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Original Article

The Hatfield-System versus the Weekly Undulating Periodised Resistance Training in trained males: Effects of a third mesocyle

MARKUS ANTRETTER, SEBASTIAN FÄRBER, LORENZ IMMLER, MATTHIAS PERKTOLD, DORIS POSCH, CHRISTIAN RASCHNER, FELIX WACHHOLZ, MARTIN BURTSCHER

Department of Sport Science, University of Innsbruck, Austria

ABSTRACT

We recently demonstrated that recreationally strength trained men, randomly assigned to either a Hatfield-System (HAT) group or a weekly undulating periodisation (WUP) group showed significant increases in strength and power during only 2 mesocycles (6 weeks) without differences between groups. The questions arise, whether an additional mesocycle would further enhance strength and power equally or differently between groups. The same 26 strength trained men, assigned to the HAT (n = 13; age = 26.8 ± 7.2 years) or to WUP (n = 13; age = 29.2 ± 9.0 years) performed an additional mesocycle (3 weeks). Anthropometric measures and strength testing were performed again after finishing the third mesocycle and were then compared with the results recorded after the second mesocycle. Both the HAT and WUP groups made significant ($p \leq 0.05$) increases in strength and power – to approximately the same extent, again, without significant differences between groups. Thus, HAT and WUP are similarly effective over a nine-week training period, and the decision to use HAT or WUP depends on the preferences of the individual athlete. **Keywords:** Hatfield-System, High volume, Periodisation, Strength training.

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Corresponding author. *Department of Sport Science, University of Innsbruck. Fürstenweg 185, Innsbruck 6020. Austria.*
E-mail: markus.antretter@gmx.at
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INTRODUCTION

In the first part of this study, anthropometric measures and strength testing were performed before (PRE), after six weeks (POST1) of training (Antretter et al., 2017). To subjectively quantify the individual's perception of the physical demands of the intensity of resistance training, a category-ratio scale (CR10) was used by the subjects after each training session. The participants of both groups trained twice a week for six weeks. The HAT and WUP programs used the same exercises, the same total training volume and the same total intensity in these nine weeks. The difference between the two programs was in the distribution of these parameters within each training phase. The HAT and WUP groups trained using a periodized strength programme with all programme variables controlled (e.g., volume and intensity).

The results in the first part showed that both the HAT and WUP groups made significant ($p \leq 0.05$) increases in strength and power. Both, the HAT and WUP group showed improvements in the different strength and power assessments (PRE to POST1) for one repetition maximum, repetition maximum with 40%, body weight squat jump, body weight countermovement jump, isometric leg extension test 120° right leg, isometric leg extension test 120° left leg, isometric leg extension test 85° right leg and isometric leg extension test (Antretter et al., 2017).

Most studies which have compared studies have compared periodized and nonperiodised training programmes directly between nine and 12 weeks to find out which form of periodisation (traditional or undulating) achieved greater effects in strength, power endurance and muscle size (Rhea et al., 2004; Fröhlich et al., 2009; Harries et al., 2015).

In relation to short-term interventions in the period of four to six weeks, the research results are indifferent or show no significant differences (Baker et al., 1994; Fleck, 1999; Schiotz et al. 1998). For example, Rhea et al. (2002) also found a significant difference favouring Daily Undulating Periodisation for strength improvement only in the first six weeks of the intervention; but no significant difference in strength gains between groups was found in the last six weeks of the intervention. The subjects were experienced (minimum 2 years). In the first part, Antretter et al. (2017) compared HAT and WUP – also for six weeks – with significant ($p \leq 0.05$) increases in strength and power. So the large improvements that were demonstrated in a relatively short time (6 weeks) in already strength-trained subjects are remarkable for determining whether a further increase in strength could be achievable through an additional mesocycle (3 weeks) or if the performance changes have already plateaued. It would also be interesting to see whether differences in the effects between groups would occur during continuation of HAT and WUP training because the first period which included only six weeks was very short.

The purpose of this study was to find out whether there is a further performance increase in two groups, which already made significant increases in strength and power during two mesocycles (6 weeks) of using the HAT and the WUP strength training after absolving a further mesocycle (3 weeks) without plateauing. Therefore, we hypothesised: (1) that further enhancement of strength and power without plateauing will be present using the HAT and WUP as well after performing a further mesocycle (3 weeks); and (2) that a potential difference with regard to strength and power development will be observed between the two groups.

MATERIAL AND METHODS

Methods have already been presented in detail elsewhere and will, therefore, be described here only in brief (Antretter et al., 2017).

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Subjects

Two groups of the same 26 healthy and resistance-trained men were randomly assigned to the HAT group, and 13 men were assigned to the WUP group. All of the participants had previous resistance training experience (≥ 1 year [range 1–10 years]) using free weight and machine resistance before the start of the study. Further details are shown in the first part of the study (Antretter et al., 2017).

Procedures

Testing sessions

Before initiating the nine-week training programme, the participants followed a one-week familiarisation programme in which the same tests were organised in circuits and performed to find the exact techniques of execution and loads. Subjects were assessed before (Pre-test: PRE), after six-week (Post-test 1: POST1), and nine-week (Post-test 2: POST2) training programmes. On the first day, the anthropometric assessments (body mass, height, circumference of thigh and skinfolds, the muscle cross-sectional area (CSA) were calculated with the Housh multiple regression (HMR) (Housh et al., 2007)) were performed at the beginning of each testing session and after the first part of the strength assessments (SJ = squat jump; CMJ = counter movement jump; ILT = isometric leg extension strength test). The second day (next day) included the second part of the strength assessments (1RM = 1 repetition maximum, RM40% = repetition maximum with 40% of the 1RM) (Antretter et al., 2017).

Resistance training protocols

The resistance training was performed by machine-loaded exercise movements (leg press, leg extension, leg curl) using identical devices from Technogym (Technogym, Gambettola, Italy) in three different gyms. Both groups had to absolve six sets on the leg extension machine, six sets on the leg curl machine and at least six sets on the leg press, twice a week (Monday and Friday) and always in this order to ensure that enough regeneration time was available. The basic control of the intensity levels was carried out by the range of numbers of the repetition in one set (goal repetitions) (Aagaard et al., 2007).

The workload distribution of the HAT programme for one workout while these three weeks has the following structure and the following characteristics. Set 1+2 (Reps: 4-6, Weight: Maximum), Set 3+4 (Reps: 12-15, Weight: Maximum), Set 5+6 (Reps: 20-25, Weight: Maximum) (Hatfield, 1984).

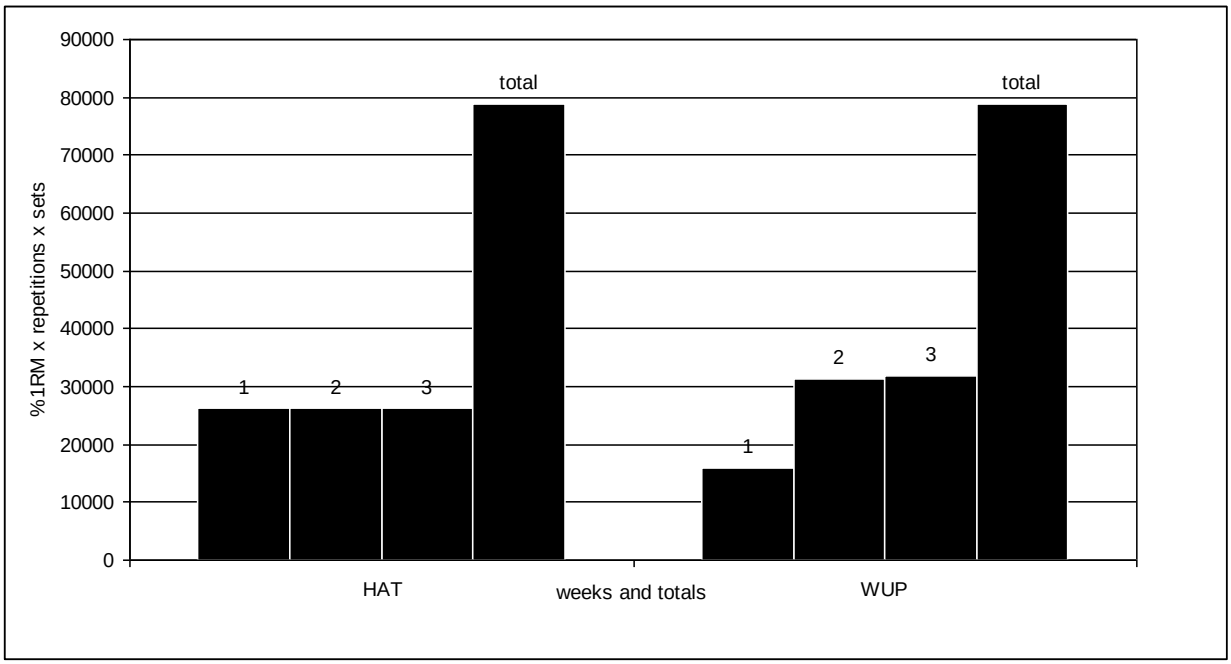
The WUP programme consisted of 3 weeks. During each week, training load progressed from a low volume and high intensity toward a high volume and low intensity. The training values for one workout for one exercise of WUP programme for each week are reported in Table 1.

Table 1. Training values for the WUP strength training program for each exercise*

	Week 1	Week 2	*Week 3*
Load dynamics	6 x 4-6 RM	6 x 12-15 RM	*6 x 20-25 RM*
Rest of set (min)	*5*	*4*	*3*

** WUP = weekly undulating periodisation; RM = repetition maximum.*

Strength training was carried out twice a week for 3 weeks. The training volume and training intensity were the same for both groups (Figure 1).



** HAT = Hatfield-system; WUP = weekly undulating periodisation; RM = repetition maximum.*

Figure 1. Training volume (% of 1RM x repetitions x sets) and intensity (% of 1RM) during three weeks provided in both groups (HAT and WUP)

Statistical analyses

The best out of three trials of 1RM, ILT, CMJ and SJ was recorded and analysed. First, the Shapiro-Wilk normality test was used to quantify the deviation of the actual data from a Gaussian distribution. Homogeneity of variance was calculated with the Levene test. Test requirements were fulfilled at a significance level of $p \leq 0.05$. A 2x2 (group x time) mixed factor ANOVA was used to analyse within group and interaction effects. All data analysis was conducted with IBM SPSS Statistics 21 programme.

RESULTS

The results showed that both the HAT and WUP groups made significant ($p \leq 0.05$) increases in strength and power. The improvements (relative percentage increases in %) for this further mesocycle (3 weeks) in the different strength and power assessments (POST1 to POST2) for 1RM (HAT = 14.5 ± 9.8%, WUP = 13.2 ± 12.1%), RM 40% (HAT = 9.4 ± 8.9%, WUP = 10.3 ± 16.8%), SJ (HAT = 3.4 ± 6.1%, WUP = 1.6 ± 9.1%), CMJ (HAT = 2.9 ± 8.8%, WUP = 2.2 ± 4.1%), ILT 120° right leg (HAT = 9.6 ± 12.5%, WUP = 10.4 ± 8.3%), ILT 120° left leg (HAT = 10.1 ± 5.5%, WUP = 12.1 ± 9.8%), ILT 85° right leg (HAT = 4.8 ± 8.5%, WUP = 5.3 ± 6.2%) and ILT 85° left leg (HAT = 4.7 ± 8.1%, WUP = 2.6 ± 8.2%). This result indicates that the first hypothesis has to be maintained.

Anthropometry

Within-group changes

The anthropometric data of HAT and WUP group are depicted in Table 2. Both the HAT and WUP group showed only small changes (relative percentage) in anthropometric measurements (POST1 to POST2). A significant main effect ($p \leq 0.05$) of time on CSA was found in the HAT group ($p = 0.047$, HAT = 1 ± 1.5%) but not in the WUP group ($p = 0.075$, WUP = 0.9 ± 1.5%). A significant main effect ($p \leq 0.05$) of time was

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found in the WUP group on Body mass (p = 0.044, WUP = 1.4 ± 2.2%) but not in the HAT group (p = 0.660, HAT = - 0.2 ± 1.4%) and on BMI (p = 0.039, WUP = - 1.3 ± 2.1%) and also not in the HAT group (p = 0.656, HAT = - 0.2 ± 1.4%). No other significant main effects of time were seen on the other anthropometric parameters.

Between-group changes

There were found significant differences between groups with regard to the anthropometric characteristics on Body Mass (p = 0.043) and on BMI (p = 0.037) (POST1 to POST2) (Table 2).

Table 2. Comparisons anthropometric measurements of both groups*

Anthropometric assessments		HAT (mean ± SD) N=13	WUP (mean ± SD) N=13	Within group effects HAT	Within group effects WUP	Interaction effects
Body mass (kg)	POST1 POST2	85.8 ± 10.4 85.7 ± 10.5	79.2 ± 10.2 80.4 ± 11.8	p = 0.660	p = 0.044	p = 0.043 F = 4.549 η^2 = 0.159
BMI (kg/m^2)	POST1 POST2	26.3 ± 3.4 26.3 ± 3.5	24.9 ± 3.1 25.4 ± 3.0	p = 0.656	p = 0.039	p = 0.037 F = 4.877 η^2 = 0.169
Right thigh circumference measurements (cm)	POST1 POST2	57.7 ± 4.7 58.1 ± 4.5	54.5 ± 5.6 54.9 ± 4.3	p = 0.165	p = 0.068	p = 0.700 F = 0.152 η^2 = 0.006
Thigh CSA (cm^2)	POST1 POST2	239.7 ± 20.3 241.9 ± 19.3	226.3 ± 16.8 228.3 ± 18.5	p = 0.047	p = 0.075	p = 0.422 F = 0.580 η^2 = 0.022

***** *HAT = Hatfield-system; WUP = weekly undulating periodisation; PRE = Initialtest; POST = Posttest; BMI = body mass index; CSA = muscle cross sectional area.*

Performance Assessments

The results of strength and power measurements of HAT and WUP group are depicted in Table 4.

Within-group changes

A significant main effect of time ($p \leq 0.05$) was found for 1RM (HAT: p = 0.000, WUP: p = 0.002), RM 40% (HAT: p = 0.007), SJ (HAT: p = 0.067), ILT right leg 85° (WUP: p = 0.050), ILT right leg 120° (HAT: p = 0.015, WUP: p = 0.013), ILT left leg 120° (WUP: p = 0.001). No significant main effect ($p \leq 0.05$) was found on time in RM 40% (WUP: p = 0.107), CMJ, SJ (WUP: 0.625), ILT right leg 85° (HAT: p = 0.4780), ILT left leg 85° (HAT: p = 0.074, WUP: p = 0.078) and ILT left leg 120° (HAT: p = 0.057). The improvements (relative percentage increases in %) in the different strength and power assessments are depicted in Table 3.

Table 3. Improvements (relative percentage increases in %) in the different strength and power assessments*

Strength assessments		PRE to POST 1 (%) (mean ± SD)	POST 1 to POST 2 (%) (mean ± SD)	PRE to POST 2 (%) (mean ± SD)
1 RM	HAT	20.1 ± 14.2	14.5 ± 9.8	37.9 ± 11.2
	WUP	16.6 ± 9.4	13.2 ± 12.1	31.9 ± 16.3
RM 40%	HAT	20.7 ± 20.6	9.4 ± 8.9	31.7 ± 22.6
	WUP	22.2 ± 14.4	10.3 ± 16.8	33.4 ± 16.6
SJ	HAT	8.1 ± 12.6	3.4 ± 6.1	11.8 ± 13.4
	WUP	11.3 ± 17.1	1.6 ± 9.1	12.3 ± 14.6
CMJ	HAT	9.1 ± 12.1	2.9 ± 8.8	12.3 ± 14.6
	WUP	4.5 ± 5.9	2.2 ± 4.1	6.8 ± 7.2
ILT right leg 85°	HAT	10.1 ± 14.2	4.8 ± 8.5	15.2 ± 16.1
	WUP	4.4 ± 18.7	5.3 ± 6.2	9.7 ± 18.7
ILT left leg 85°	HAT	6.4 ± 12.3	4.7 ± 8.1	11.6 ± 15.5
	WUP	20.2 ± 19.2	2.6 ± 8.2	22.6 ± 16.1
ILT right leg 120°	HAT	26.2 ± 22.2	9.6 ± 12.5	40.6 ± 26.7
	WUP	46.8 ± 37.3	10.4 ± 8.3	50.9 ± 22.8
ILT left leg 120°	HAT	23.5 ± 30.3	10.1 ± 5.5	45.4 ± 13.4
	WUP	50.8 ± 28.7	12.1 ± 9.8	67.5 ± 22.4

** HAT = Hatfield-system; WUP = weekly undulating periodisation; PRE = Initialtest; POST = Posttest; RM = repetition maximum; SJ = squat jump; CMJ = counter movement jump; ILT = isometric leg extension strength test.*

Between-group changes

No significant ($p \leq 0.05$) differences in the different strength and power assessments were noted at baseline among any of the groups (HAT and WUP) (Table 4). These results indicate that the second hypothesis has to be rejected.

Table 4. Results of strength and power measurements*

Strength assessments		HAT (mean ± SD) N=13	WUP (mean ± SD) N=13	Within-group effects HAT	Within-group effects WUP	Interaction effects
1 RM (kg)	POST1	398.4 ± 117.9	350.0 ± 98.9	p = 0.000	p = 0.002	p = 0.629 F = 0.239 η^2 = 0.010
	POST2	450.5.4 ± 112.5	395.3 ± 105.2			
RM 40% (Reps)	POST1	37.8 ± 8.2	33.7 ± 5.0	p = 0.007	p = 0.107	p = 0.973 F = 0.001 η^2 = 0.000
	POST2	45.0 ± 9.7	41.5 ± 9.4			
SJ (cm)	POST1	30.7 ± 4.3	28.9 ± 5.8	p = 0.067	p = 0.625	p = 0.374 F = 0.822 η^2 = 0.033
	POST2	31.7 ± 4.2	29.2 ± 5.7			
CMJ (cm)	POST1	38.4 ± 5.5	35.5 ± 5.3	p = 0.271	p = 0.081	p = 0.826 F = 0.049 η^2 = 0.002
	POST2	39.3 ± 5.8	36.2 ± 5.7			

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ILT right leg 85° (N)	POST1 POST2	1200.8 ± 217.5 1224.2 ± 196.5	1067.8 ± 266.5 1128.2 ± 197.6	p = 0.478	p = 0.050	p = 0.393 F = 0.757 η^2 = 0.031
ILT left leg 85° (N)	POST1 POST2	1097.9 ± 234.9 1142.8 ± 217.7	992.5 ± 264.2 1037.1 ± 201.0	p = 0.074	p = 0.078	p = 0.993 F = 0.000 η^2 = 0.000
ILT right leg 120° (N)	POST1 POST2	2739.1 ± 898.0 3224.6 ± 1204.6	1965.7 ± 607.3 3055.2 ± 628.7	p = 0.015	p = 0.013	p = 0.828 F = 0.024 η^2 = 0.001
ILT left leg 120° (N)	POST1 POST2	2688.7 ± 1017.8 3054.5 ± 1102.1	2598.1 ± 869.9 3017.4 ± 617.2	p = 0.057	p = 0.001	p = 0.787 F = 0.075 η^2 = 0.003

** HAT = Hatfield-system; WUP = weekly undulating periodisation; PRE = Initialtest; POST = Posttest; RM = repetition maximum; SJ = squat jump; CMJ = counter movement jump; ILT = isometric leg extension strength test.*

Psychophysical assessment

The RPE indicated a mean of 7.9 (SEM: 0.16) in the HAT group and a mean of 6.4 (SEM: 0.20) in the WUP. There is a mean difference of 1.5 (SEM: 0.14) in the rating of REP. This showed that the HAT group perceived that their programme was more exhausting than the WUP group. Compared to week 1-6, the HAT group's "more stressful" feeling has increased by 0.2 while it remained the same in the WUP group.

DISCUSSION AND CONCLUSION

In the first part of the study, Antretter et al. (2017) compared HAT and WUP for six weeks with significant ($p \leq 0.05$) increases in strength and power within groups. Only in the ILT left leg 85° (HAT: $p = 0.106$, WUP: $p = 0.055$) was there no significant main effect ($p \leq 0.05$) found for the time; but changes did not differ between groups. To find out whether there was a further performance increase in two groups of using the Hatfield-System (HAT) and the weekly undulating periodisation (WUP) strength training after absolving a further mesocycle (3 weeks); and discovering this difference between training programs was the purpose of this study. A second goal was to find out if a potential difference with regard to strength and power development was observed between the two groups. In the continuation again, a significant main effect ($p \leq 0.05$) was found for time in 1RM and the relative percentage for 1RM which increased from PRE to POST 1 – again increased for the further mesocycle (3 weeks) from POST1 to POST2. At least a constantly increasing of the relative percentage for 1RM from PRE to POST 2 while absolving the complete nine weeks was observed. Similar results were found in the other strength assessments (RM40%, SJ, CMJ, ILT 85°, ILT 120°).

Again, the findings indicate that both HAT and WUP programmes were highly effective in improving strength but changes did not differ between groups. But the high volume of training (18 sets for the legs, distributed (six sets each) over three exercises) which both groups performed could be a reason for the effects in this study because strength gains, muscular adaptations, as well as better sustainability of effects are directly related. However, the fact remains that a strategy of higher volume training (exercises, sets) per workout, even for a short period (e.g., 6 weeks), will cause higher maximum strength values in the lower extremities (Antretter et al, 2017; Krieger et al., 2010; Paulsen et al., 2003). The study of Robbins et al., (2012) also found out similar results in a period of 10 weeks. The objective of their study was to examine the chronic effects on lower-body strength in resistance-trained men of performing varying training volumes over 10 weeks. Participants were randomly assigned to three groups. An intensity-matched (80% of 1RM) low (1-

SET), moderate (4-SET), or high (8- SET) volume group. In addition to significant strength increases in all groups at the end of the six-week period, increases were observed at three weeks under the 4- and 8-SET groups, which were larger than the improvement under the 1-SET group. At six weeks and especially at 10 weeks, the magnitude of improvement was larger for the 8-SET group, as compared with that of the 1-and 4-SET group. The results suggest that ‘‘high’’ volumes (i.e.,>4 sets) are associated with enhanced strength development, but that ‘‘moderate’’ volumes offer no advantage. This means that strength development may be dependent on appropriate volume doses and training duration. In summary, a further enhancement of the parameters strength and power without plateauing was found, but no difference with regard to strength and power development was observed between the two groups. Therefore, the question arises again which changes would be expected if the training would continue.

PRACTICAL APPLICATIONS

Subjects in both groups showed significant increases in all types of strength despite the fact that they were already experienced in strength training. The most impressive advantages of both periodisation models are the large improvements within a short period of time (6 or 9 weeks) without plateau and remarkable changes in body mass. This could be a reason to use these programmes for optimal gain in maximal strength (relative strength) for all types of sports, where the capacity should increase but the body mass should not increase (e.g., boxing, tennis, or wrestling). The use of both models is very effective, but similar. The decision to use HAT or WUP depends on the type of athlete because the basic principle of both periodisation models is a very high volume of training. It has been found that there is a somewhat higher level of exertion with HAT. If someone likes the structure of the programme (all-in-one), then he or she should take HAT. Meanwhile, if someone likes changes from week to week, then he or she should take WUP. With both systems, it is possible to carry out a focus-like continuation in the area of maximum strength, strength endurance or hypertrophy, as it was trained in advance on a high level. A respective entry into these areas, therefore, does not require any time of specific adaptation in it. Where, from the perspective of the authors, a small advantage in the Hatfield system is recognisable because of the "all-in-one” character in each workout. The biggest disadvantage of using these periodisation models could be the tiredness during this period, which sometimes could have a big influence on the specific accompanying workout for the actual sport. There could also be disturbing influences in the technical and coordinative training in the form of motoric deficits during this time.

Future research should focus on the effects of resistance training volume on protein synthesis, and other cellular and molecular changes that may impact changes in anthropometry, strength and psychophysical values.

DEDICATION

Our special thanks go to Fredrick C Hatfield, who surprisingly passed away on 14th of May 2017 and who provided the impulse for this study with his famous training system. In memory of him we would like to dedicate these results to him.

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