# A reduction in training volume and intensity for 21 days does not impair performance in cyclists

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**Abstract**

***Objectives*—(*a*) To investigate the effects of reduced training on physical condition and performance in well trained cyclists; (*b*) to study whether an intermittent exercise programme would maintain physiological training adaptations more effectively than a continuous exercise programme during a period of reduced training.**

***Methods*—Twelve male cyclists participated in a 21 day training programme and were divided into two training groups. One group (age 25.3 (7) years; weight 73.3 (5.7) kg; $VO_2$MAX 58.6 (4.5) ml/kg/min; means (SD)) underwent a continuous endurance exercise training programme (CT) whereas the second group (age 22.8 (3.5) years; weight 74.1 (7.0) kg; $VO_2$MAX 59.7 (6.7) ml/kg/min) followed an intermittent endurance exercise training programme (IT). During this reduced training period, both groups trained for two hours a day, three days a week.**

***Results*—Neither group showed changes in maximal workload (WMAX) (4.6 (0.5) *v* 4.8 (0.5) W/kg and 4.6 (0.5) *v* 4.7 (0.6) W/kg for the CT and IT group respectively) and $VO_2$MAX (58.6 (4.5) *v* 60.1 (5.8) ml/kg/min and 59.7 (6.7) *v* 58.8 (7.5) ml/kg/min for the CT and IT group respectively). During the submaximal steady state exercise test, substrate use and heart rate remained unchanged after reduced training.**

***Conclusions*—These results indicate that well trained cyclists who reduce training intensity and volume for 21 days can maintain physiological adaptations, as measured during submaximal and maximal exercise. An intermittent training regimen has no advantage over a continuous training regimen during a detraining period.**

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In order to improve endurance performance, some athletes reduce their training load for 6–21 days before a major event,[1 2] a training technique known as tapering. Planned tapering generally consists of high intensity exercise, but with low volume. After a planned period of tapering, increased performance has been shown in several studies on swimmers,[2–6] runners,[7–10] and cyclists.[11 12] On the basis of these studies it has been concluded that a low volume high intensity taper programme may enhance performance.[10 11 13 14] Such a tapering period is usually planned and included in the training programme. However, athletes are sometimes forced to reduce both training volume and intensity for several weeks because of illness, injury, or for other reasons. Although scientific studies are lacking, athletes and coaches are concerned that such low intensity exercise may result in a decrement in physical conditioning and performance, as shown in some detraining studies.[8 13 15 16] However, these studies reduced training volume but maintained high intensity. Therefore the first aim of this study was to investigate whether cyclists who reduce their training volume by 50% and also reduce the intensity for 21 days can maintain physical performance capacity. The second aim was to investigate whether an intermittent training programme has any advantage over continuous exercise when both training volume and intensity are reduced. As endurance training and detraining may be reflected in changes in relative fat oxidation during exercise, changes in the rate of fat oxidation after a period of reduced training were also studied.

## Materials and methods

### SUBJECTS

Twelve well trained male cyclists aged 24 (5) (mean (SD)) years participated in this study. All testing and training procedures were approved by the medical ethics committee of Maastricht University, and an informed consent form was signed by all participants. Table 1 gives the physical and training characteristics of the subjects at the start of the study.

### GENERAL DESIGN

To create a realistic reduced training scenario, 12 well trained non-elite cyclists were recruited who were fully prepared for a competition season.

The training status of every subject over the preceding two months and the training history were obtained by questionnaire, training log, and personal interview. We considered the subjects to be well trained if they had trained

*Table 1 Physical and training characteristics of cyclists at start of the study (maxtest 1)*

| | *CT* | *IT* |
|---|---|---|
| Age (years) | 25.3 (7.0) | 22.8 (3.5) |
| Height (cm) | 181.8 (6.1) | 187.5 (5.3) |
| Weight (kg) | 73.3 (5.7) | 74.1 (7.0) |
| Percentage fat | 12.4 (2.5) | 12.8 (2.7) |
| Fat-free mass (kg) | 64.1 (4.6) | 64.6 (5.4) |
| Maximal power output (W/kg) | 4.5 (0.46) | 4.5 (0.54) |
| $VO_2$ MAX (ml/kg/min) | 58.4 (5.5) | 59.2 (4.8) |
| Lactate threshold (% $VO_2$ MAX) | 68.7 (3.0) | 67.6 (4.9) |
| Years of training | 6.0 (2.1) | 7.5 (4.2) |
| Training volume (hours/week)* | 15.6 (1.1) | 16.1 (1.5) |

Values are mean (SD); n=6 cyclists per group.
*Training volume over the two months preceding the start of the study.
CT, Continuous training programme; IT, intermittent training programme.

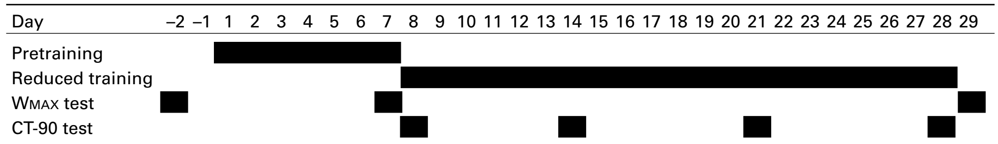


*Figure 1 Schematic overview of study design.*

for at least five years, two hours a day four to five times a week. Only subjects who met these criteria were included in the study. Two days before the start of a seven day pretraining period, each subject performed a maximal cycle ergometer ride (maxtest 1) to determine maximal workload (WMAX) and maximal oxygen uptake ($VO_2$MAX). This test was repeated at the end of the pretraining week (fig 1). After this WMAX test, the subjects were assigned to either the intermittent exercise training group (IT group, n = 6) or the continuous exercise training group (CT group, n = 6). To obtain comparable groups, subjects were matched for weekly training volume (hours/week), training history (years of training), age, and $VO_2$MAX.

To familiarise subjects with the laboratory procedures and give added training stimulus, all subjects underwent a seven day training period before the 21 day experimental period, which consisted of three hours training a day at an intensity of 80% $VO_2$MAX. WMAX tests were performed immediately before the 21 day reduced training period (maxtest 2) and at the end of the period (maxtest 3) (fig 1).

During the study, training volume was reduced to 50% of each subject's average normal weekly training volume (hours/week).

On days 7, 14, 21, and 28, the subjects performed a 90 minute steady state indirect calorimetry cycle test (CT-90) (Excalibur, Lode, Groningen, The Netherlands) at their individual lactate threshold so that substrate use during exercise could be studied. Gas exchange was measured at 8, 33, 58, and 83 minutes after the start of exercise while the subjects were temporarily connected to a metabolic system (Oxycon Beta, Jaeger Mijnhardt, The Netherlands) for seven minutes per measurement.

The subjects completed the whole training programme (pretraining and 21 day reduced training) in the laboratory under supervision. Training sessions were performed on calibrated electrically braked cycle ergometers (Excalibur or Recordtrainer; Avatronic Systeme, Leipzig, Germany).

### TEST PROCEDURES

All tests were performed between 0800 and 1000 after an overnight fast. The subjects were requested to maintain their normal diet and abstain from training on the day before a laboratory test.

### WMAX TEST

To determine submaximal and maximal metabolic and cardiorespiratory capacity, an incremental exercise test was performed on an electrically braked cycle ergometer (Excalibur). The initial workload of the WMAX test was set at 95 W and thereafter increased by 35 W every five minutes until volitional exhaustion. WMAX was defined as the last completed workload (W) plus the fraction of time spent in the final work rate multiplied by 35 W.[17] During the test, gas exchange (Oxycon Beta) and heart rate (Sporttester; Polar, Oy, Finland) were measured continuously. Before each test, the respiratory gas analyser was calibrated using certified calibration gas (carbon dioxide 3.994 (0.040)% (v/v); oxygen 15.99 (0.16)% (v/v); nitrogen 80% (v/v)), and flow volume accuracy was checked using a 3 liter syringe (Hans Rudolf Inc, Kansas City, Kansas, USA). In addition, venous blood samples for lactate determination were collected during the WMAX tests. These samples were collected immediately before the start of the WMAX test, during the last 30 seconds of every stage, and immediately after the end of the test. the samples (1 ml) were collected in heparinised tubes, centrifuged, and the plasma frozen at −20°C until analysed for lactate on a semiautomatic analyser (Cobas Fara; La Roche, Basel, Switzerland). Lactate levels were used to estimate training intensity and to evaluate training effects in both groups.

### INDIRECT CALORIMETRY

Because one of the effects of endurance training is a shift from carbohydrate to fat metabolism, reduced training may yield the opposite effect. For this reason, substrate use during exercise was measured. Indirect calorimetry was used for this over a 90 minute steady state cycle test (CT-90). The initial exercise intensity during this test was set at the subject's lactate threshold[18] minus 5% obtained during the second WMAX test (maxtest 2). Subjects were instructed to maintain pedalling cadence at 85–95 rpm during all four tests. Gas exchange was measured at 8, 33, 58, and 83 minutes after the start of exercise. Each measurement lasted seven minutes. Expired gases were autoanalysed, and averages calculated over eight breaths (Oxycon Beta). Before each test, the gas analysers of the Oxycon Beta were calibrated.

From respiratory $VO_2$ and $VCO_2$ measurements, rates of oxidation of carbohydrate and fat during each seven minute period were calculated using the non-protein respiratory ratio.[19]

$$\text{Fat oxidation rate} = 1.695VO_2 - 1.701VCO_2$$

$$\text{Carbohydrate oxidation} = 4.585VCO_2 - 3.226VO_2$$

with $VO_2$ and $VCO_2$ in l/min and oxidation rates in g/min.

The mean amount of fat oxidation of these four measurements was used to examine changes in fat oxidation during the reduced training period. Heart rate was measured continuously during the CT-90 test. The CT-90 tests were part of the reduced training programme.

*Table 2 Overview of maximal and submaximal data obtained before (maxtest 2) and after (maxtest 3) the taper period*

| | *Continuous training* | | *Intermittent training* | |
|---|---|---|---|---|
| | *Maxtest 2* | *Maxtest 3* | *Maxtest 2* | *Maxtest 3* |
| At 165 W | | | | |
| Heart rate (beats/min) | 133 (11) | 133 (11) | 134 (16) | 136 (15) |
| Lactate (mmol/l) | 1.4 (0.4) | 1.4 (0.3) | 1.7 (0.6) | 1.2 (0.2) |
| Oxygen uptake (ml/kg/min) | 29.9 (1.4) | 27.5 (3.7) | 30.6 (3.8) | 29.5 (4.6) |
| At 270 W | | | | |
| Heart rate (beats/min) | 172 (8) | 169 (11) | 169 (14) | 166 (21) |
| Lactate (mmol/l) | 5.0 (0.4) | 3.9 (0.3) | 4.9 (0.3) | 4.0 (0.9) |
| Oxygen uptake (ml/kg/min) | 47.9 (7.4) | 47.6 (8) | 47.5 (3.8) | 47.4 (5.3) |
| Maximal | | | | |
| Heart rate (beats/min) | 192 (6) | 193 (5) | 196 (3) | 195 (4) |
| Power output (W/kg) | 4.6 (0.5) | 4.8 (0.5) | 4.6 (0.5) | 4.7 (0.6) |
| Oxygen uptake (ml/kg/min) | 58.6 (4.5) | 60.1 (5.8) | 59.7 (6.7) | 58.8 (7.5) |

Values are expressed as mean (SD).

#### PRETRAINING PROGRAMME

Before the reduced training period, the subjects followed a seven day controlled endurance training programme, in which they had to train for three hours a day at an intensity of about 80% of the individual WMAX obtained in the first WMAX test (maxtest 1).

#### REDUCED TRAINING PROGRAMME

During the 21 day reduced training programme, training volume and frequency were reduced by 50% and 20% respectively. The programme consisted of training for two hours a day on three days each week (CT-90 not included). To define exercise intensity during this period, the lactate curves obtained during maxtest 2 were used to determine the lactate threshold as described by Farrel *et al*.[18] The exercise intensity for the CT group was equal to the lactate threshold minus 5%. The average exercise intensity in the CT group corresponded to 68% $Vo_2$MAX. For the subjects in the IT group, the individual lactate threshold point minus 5% was also calculated. Subjects performed an alternating training programme at an exercise intensity of 10 minutes at 15% below and 10 minutes at 15% above this point. The mean exercise intensities were 53% and 83% $Vo_2$MAX respectively. The mean work output per training session was the same for both groups.

#### STATISTICAL ANALYSIS

The results are presented as mean (SD). The effect of training reduction on maximal and submaximal variables within each training group was analysed by a repeated measures two way analysis of variance. When a significant difference was observed, a post hoc Scheffé F test was performed to determine the location of the significant differences. Significant differences between the two training groups for performance was determined using an unpaired t test. A p value of less than 0.05 was regarded as significant.

*Table 3 Mean heart rate and mean rate of fat oxidation before (day 0), during (day 7 and day 14), and at the end (day 21) of the reduced training period*

| | *Day 0* | *Day 7* | *Day 14* | *Day 21* |
|---|---|---|---|---|
| Continuous training group | | | | |
| Mean heart rate (beats/min) | 145 (2) | 145 (30 | 145 (1) | 145 (1) |
| Mean rate fat oxidation (g/min) | 0.40 (0.10) | 0.49 (0.12) | 0.47 (0.17) | 0.47 (0.09) |
| Intermittent training group | | | | |
| Mean heart rate (beats/min) | 148 (3) | 145 (1) | 141 (1) | 144 (2) |
| Mean rate fat oxidation (g/min) | 0.54 (0.07) | 0.54 (0.09) | 0.57 (0.08) | 0.51 (0.14) |

Values are expressed as mean (SD).

## Results

All subjects completed the whole study, and data from all subjects were included in the analyses. There were no significant differences between selected characteristics among the subjects (table 1).

No significant differences were found within or between the groups for WMAX and $Vo_2$MAX obtained in the three WMAX tests. The reduction in training volume and intensity had no effect on submaximal oxygen uptake ($p<0.43$) and heart rate ($p<0.27$) within or between the two groups (table 2). Table 3 displays the data obtained during the CT-90 test. Neither group showed a difference in the rate of fat oxidation after seven, 14, or 21 days of training reduction. In addition, no changes in mean heart rate were found during the CT-90 test.

## Discussion

This study examined the effects of two different training programmes in which both the volume and intensity were reduced for 21 days. To ensure a similar training state in the athletes before the intervention, a seven day high intensity training programme was followed. This programme had no effect on mean WMAX and mean $Vo_2$ max. Therefore it could be expected that a reduction in the weekly training intensity to maximal 68% and 83% $Vo_2$MAX for the CT group and IT group respectively and a 50% and 20% reduction in training volume and frequency respectively might induce detraining effects.[13] However, it was found that mean WMAX and mean $Vo_2$MAX in the incremental cycle test did not change over the 21 day period with reduced training. This is an important finding, because, in previous studies on the effects of reduced training volume that reported that WMAX and $Vo_2$MAX were maintained for 10–28 days in trained endurance athletes,[3–5 8 9 12 15 20] the training intensity was maintained or even increased. An important finding of the present study is that WMAX and $Vo_2$MAX can be maintained in well trained cyclists for a period of three weeks, by reducing both volume and intensity to <70% $Vo_2$MAX. This contradicts the findings of Hickson *et al*,[13] who concluded that a high training intensity (70–100% of the normal training load) is an essential requirement for maintaining physiological adaptations gained by endurance training.

Changes in performance capacity may be reflected in changes in the physiological response of heart rate and respiratory expiration ratio (RER) during exercise.[21–23] The results in our study do not support these findings, as there was no significant ($p<0.24$) change in submaximal and maximal heart rate during the incremental cycle test or the CT-90 test. Also no changes in RER during submaximal exercise were found. An increase in RER during submaximal and maximal exercise has been shown after periods of reduced training and detraining, indicating a shift towards an increased reliance on carbohydrate during exercise.[8 9 22] In our study, on the basis of RER values, no differences in substrate use and rate of fat oxidation were found in either of the two training protocols throughout the 21 days of reduced training. This indicates that a 50% reduction in weekly training volume, with a reduction in training intensity for three weeks, does not necessarily affect performance characteristics in cyclists. One of the aims of this study was to investigate whether intermittent exercise had different effects on performance characteristics from continuous exercise. As the effect on performance was not different between the two exercise regimens, it can be concluded that an intermittent training programme has no advantage over a continuous training programme on performance characteristics.

To summarise, this study shows that well trained cyclists who reduce training volume, frequency, and intensity can maintain their submaximal and maximal performance level for a period of at least 21 days. In a reduced training period, intermittent exercise has no advantage over continuous exercise. These findings may have practical relevance, especially for athletes forced to cut down their training intensity for some reason.

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**Take home message**

Reduced training for 21 days does not affect performance level and fuel use in well trained athletes.

# Commentary

Often during the course of a season, but always during the final preparation for a championship event, reductions in training occur. Athletes may look positively upon these reductions in training if a championship event is at hand, but negatively if the reductions are due to illness or injury. Whichever the case, high intensity intermittent exercise has always been recommended over low intensity continuous exercise. In this study, male competitive cyclists performed 21 days of reduced training using either high intensity intermittent or low intensity continuous exercise. Both training programmes resulted in maintenance of exercise performance during submaximal and maximal exercise. As both an exercise physiologist and a coach of triathletes, I have worked with athletes who would rather perform high intensity incremental exercise and those who would rather perform low intensity continuous exercise in preparation for a championship. The results of this study show that both types of reduction in training are appropriate, and thus final preparation can be tailored by the coach for each athlete, with comparable results. Likewise, enforced time off during the season, although never looked upon as a positive, should not be viewed as a total negative if low intensity continuous exercise can be maintained throughout.

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