurance

the maximum strength and muscle mass (6 sets with 4–6 RM), in week 2 to the training goal increasing muscle mass (6 sets with 12–15 RM) and in week 3 to the training goal increasing strength endurance (6 sets with 20–25 RM). Comparing this structure with that of HAT highlights the "all-in-one" system. Two of the 6 sets will be spent at achieving each of the 3 training goals within each training session. However, this means that the volume for each training session for each training goal covers only 2 sets (33%) compared to WUP (6 sets). HAT intends to achieve an additional goal compared to WUP representing the increase of speed power. For this, HAT provides different speeds to perform the concentric movements in set 1 and 2 (table 1). Compared to WUP, a special regulation of the pauses between the exercises and between the sets in the HAT could support achieving respective training goals (i.e., with pauses between each repetition (maximum: 2 seconds), no rest pauses through the entire set).

From a practical comparison experiment of HAT and WUP in trained adult males (9-week training period) it was concluded that both HAT and WUP programmes were highly effective in improving strength, but changes did not differ between programmes (1, 2). Furthermore, it was demonstrated that strength improvements by both periodization models occurred without remarkable changes in body mass (1, 2). If strength can be improved while body mass is maintained, strength relative to body mass (relative strength) will increase. This is a desirable outcome for athletes of weight class sports such as wrestling, boxing, judo or weightlifting. There are additional studies confirming these findings and conclusions (9, 14). No doubt, novelty and/or training variability are important factors for stimulating further strength development. When the work performed is equal, each periodized approach can be used to provide variety resulting in enhanced adaptation. However, careful consideration should be given to the training history and current training status of athletes. The feeling of effort, strain, discomfort, and/or fatigue experienced during resistance training are other important aspects to be considered. Athletes who used HAT perceived that their programme was more exhausting compared to athletes using WUP (1, 2, 7). From a practical perspective there are two important points in which HAT differs from WUP or other periodization models. First, there is no "temporary conditioning" in only one area of strength (e.g., maximum power, strength endurance, speed power) and therefore no "deconditioning" of the neuro-muscular system when the training load changes in a subsequent mesocycle. Second, HAT is an "all-in-one" system and does not change training goals throughout the entire training period. Thus, improvements of strength endurance, maximal strength or hypertrophy might be achievable without the usually necessary specific and time-consuming transition phase. However, it remains to be demonstrated in which athletes under which conditions these aspects would result in a more favorable outcome than the use of WUP.

Suggested Physiological Effects of Load, Volume, and Rest in Strength Training

As the physiological reasoning for specific training responses to both periodization models is rather weak, some more theoretical consideration are provided. To the question to what extent periodic structures in training with the goal of increasing of strength (maximum power, strength endurance, speed power) and muscle mass are fundamentally promising, no clear answers are available. This may at least partly be due to interindividual variability of responses, different assessment methods, and often similar training outcomes (14). Issurin (29) for example suggested that the endocrine status of athletes is strictly dependent on appropriate blocks such as voluminous extensive workloads combined with resistance training (accumulation), lower-volume intense training (transmutation), and event-specific precompetitive training (realization). In order to provide some possible physiological mechanisms, short considerations of cellular responses and molecular signalling pathways are discussed.

Load

Hypertrophy/specific fibre development to increase muscle mass, maximum power and speed power are primary goals of both models. The mechanistic target of rapamycin (mTOR) is considered as one of the main force-integrator in strength training being responsible for increased synthesis of major myofibrillar proteins through translation initiation and translation elongation (8). Basically, a high load (high-force contractions, high-frequency electrical stimulations) promotes phosphatidylinositide 3 kinases (PI3K)/Akt/mTOR signalling favouring muscle growth. Protein synthesis dependent myofibrillar hypertrophy is essentially limited to an increase of about 20% without satellite cell activation (31). As growth increases, satellite cells are activated, and their cell nuclei integrated into the skeletal muscle fiber (myofibrillar splitting) (31). It is believed that this happens to maintain the core/cytoplasmic ratio. Hatfield's hypotheses to include low reps (i.e., 4, 5, 6) with a heavy load to stimulate the myofibrils of muscle fibers and improve maximum power and moderate reps (i.e., 12, 13, 14, 15) to enhance cell plasma and to achieve muscle growth may actually follow these facts (26). Of course, the same would apply to WUP. However, there is one important difference; Hatfield recommends quite different times to rest because of his "all-in-one" system and this may trigger very complex physiological effects. Thus, it is difficult to say whether the effects are based on the aforementioned effects or not. On the other hand a low load (low-force contractions, low-frequency electrical stimulations) promotes Adenosine Monophosphate-Activated Protein Kinase (AMPK) activity favouring muscle endurance adaptation (3, 11, 15, 27, 47), because AMPK is known as a kind of energy sensor of the cell, as high AMP and low glycogen concentrations (i.e., markers of low cellular energy) activate AMPK (52). Furthermore, the activation of m-TOR may be inhibited by gradually increasing intracellular AMP concentration as well as glycogen depletion and the concomitant AMPK activation (4, 49). This mechanism makes it possible to block highly energy-dependent processes, such as protein biosynthesis when the energy consumption of the muscle cell is high or the glycogen stores are low (4, 49). The mitochondrial density of a muscle cell is controlled by the protein peroxisome proliferator-activated receptor-gamma coactivator (PGC) 1-alpha, which depends on the two enzymes AMPK and sirtuin 1 (Sirt1) (19, 46, 52). Hatfield's next hypothesis to include high numbers of reps (i.e., 20–25) was intended to improve strength endurance by increasing the number of mitochondria in muscle cells and generating new capillaries. Again, this mechanism should equally apply to HAT and WUP. Practice shows that HAT does not evoke more pronounced gains in strength endurance than WUP (1, 2). Because HAT contains similar intensive power-endurance units combined with hypertrophy, maximum power and speed power, the question arises as to whether this will then produce counterproductive effects or not (26, 27). In addition, it has to be noted that low load protocols might not recruit type II fibres (as suggested by the

size principle), unless the exercise is performed explosively and/or there is significant muscle fatigue (40). Fact is, that long-term strength training leads to substantial increases in individual fiber cross sectional area, whereby there is a larger increase in the area of fast twitch than slow twitch muscle fibers (32, 47). Type II fibers can reach larger sizes than type I fibres, but the distribution of ST to FT fibres is generally reported to remain unchanged with strength training (6). If intense strength training is carried out for longer periods, there is a shift within FT subtypes and an almost complete disappearance of type FTx fibers with a concomitant increase of type FTa fibers (17, 18, 32). These observations might partly support the hypotheses of Hatfield.

Volume

High volume training (multiple sets and rather low intensity) causes pronounced growth hormone (GH) and testosterone responses and thus favouring muscle growth (protein synthesis) but on the other hand, high volumes deplete glycogen stores and promote AMPK activity and consequently endurance effects (22, 27). However, the fact remains that a strategy of higher volume training (exercises, sets) per workout, even for a short period (i.e., 6 to 10 weeks), will result in higher maximum strength values in the lower extremities (1, 2, 34, 41, 45). These results suggest that "high volumes" (i.e., >4 sets) are associated with enhanced strength development (51), but that "moderate" volumes do not offer clear advantages.

Rest

Short rest periods between sets and exercises also promote GH increase and may be used to stimulate hypertrophy whereas long rest periods may maximize strength gains (47). Hatfield (26) suggests different pause periods in the "all-in-one" system. These pauses last between 0 to 2 seconds and between 3 to 5 minutes. The pause durations are always dependent on the training goal and the associated number of repetitions. Hatfield assumed that these different pauses would help to stimulate specific components (e.g., myofibrils, mitochondria, sarcoplasm and capillaries). Nevertheless, practice shows that HAT does not cause larger effect gains than WUP (1, 2).

Taken together, the great complexity (especially the inter-individual variable training responses) and the lack of specific comparative physiological studies do not allow identifying different effects between WUP and HAT based on differences in theoretically related mechanisms/signalling pathways. Both training programmes result in similar improvements and the fine-tuning of desirable effects is rather based on individual decisions of the coach/athlete than the knowledge of extremely complex interactions of signalling pathways.

Conclusion/Practical applications

The use of both models (WUP and HAT) is very effective as both are able to elicit significant increases in all types of strength especially in experienced athletes. The most impressive advantages of both periodization models are the large improvements within a relatively short time period (6 or 9 weeks) without plateau, without remarkable changes in body mass and without any adverse effects in already well-trained male subjects. This is of particular interest for all types of sports where strength should increase without gain in body mass (e.g., boxing, tennis, or wrestling, judo, rock climbing, etc.). However, there are no outcome differences that would potentially be expected by different training strategies and the associated different physiological mechanisms/signaling pathways. Thus, the decision to use WUP or HAT depends on the type of athlete because both periodization models rely on a very high volume of training. There is a somewhat higher level of perceived exertion with HAT, but if the athlete likes the structure of the programme (all-in-one) he/she will use HAT. In contrast, if the athlete likes rather changes from week to week, he/she will use WUP. From the perspective of the authors (who might be a bit biased), two advantages of HAT could potentially result from the "all-in-one" character of each workout: (a) a corresponding continuation or entry into the areas of gaining more strength and muscle mass requires no additional time for specific adaptation and (b) there is no "temporary conditioning" in only one area of strength (i.e., maximum power, strength endurance, speed power) and therefore no "deconditioning" of the neuro-muscular system when the training load changes in the subsequent mesocycle. The most important disadvantage to be mentioned when of using these periodization models might arise from the developing tiredness, potentially negatively affecting the technical and coordinative training. An interesting approach for the future would be to compare HAT with daily nonlinear periodization. There is some evidence that this is the most frequently used type of nonlinear periodization and that it might result in greater gains in strength compared to non-periodized programs (13, 51). Another aspect that could be considered in future research would be the integration of different periodization models into individual training plans as this approach may provide advantages over rigid periodization structures (13).

Finally, professionals concerned with designing optimal training programs for their athletes should primarily consider that the appropriate periodization model will be selected based on the individual training status and preferences.

Conflict of Interest

The authors have no conflict of interest.

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