Effects of Traditional and Reverse Periodization on Strength, Body-Composition and Swim Performance.

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Abstract: Periodization of athletic training is conceptualized as a pedagogical process, which involves varying volume, intensity and frequency of training in attempt to optimize sporting performance. The primary purpose of this research was to compare changes in 100m swim performance (t100c), Muscular Strength and Body-composition values after 14 weeks of training traditional periodization (control) and reverse periodization (treatment). There were 26 volunteer swimmers (16.02±0.6 yrs. 1.72±9.3 cm 64.1±9.3 kg) divided in two groups traditional periodization (TP) and reverse periodization (RP). Results at the 14th week showed significant improvements (p<0.05) in values of t100c (6.9%), Body-weigh (Bweigh 1.8%) and Maximal drag charge (MDC 10.0%) by RP above TP values. Moreover, TP exhibited substantial improvements in body composition decreasing significantly (p<0.05) fat mass. The results demonstrated that reverse periodization is specific and an efficient strategy of training for sprinters at time to economize load volume; traditional periodization is recommended option for improving physical appearance.

KEYWORDS: Reverse periodization, high-intensity, high-volume, threshold-training, body-composition, strength-training.

INTRODUCTION:
In the competitive sports, most of coaches and athletes, from beginners to elite level of competition, frequently organize their training program in a periodical plan in an attempt to maximize performance, achieved through correct balance of stress/recovery relationships. Periodization; has been described as a pedagogical process which including variations of volume, intensity and frequency of training in order to improve athletes’ sports performances.

A program of traditional periodization (TP) usually starts on a basic period by high volume of aerobic training and gradually altering the preparation by reducing the total amount of volume at time to increasing the intensity of the exercise into a period called competitive. In swimming training, the plan of TP adapted by Maglischo, Costill and Richardson (1992) includes four periods designated as follows: general endurance; specific endurance, competitive period and a taper period.

To date, there have been only a limited number of studies comparing different periodization models in competitive swimming and most of the researches are focused to compare TP to Block periodization program (BP) which is characterized by an accumulation mesocycle that demands a high volume training (HVT) performed at relative low-intensity followed by a transformation and realization blocks, the main characteristic of BP is a mesocycles more intensive and shortened of the TP. Both of them TP and BP model is often referred to as the “classic linear periodization model” or “block with linear increase”.

One of the characteristics of the TP often discussed is the HVT used in the general and specific endurance periods to prepare different distances of competition, also included training preparation of a sprinters. At this respect Costill, et al. (1991) reflects... Since the majority of the competitive swimming events last less than 3 min, it is difficult to understand how training at speeds that are markedly slower than competitive race pace for 3-4 hr/day, will prepare the swimmer for the supramaximal efforts of competition.

Swimming races being decided by only fractions of a second and many different training methods have been devised to improve performance. Currently it is known that short periods of high-intensity interval training (HIIT), with adequate resting time, it can produce similar initial adaptations to HVT endurance training.
In swimming training there are different versions of HIIT which has become popular; an example is the ultra-short race pace training (USRPT). Billat, (2001) explains how 10 seconds of workout at HIIT can be very easily balanced by rest periods of 10-20 seconds, maintaining the specific speed of sprint races for a longer time than endurance training. Moreover, well conducted studies have demonstrated that HVT has similar benefits and adaptations to HIIT, even reducing the amount of HVT.

Considering the lack of study comparing TP to BP models; reverse periodization (RP), introduced a paradigm that is completely opposite to the tendency of training load programmed by TP. the approach of reverse periodization, proposes first develop the competitive capacities based on the intensity, and then in a subsequent mesocycle expand the aerobic endurance.

Previous investigation in reverse periodization, noticed that while total workload remained constant between BP and RP programs, the direction of volume and intensity affects differently the swimming improvements throughout the total of ten weeks. The cited study concludes that: RP indicates success results in swimming performance, and BP appears preferred option to improve body composition values in moderately trained female swimmers.

The purpose of this research is compares change in 100m swim performance; strength and body composition values, after 14 weeks of training traditional periodization and reverse periodization.

**MATERIALS AND METHOD:**

**Participants**

The participants were recruited by regional competitive program with average 5 years of experience training for a competition. In this study there were 26 volunteer participants (16.02±0.6 yrs. 1.72±9.3 cm 64.1±9.3 kg) divided in two groups of 13 swimmers (5 women, 8 men each group); subjects did not report any characteristics that would impede their participation in high-intensity or high-volume swimming training. Each participant and his parents were informed about the porpoise of the study and possible risks before the investigation and signed an informed consent document approved by Castilla-La Mancha University’s ethics research committee. All procedures were in accordance with the Declaration of Helsinki. The control group participated in the traditional periodization program (TP) and the experimental group participated in the reverse periodization program (RP); this research lasted 14 weeks in which 5 assessments were made. They Consisted of a baseline (T1) and four post-tests: at 4th week (T2) at 8th week (T3) at 12th week (T4) and at 14th (T5).

**Testing protocols**

Volume and intensity were strictly controlled for both groups throughout the training program; in the same way that all participants received nutritional information and were required to do not eat food supplements during the study. An attempt was made to control physical activity outside of the training program. All subjects performed a familiarization with the various test and assessment tools, 2 days before the first test and beginning of the study.

(a) Test of Body Composition

We used a segmental multifrequency bioimpedance analyzer (InBody 720, Biospace Co. Ltd., Seoul, South Korea) to assess body composition and measurements. The “InBody 720” is a multifrequency impedance plethysmograph body composition analyzer, which takes readings from the body using an 8-point tactile electrode method, measuring resistance at 5 specific frequencies (1, 50, 250, 500 kHz, and 1 MHz) and reactance at 3 specific frequencies (5, 50, and 250 kHz) on each of 5 segments (right arm, left arm, trunk, right leg, and left leg).

Participants were instructed not to do any type of physical activity for 24 hours before testing. They were also told not to eat any food for 4 hours before the test to maintain a good hydration status, and then 30 minutes before beginning the tests, they were asked not to drink anything, not to urinate, and or defecate.

The participants stood barefoot in an upright position on foot electrodes on the instrument platform; both arms and legs were widely separated from each other. Four foot electrodes were used (2 oval-shaped electrodes and 2 heel-shaped electrodes), and participants were asked to grip the 2 palm-and—thumb electrodes (2 thumb and 2 palm electrodes per athlete). They did this barefoot and without any excess clothing.

The skin and electrodes were cleaned and dried before testing. In case of woman the phase of the menstrual cycle was also taken into account, and all testing were carried out during the estrogenic phase for a women participants. The body height was measured using a commercial scale.

We determined parameters of body-weigh (B(weig)): fat-free mass (FFM), and fat mass (FM). Data were electronically imported to Excel using Lookin’Body 3.0 software. The system was calibrated before each testing session.
(b) Stroke Force
Stroke force (Sforce) of arms, were measured on isokinetic swim bench (BioMeter®, Fahnemann; Hbg, Germany); this tool is described as generator producing an isokinetic resistance for swim-specific dry land training in 9 levels of acceleration in proportion to force applied by the user. Participants practice a single stroke in each resistance level in order to detect where resistance level the participant reaches the highest values of force. After five minutes of passive rest, the data was collected in the following procedure: the subjects were held in a position with a strap around their hips; the hands were placed in the paddles and the arms extended in horizontal position. Participants were encouraged to make three attempts at maximum effort with a minute rest between each attempt and recording the average as a sample.

(c) Swimming Performance
In each application of the tests all swimmers performed a warmup that consisted of 600m swim followed by rest period of 5 to 7 minutes before the test. The test consisted in a maximal 100m front crawl, performed in an indoor 25m swimming pool. Data times of 100m crawl (t100c), were recorded with a Colorado Timing System (Loveland, CO, USA) consisting in Infinity Start System INF-SSM; Aqua grip touchpad (188.5 x 90 cm) TP-188.5G and System 6 timing Console SYS6, and data was imported to a personal laptop with the Meet-Manager program of competition.

(d) Maximal drag charge
To obtain the variables of maximum drag charge (MDC) was required a concentric tool of tethered swimming training named Power-rack. The test’s protocol follows the next procedure previously described by Patnott et al. (2003) and Wright et al. (2009). Each participant used a belt connected to external weights load by non-elastic cable. The swimmer should start into the pool in a supine position, without any impulse of push out from the wall; then the participant swim 10 m maximum effort starting with the less load (15kg) and increasing load (10kg) in each try, participants resting in passive form almost 4 minutes between each repetition until is able to complete the distance test.

Training and assessment protocols
The participants commenced the study after summer period without training (figure 1). During the 14 weeks of training, five evaluations were applied, it’s comprises four mesocycles. Group of TP began its training program with aerobic general mesocycle ending at the 4th week (T2) and then aerobic specific mesocycle at the end of the 8th week (T3). Group of RP began its program of intensity period were train USRPT mesocycle (T1 to T2) and then HIIT (T3). Both groups perform identical volume and intensity during competitive mesocycle, at 12th week (T4); and taper mesocycle at 14th week (T5).

Subjects trained six days per week, in the initial period three sessions training was performed the main target of the period and three sessions performing complementary regenerative training; when they initiated the next periods, the participants

![Figure 1. Tendency of load distributions. Represents by total weekly volume in each period; LIT=low-intensity training; ThT=aerobic threshold training; HIT=high-intensive interval training.](image-url)
maintained one day per week training a session of the past period to avoid lost the precedent stimulation.

Three zones of training were required to control and quantify volume and intensity of training: \( T1 = \text{Low Intensity training (LIT)} < 2 \text{ mM/l.} \) \( T2 = \text{Threshold Training (ThT)} 2-4 \text{ mM/l.} \) and \( T3 = \text{High intensity of Training (HIT)} > 4 \text{mM/l.} \). Traditional periodization group swam in the 14 weeks a total of 324 km, the volume distribution was 228 km to LIT; 82 km to ThT; and 14 km to HIT. Reverse periodization group complete 212 km of total volume were, 104 km swam to LIT; 70 km to ThT; and 14 km to HIT.

**Statistical analysis**

Values are presented as mean ± SD. The normality of data was checked using Shapiro-wilk’s test. All variables presented normal distribution and homoscedasticity, and data was analyzed using analysis of variance for repeated measures (ANOVA) and between-group per moment comparisons with Tukey’s post hoc test. Significance level was accepted at \( p \leq 0.05 \); (Table 1).

### Table 1. Summary of assessments to 14 weeks.

<table>
<thead>
<tr>
<th>Group</th>
<th>Variable</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>% Change T1-T5</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>( B^{\text{weigh}} ) (Kg)</td>
<td>66.2 ± 1.7</td>
<td>66.9 ± 1.8</td>
<td>67.3 ± 1.9</td>
<td>66.8 ± 2.0</td>
<td>66.8 ± 2.1</td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>FFM (Kg)</td>
<td>30.6 ± 1.6</td>
<td>31.0 ± 1.6</td>
<td>32.0 ± 1.6</td>
<td>31.7 ± 1.8</td>
<td>31.7 ± 1.8</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>FM (Kg)</td>
<td>11.4 ± 1.7</td>
<td>11.5 ± 1.7</td>
<td>10.4 ± 1.5</td>
<td>10.4 ± 1.6</td>
<td>10.3 ± 1.6</td>
<td>↓ 10.6</td>
</tr>
<tr>
<td></td>
<td>( S^{\text{force}} ) (N)</td>
<td>99.75 ± 1.6</td>
<td>80.42 ± 3.4 *</td>
<td>98.25 ± 2.6</td>
<td>98.08 ± 3.3</td>
<td>104.33 ± 4.3</td>
<td>14.6</td>
</tr>
<tr>
<td></td>
<td>MDC (Kg)</td>
<td>49.7 ± 4.3</td>
<td>47.9 ± 4.3 *</td>
<td>49.5 ± 4.2</td>
<td>50.8 ± 4.1</td>
<td>51.4 ± 3.7</td>
<td>↑ 3.4</td>
</tr>
<tr>
<td></td>
<td>t100c (s)</td>
<td>61.6 ± 1.1</td>
<td>61.3 ± 1.0</td>
<td>61.2 ± 1.0</td>
<td>61.2 ± 1.1</td>
<td>61.3 ± 1.2</td>
<td>↓ 0.4</td>
</tr>
<tr>
<td>RP</td>
<td>( B^{\text{weigh}} ) (Kg)</td>
<td>60.8 ± 2.7</td>
<td>60.7 ± 2.5</td>
<td>61.4 ± 2.5</td>
<td>61.7 ± 2.5</td>
<td>61.9 ± 2.5</td>
<td>↑ 1.8</td>
</tr>
<tr>
<td></td>
<td>FFM (Kg)</td>
<td>28.4 ± 1.6</td>
<td>28.4 ± 1.5</td>
<td>28.8 ± 1.5</td>
<td>29.2 ± 1.6</td>
<td>29.2 ± 1.5</td>
<td>↑ 12.8</td>
</tr>
<tr>
<td></td>
<td>FM (Kg)</td>
<td>9.8 ± 1.2</td>
<td>9.5 ± 1.1</td>
<td>9.7 ± 1.1</td>
<td>9.2 ± 1.3</td>
<td>9.4 ± 1.3</td>
<td>↓ 4.2</td>
</tr>
<tr>
<td></td>
<td>( S^{\text{force}} ) (N)</td>
<td>72.92 ± 4.3</td>
<td>80.23 ± 5.1 *</td>
<td>80.06 ± 4.2</td>
<td>79.23 ± 2.4</td>
<td>80.02 ± 2.1</td>
<td>↑ 10.5</td>
</tr>
<tr>
<td></td>
<td>MDC (Kg)</td>
<td>45.7 ± 3.9</td>
<td>46.1 ± 3.9</td>
<td>49.6 ± 4.2</td>
<td>49.6 ± 3.4</td>
<td>50.3 ± 3.9</td>
<td>↑ 10.0</td>
</tr>
<tr>
<td></td>
<td>t100c (s)</td>
<td>62.7 ± 1.5</td>
<td>60.9 ± 1.4</td>
<td>59.1 ± 1.2 *</td>
<td>58.6 ± 1.5</td>
<td>58.6 ± 1.3</td>
<td>↑ 6.9</td>
</tr>
</tbody>
</table>

\(*=p<0.05 \text{ vs T1}; \; ^{\dagger}=p<0.05 \text{ vs T2}; \; ^{\ddagger}=p<0.05 \text{ vs T3}\) between-group comparisons.

TP=Traditional periodization; RP=Reverse periodization; \( B^{\text{weigh}} = \text{body-weigh}; \; FFM = \text{fat-free mass}; \; FM = \text{fat mass}; \; S^{\text{force}} = \text{Stroke force}; \; MDC=\text{Maximal drag charge}; \; t100c=\text{time 100m crawl}; \; T1=\text{baseline valuation}; \; T2=\text{evaluation after 4 weeks of training}; \; T3=\text{evaluation after 8 weeks of training}; \; T4=\text{evaluation after 12 weeks of training}; \; T5=\text{evaluation after 14 weeks of training}. \) The values were expressed by mean ± standard error of the mean.

**Results**

Results at the 14th week show significant \((p<0.05)\) differences between groups per moment of T1 to T5 in variables of: \( B^{\text{weigh}}, \; \text{FM, MDC and t100c}. \)

At inside-group assessments, group of TP increase significantly \((p<0.05)\) FFM in the T3 tests; at time to decrease significantly \((p<0.05)\) values of FM in T3, T4 and T5 assessments; \( S^{\text{force}} \) and MDC decrease significantly in T2. The rest of assessment parameter did not change significantly in this group.

Inside-group assessments of RP, increase significantly \((p<0.05)\) \( B^{\text{weigh}} \) in T3 compared to T1; forward is located new significant \((p<0.05)\) increases in T3 and T4 compared to T1 and T2 respectively.

FFM increase significantly \((p<0.05)\) in assessments T4 and T5 compared to T1.

FM decrease not significantly for this group.

\( S^{\text{force}} \) increase significantly \((p<0.05)\) in T2 assessment compared to T1.

MDC increase significantly \((p<0.05)\) in T4 compared to T1; and T5 compared to T1 and T2. This group set four times significant \((p<0.05)\) improvements of the variable t100c, at T2 compared to T1; further T3 and T4 compared to T1 and T2; and finally T5 compared respectively to T1, T2 and T3.
Discussion
Swimming Performance
The primary purpose of this research was to compare change in 100 m swim performance, muscular strength and body composition values, after 14 weeks of training traditional periodization and reverse periodization. Results show that reverse periodization produced highest improvements in 100 m swim performance than traditional periodization. The present study confirms the effectiveness of RP to improve performance for sprinters of 100 m.

Data on the performance in t100c between T1 to T5, show how the final results for both groups were highly influenced by the first period of training. The statistical data show how the main differences between groups were set among the first four weeks of training, at the mesocycles when aerobic training were performed for group of TP, and HIIT for group of RP. The best performance to TP was asset at the T3 assessment, subsequent evaluations is observed discrete no significant reductions on performance.

The experimental group RP reduce significantly (p<0.05) every assessment after the baseline (figure 2).

RP group obtain better results mainly attributed to the strategy of began the program from the USRPT and HIIT; this results coinciding partially with previous researches showing how HIIT would be trained at the beginning of a cycle preparation and the assimilation occurs in less time than the aerobic period of volume training, at same time than differs of cited studies about that, in the present study HIIT appears as a better strategy to prepare sprinters of 100 m compared to HVT.

Muscular Strength Values
We found low correlation of between variables of muscular strength (S\text{force} & MDC) at the beginning r=0.42 and at the end of the study r=46. That could be attributed to the inclusion of the legs work at moment to test MDC different to the S\text{force}, were tested arms stroke. However, these two variables offer an important support about the comparison of HIIT to HVT.

TP group begun the program by the HVT after this 4 weeks of training (T2) the values decrease significant (p<0.05) for the S\text{force}; and not significantly reduction of the MDC. Than may be interpreted as: HVT affects negatively the muscular

Figure 2. Swimming Performance comparison; \( \hat{r} = p<0.05 \) for between-group comparisons.
strength. On the other side of the comparison, RP group increase significantly (p<0.05) for the Sforce, and not significantly the MDC.

The HIIT, is the recommended workout training for improving the two aerobic and anaerobic metabolic functions as well as muscle buffering capacity and lactate tolerance, as explained by Maglischo. The first stage of adaptation is a neural reorganization of physical resources, which translates into improvements in speed movement in the training activity. This “reorganization” is represented in the brain and muscle fibers as a new pattern of movement.

Some studies explain how these improvements come from adaptations of the nervous system during speed or strength intensive training. These improvements occurring in both, transmission from the central nervous system and responses such as a reflex-type level of the spinal cord with an increase of an agonist muscle activation and antagonist muscle relaxation; these may explain the increases in the Muscular Strength Values for the RP group.

Elite swimming races of 200m and less, are completed in less than two minutes, nevertheless traditional programs expend 12 or 18 hours per week swimming excessive training volumes, with more than 75% of this volume expended under the aerobic threshold. Some experts believe that, this low intensity training is the main weakness that causes extreme stroke rate reductions.

Body-composition
At the present research, although both groups increase Btexthigh by the increases of FFM and reductions of FM; results of the 14 weeks show significant (p<0.05) in the FM reduction for the TP above the RP at the comparison group per moment.

These results provide substantial information about prescription of training programs and exercise metabolisms. The TP perform 4 weeks aerobic low-intensive training (T1 to T2) and aerobic intensive training (T2 to T3) during the execution of these two periods of training the group increase FFM with significant (p<0.05) improvements for the T3 assessment at time to reduce significantly (p<0.05) FM near to the total 10,6% reductions for the 14 weeks.

Some relevant finding of the present research is that: at the moment to increase the intensity of training for TP group, into the competitive period and taper period the reduction of FM maintains similar and less values at time to FFM were affected and partially reducing the improvements registered at the end of the 12th week (T3).

These variations in body-composition values are similar to previous researches; Wilmore and Costill, 1988; explained it this way "... increases in exercise intensity are often accompanied by swelling and muscle pain like a similar experiencing a sedentary subject to Launch in physical activity. This soreness is caused by micro-cracks in the Z band, responsible for muscle contraction ". However, consider that there is no scientific consensus because the investigations of muscle damage caused by prolonged exercise have been studied mainly in laboratory animals and still are limited research involving human beings, however these experts They have expressed that, these symptoms are result of physical over-training. It is also believed that there is a common denominator associated with significant levels of fatigue and muscle catabolism; characterized by a decrease in the capacity to generate ATP coupled with high metabolism thereof; accompanied by high concentrations of lactate and depletion of phosphocreatine.

These statements are by Wilmore and Costill, who also observed how swimmers over-trained at moment to resting recorded high levels of lactic acid performing technical errors associated with overtraining and possibly modified technique with the intent to keep pace of swimming training.

While acute fatigue is a necessary element in the training process in order to achieve improved states of athletic performance, has to take care to avoid chronic fatigue that is a consequence of particularly muscular organic catabolism caused by overloading training or by an inadequate recovery between training sessions.

Values obtained in fat reduction of the TP group are highest (10,6% vs 8,4%) than the data presented by Sideraviciute et al. for a same period study of 14 weeks. Differences could be attributed to the inclusion of HIIT into the preparation to TP group and to training six sessions per week. The study by Sideraviciute et al. (2006) is similar in terms of 14 weeks. But differs to the present study in practice and workout; participants of the cited study trained two times per week, at a moderated aerobic training pace (LIT).

Data collected of RP group are discrete compared to TP for the FM reduction (4,2% vs10,6%), in this RP group values show significant (p<0.05) increases in FFM for the T4 and T5 assessments. That could be interpreted as the reverse periodization plan were optimal of the experimental group at time to the high
volume of training for the traditional periodization was exhaustive for the respective group.

The processes of periodization are accompanied by changes in body composition, in some cases anthropometric measures may be related to performance, but in a previous study it was concluded that lean body mass appears to influence swimming performance, while body fatness is relatively unimportant.

Thomas, et al. consider that is beneficial for the swimming performance increase the volume of training previously to the taper reduction but at same time is required more time of taper period (21-28 days) to express the benefits by the overload work; at this respect we can see by the results how the strategy of volume modulation for TP was exhaustive and apparently the moderate volume of RP was better option. Most of swimming training programs based on a HVT expects improvements after the taper period. The present and previous studies show that aerobic HVT does not always result in improved competitive performances after reducing the workload period.

The results exhibit at the present study support the conclusions expressed of Rhea et al. the cited author didn't find significant differences between groups comparison of traditional periodization, daily undulating periodization and reverse linear periodization. However, the authors concluded that making gradual increases in volume and gradual decreases in intensity was the most effective program for increasing muscular endurance.

Furthermore, Ebben et al. demonstrated how a similar type of training than reverse periodization (reverse step load) is apparently better option to improve endurance performance for female varsity rowers relatively untrained. Otherwise a previous research accomplished from Arroyo-Toledo et al. appear concordant to the present study displaying how reverse periodization is an optimal option to develop swim performance at time than traditional periodization in a block or linear plan, appears better option for a body composition values.

The data obtained at the present study differs to the findings of a research conducted by Prestes et al. cited authors, compared linear and reverse linear periodization to determine the effects on maximal strength and body composition in previously trained women and exhibit a Traditional periodization plan, represented more positive effects on body composition and maximal strength when intensity was between 4 and 14 RM and participants were untrained for a period of six months prior to begin workouts. In that case we can consider traditional periodization is the option to train swimmers and athletes in all range of sports when they have been inactive for a long period.

The present research confirms how HVT has not advantage above HIIT, similar than previous studies, and confirms how short periods of HIIT, with adequate resting time, produce similar and better initial adaptations than high volume of traditional endurance training, coinciding with Gibala, et al. statements. Future studies would replicate the present research including a higher number of participants to compare results.

CONCLUSION
With these results is concluded: reverse periodization planning is specific and efficient strategy for training sprinters 100 m at time to economize load volume; moreover, 14 week of traditional periodization of swimming training, ends with a great reductions of fat mass. Farther, high volume of training. Does not always result in improved competitive performances and does not show superiority to High-Intensive Interval Training.


[8] Sperlich, B. Haegle, M. Heilemann, I. Zinner, C. De Marees, M. Achtzen, S. and Mester, J. High-intensity interval training improves VO2peak, maximal lactate accumulation, time trial and competition performance in 9–

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