
Research article

OPTIMIZING PHYSIOLOGICAL AND PERFORMANCE OUTCOMES USING RECOVERY STRATEGIES AMONG JUNIOR CYCLISTS

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Abstract

Journal of Sports Science and Physical Education 2(1): 1–10, 2014 - The aim of this study was to investigate the effects of a two week reduction in training load on selected physiological and performance among junior cyclist. Twenty seven male junior cyclists (age= 16.6±0.7 years, height=165.6±6.1 cm, weight= 54.1±8.1 kg) were matched into either the control group (n=13) or the experimental group (n=14) using their initial VO_{2max} values. Both groups followed a 12-week progressive endurance training program and subsequently, the experimental group (EXP) engaged in a two week tapering (recovery via a reduction in training loads) phase. The control group continued with their normal training routine. A simulated 20 km time trials performance and a graded exercise test on cycle ergometer were performed before and after endurance training and after the two week tapering protocol. Following the conclusion of the two week intervention or no intervention program both groups undertook a TT_{20km}. Results showed no significant difference in the TT_{20km} performance. Compared to the CON group, the EXP group showed significant changes in all the selected physiological variables tested, $p<0.05$. We conclude that a reduction in training loads can enhance recovery and benefit subsequent exercise sessions and competitions.

Keywords: Junior cyclists, reduced training workload, exercise performance

Introduction

Athletes, coaches, and sport scientists throughout the world are constantly pushing the limits of human adaptation to increasing training loads with the ultimate aim of achieving optimal training adaptations and performance in sports. These outcomes are achievable through a precisely designed training program to induce positive adaptations through improvements in physiological, psychological, performance and also automation in skills. The dynamics of training involves the gradual increase in training loads (intensity, volume, frequency of exercise and rest) in an attempt to gain optimal performance (Smith, 2003).

Periodization is an important aspect of training where new challenges are imposed upon the body from time to time in an effort to continuously make gains in physiological adaptations thus enabling the athlete to better their performance. In order to reduce the risk of overtraining, recovery should be an integral part of the periodization plan to enable athletes to optimally balance training stresses and subsequent recovery (Kellman, 2002) for optimal performance in training and competitions. It is often noted that optimal performance is only achievable if athletes balance their training and competition stresses with adequate time for recovery

(Coutts & Sirotic, 2004; Fuller & Paccagnella, 2004; Kellmann, 2009). Lambert and Borresen (2006) suggested that inadequate recovery prevents athletes from producing peak performances.

Recovery is one of the basic principles of training methodology and it has two primary roles. The first is monitoring the athlete's adaptation to training and stress so that an appropriate recovery strategy can be determined. The next role relates to the selection of specific recovery techniques and strategies to minimize any residual fatigue from training before competition (Rushall & Pyke, 1990). Optimising recovery from training and performance may benefit subsequent training over periods of time for enhancement of performance (Gill et al., 2006).

According to the fitness-fatigue model, fitness and fatigue can be maximized by manipulating the training load (Mujika, 2009). Achieving an appropriate balance between training stress and recovery is important in maximizing performance. A systematic reduction of training loads is a key part of preparation for recovery process in a major competition (Houmard, 1992; Mujika & Padilla, 2003; Smith, 2003). Mujika and Padilla (2003) have termed the reduction of training loads as tapering. During the taper, the training load is reduced in a non linear fashion over various periods of time. The purpose of this reduction is to reduce physiological and psychological stresses of daily training and to optimize sports performance.

Specific steps of the taper involves a gradual reduction in training workload (intensity, volume-duration, frequency) which results in a maximum difference between the positive (fitness) and negative (fatigue) effects of training. Its specific aim is to reverse fatigue caused by intense training, hence allowing the athlete to achieve peak performance (Hooper, Mackinnon & Ginn, 1998). The facilitation of full recovery by means of tapering the

training load often results in performance enhancements between 0.1 and 6% (Mujika & Padilla, 2003). A study to that effect was conducted by Martin, Seifres, Zimmerman and Wilkinson (1994) on subjects who participated in a high intensity training program of six weeks and a subsequent two week taper. They found that cycling performance increased significantly during training (15%) and increased further during the taper period (8%). The researchers concluded that two week taper can improve cycling performance.

The relationship between the reduced training loads during taper and performance benefits has been well established in highly trained runners, swimmers, cyclists and triathletes but for junior cyclists this relationship has not been elucidated. This study therefore was designed to determine the effects of a reduction in training loads and a maintained training load on physiological and performance outcomes during recovery periods amongst junior cyclists.

Materials and methods

Experimental approach to the problem

This study employed a pre-post experimental design with a control group. Subjects were randomly divided into an experimental (EXP) or a control group (CON) after a 12 week training program before entering the next phase. This next phase comprises of another two weeks of training with either a reduced training workloads or a continuation of normal training loads. Data for the physiological measures, work output and time taken for the 20km time trial were obtained prior to and after the two week training program. Approval by the Ethics Committee of Universiti Sains Malaysia was obtained prior to the start of this study.

Subjects

27 subjects were recruited from the Kelantan state cycling team. In order for inclusion in this study subjects must be

medically fit male cyclist, age between 16 to 18 years, have been training regularly at least five times per week and also have also competed in excess of four times in one calendar year. Informed written consent form was obtained from all participants. The subjects were matched into matched into either the control group (n=13) or the reduced training load group (n=14)

VO_{2max} and power output

VO_{2max} was determined during incremental exercise to volitional fatigue on an electromagnetically brake cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands). This was done to determine maximal oxygen uptake (VO_{2max}) and power output (watt, W) before and after their participation in the 12 week training program. In this test subjects initially cycled at load of 50W and thereafter the workload was increased by 16W every minute until volitional fatigue. Seat height was set appropriately for each individual, with handlebars adjusted based on individual preference. Participants were required to maintain a cadence of 60 $\text{r}\cdot\text{min}^{-1}$ and were fitted with heart rate (HR) monitor transmitters (Polar electro, Finland) at the level of the sternum. Heart rate was continuously monitored and recorded at 10 second intervals. A metabolic measurement system (SensorMedics Corp., USA) was used to analyze expired gas by open circuit spirometry. Gas exchange variable were monitored at 20 second intervals. The gas analyzer was calibrated with primary standard gases (16.0% O₂, 4.0% CO₂) before and after each test.

Testing was terminated when subjects met any of the following criteria: subject requested that the test be stopped for any reason, subject reached volitional exhaustion, subject displayed signs or symptoms that indicated the exercise test should be stopped (poor perfusion, pallor, etc.), subject could no longer maintain the required workload during testing, or testers

felt for any reason it was unsafe for the participant to continue (ACSM, 2009). Criteria for achievement of VO_{2max} were (i) rating of perceived exertion (RPE) ≥ 19 (ii) respiratory exchange ratio (RER) ≥ 1.1 , (iii) plateau of oxygen consumption (VO₂) with increased workload, and (iv) $>85\%$ of age predicted maximum HR (Maud and Foster, 2006).

12 weeks training program

After baseline testing both experimental groups followed a 12-week progressive endurance training program and subsequently, a two-week training program comprising of either a reduced training workload (EXP) or a continuation of the workload specified for the 12 week training program (CON). The subjects was trained under the supervision of the qualified coach and then closely monitor for a period 12 week in total, which was divided into three distinct phase (Halson et al, 2002). The first phase subjects were training with high volume, low intensity protocols at intensity 60-70% of HR_{max} (Maximal Heart Rate) x 60-180 min x 6 d.wk⁻¹ for three weeks (Jeukendrup et al, 2002)

The second phase subjects were training with moderate intensity, moderate volume protocols at 75-85% of HR_{max} x 90-150 min x 6 d.wk⁻¹ for the five weeks (Jeukendrup et al, 2002). The third phase of the training program consisted of high intensity, low volume protocols were intensity at 85-95% of HR_{max} x 60-90 min x 6 d.wk⁻¹ for the four week (Jeukendrup et al., 2002). During training session all the subjects received a heart rate monitor (Polar Electro, Finland). Each subject was given a training log to record duration of training, distance covered, maximal and average heart rate.

Two weeks training program

Following the 12 week training program, EXP group was assigned to the reduced training load program (normal exponential taper program) and continued their training

for a further two weeks, while the CON group continued with their normal training until the end of this session. During the reduced training load (tapering) program, the subjects assigned to it continued their training under the supervision of a qualified coach and closely monitored by the researchers. The magnitude of the reduced training load (volume) was determined from the average hours of training of the three weeks preceding the taper. The reduced training load program consisted of progressive reduction of training loads to 40-60% of pre-taper value (i.e. 60, 10, 65, 50, 40, 10, 50, 40, 10, 55, 40, 40, 40 and 10% during tapering days, 1 - 14, respectively).

Testing procedures

All the subjects performed a simulated 20 km time trial before and after the reduced training load program in order to evaluate the physiological and performance effects of the training program. All the subjects in this study used the same road bike (Trek corp, USA) which was mounted on a jetfluid trainer cycling roller (Cycleops, USA). The air pressure of the bicycle tires were checked before and after the reduced training load program taper to ensure that maximum pressure for the tires was maintained. Cyclo computer wireless (Cateye corp, Japan) was used to record speed, cadence (RPM) and distance travelled. For recording the duration of work (cycling), a digital timer recorder was used (Seiko, Japan). All the testing sessions were conducted under the same conditions i.e room temperature and humidity levels.

After warming-up for 15 minute via cycling at 50% of VO₂max, subjects performed a simulated 20 km time trial. Instructions to cycle as fast as possible were given to all the subjects. During the actual 20 km time trial ride, subjects were not given any feedback about the time before and after the reduced training load program (Neary et al., 1999). Each cyclist

received verbal encouragement during all test by the same laboratory personnel. Respiratory gas exchange responses (20-s interval) were monitored for three minutes at every five km intervals during the simulated ride. Heart rate was recorded continuously throughout the 20 km time trial using polar heart rate monitor (Polar electro, Finland). Ratings of perceived exertion (RPE) were also taken at every five km interval using the Borg 6-20 scale (Borg, 1982).

Measurements

Measurements for this study comprise of physiological and performance outcomes. For physiological measures, pre and post two weeks data for maximum oxygen uptake (VO₂max), heart rate (HR), rating of perceived exertion (RPE Borg's Scale), red cell volume and haemoglobin (Hb). Performance outcome data collected were work output (Watt) and time taken to complete the 20 kilometer cycling time trial (TT_{20km})

Statistical analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS version 20). Descriptive statistic and Mixed Factorial ANOVA was used for data analysis. The level of significant value was set at $p < 0.05$. All values are expressed as mean \pm SD.

Results

After the two week training program, maximal oxygen consumption (VO₂max) increased significantly from 64.44 \pm 2.34 to 75.27 \pm 2.50 ml.kg⁻¹.min⁻¹, $p > 0.04$ for the experimental group (EXP) but was not significantly differently for the Control group(CON) (64.70 \pm 9.99 to 65.50 \pm 7.83 ml.kg⁻¹.min⁻¹). Maximum heart rate (HR_{max}) decreased significantly for EXP (199.0 \pm 1.00 to 194.14 \pm 1.34 b.min⁻¹, $p > 0.00$) but remained unchanged in CON (199.20 \pm 1.64 to 198.0 \pm 1.41 b.min⁻¹).

Table 1: Selected physiological and performance outcomes following either reduced or unchanged training loads (2 weeks training program)

Variable	Pre Recovery		Post Recovery		P value
	CON	EXP	CON	EXP	
VO _{2max} (ml.kg ⁻¹ .min ⁻¹)	64.70±9.9	64.44±2.3	65.50±7.8	75.27±2.5*	0.04
Power output (watt)	249.40±33.1	254.28±26.6	259.60±30	315.71±13.4*	0.05
RPE	15.60±0.9	15.28±0.8	15.20±0.8	18.57±0.5*	0.00
HR _{max} (b.min ⁻¹)	199.20±1.6	199.0±1.00	198.0±1.4	194.14±1.3*	0.00
Red blood cell (cells/mcL)	5.43± 0.5	5.57 ± 0.5	5.35±0.3	6.01± 0.4*	0.00
Haemoglobin (g/dL)	15.13±0.8	15.22±1.1	15.52±0.6	16.75±0.8*	0.00
20kmTT (min ⁻¹)	46.67±7.3	44.15±3.4	43.84±2.4	37.37±1.2	0.18

Notes

CON= Control group, EXP = Experiment group. * Significantly different from pre-12 weeks training ($p < 0.05$).

After the intervention, there was a significant increment in power output (Watt) in EXP (254.28±26.55 to 315.71±13.42, $p=0.05$) but not in CON (249.40±33.12 to 259.60±30.02 Watt). In ratings of perceived exertion (RPE) showed a significant increase for EXP (15.28±0.75 to 18.57±0.53, $p =0.00$) but not in CON (15.60±0.89 to 15.20±0.83). The amount of red blood cells increased significantly for EXP (5.57 ± 0.48 to 6.01± 0.44 cells/mcL, $p=0.00$), but for CON, the number of red blood cells remained relatively unchanged from the pre recovery period (5.43± 0.51 to 5.35±0.33 cells/mcL). Haemoglobin values showed a significant increase for EXP (15.22±1.05 to 16.75±0.79 g/dL, $p=0.00$) following the recovery program when compared to CON (15.13±0.81 to 15.52±0.57 g/dL)

For the performance outcome, although the two week recovery program showed a decrease in time taken to complete the 20 km time trial, there no significant differences between both groups (CON: 46.67±7.31 to 43.84±2.37; EXP: 43.84±2.37 to 37.37±1.17 minutes), $p = 0.18$.

Discussion

The main focus on this study is to investigate the effects of two week reduction in training workload program on selected physiological and performance among junior cyclist. Two null hypotheses were tested in this study were (i) there is no significant differences in selected physiological (maximal oxygen consumption, power output, ratings of perceived exertion, maximal heart, red blood cells and haemoglobin between the experimental (reduced training workload) and control groups and (ii) there is no significant mean difference in TT_{20km} between the experimental and control groups.

The major finding of this study was that a two weeks taper with reduced training loads showed a significant enhancement of VO_{2max} and maximal heart rate when compared with the control group. A study by Jeukendrup (1992) using cyclist, indicate that tapering for duration of two weeks resulted in an increased of 4.5% in VO_{2max}, 10% increased in the peak power output and 7.2% faster time in an 8.5km outdoor time trial. Similarly, Zarkardas et al., (1995)

observed a 6.3% improvement in VO_{2max} after two weeks of a tapering program in triathletes. In line with these results, Margaritis et al., (2003) reported a 3% gain in VO_{2max} during a 14 days in long distance triathletes.

Improvements in aerobic capacity are related with maintained or increase intensity during tapering training (Houmard & Johns, 1994). Clearly, that when maintain intensity at 90% of MHR can improved VO_{2max} capacity (Costill et al., 1985; Johns et al., 1992; Shepley et al., 1992). VO_{2max} is dependent on both oxygen deliver and oxygen uptake by muscle tissue an increase in hematological parameters may be the underlying cause of VO_{2max} changes seen during the taper (Gledhill, 1985). The major influence of training intensity on retention or improvement of training induced adaptations could be explained in the role of regulation of concentrations and activities of fluid retention hormones (Mujika, 1998). The relevance of an increase in training load at the end of taper is corroborated anecdotally by the progressive improvement in performance often observed in an athlete from the first round of a competition to the final (Thomas et al., 2009)

In this study, heart rate was shown to be significantly reduced in the post-taper for the experimental group. Heart rate after maximal exercise (HR_{max}) may be an additional tool to monitor recovery (Hooper et al, 1999). A study by Synder et al, (1995) found that HR_{max} values post taper were significantly reduced after 14 days taper when compared with baseline value in cyclists. The reduction in HR_{max} with taper training is consistent with catecholamine depletion and an associated In conjunction with plasma norepinephrine change (Lehmann et al, 1991; Lehmann et al, 1992).

Cycling power output improvements were also seen with taper training and it is well accepted that VO_{2max} increase in proportion to an increase in power output

(Neary et al., 2003). Meanwhile, the results of power output showed a significant increased after two week taper in both taper groups with 18.9% and 24.1% for modified exponential and normal exponential taper groups, respectively.

However, normal exponential elicited more improvement when compare with modified exponential. A study by Zarkadas et al, (1995) was reported that a significant increase in power output 8% after using exponential taper for triathletes. While, Neary et al., (1992) found a significant increased in power output for the four days (27.4 W) and eight days (27 W) groups, respectively. Muscle glycogen level been documented have a correlated in increased muscle power output activity in cycling performance (Neary et al., 1992). Many studies have been shown that glycogen level have a determining effect on exercise duration during high intensity effort (Costill et al., 1985; Neary et al., 1992).

In this study, the ratings of perceived exertion (RPE) showed a significant increased during all out time trial performance after tapering for both intervention groups. Mujika (2009) stated that the reduced training load associated with the taper facilitates a recovery of an athlete RPE. The relevant of an increase RPE after end of taper phase could be related with the feeling of being more energized and having sufficient recovery to work at maximum effort during the time trial (Bosch, 2008). Our present study did not show any statistically significant difference in the 20 km time trial performance. Nevertheless, time taken for both pre and post taper showed significant change for both groups (EXP: 43.84 ± 2.37 to 37.37 ± 1.17 minutes; CON: 46.67 ± 7.31 to 43.84 ± 2.37). Thomas et al., (2009) stated that performance benefits using a computer simulation could be low because they have already optimized their performance thus reducing the margin for performance improvement. However, this

study provided the researchers with an opportunity delve into the field of tapering in order to explore and suggest innovative new strategies for junior athlete especially junior cyclists.

In conclusion, the present study show that the effects of tapering were significantly better in experimental (EXP) than the control group (CON). A reduction in training workloads following a normal training load has been found to show a significant improvement in maximal oxygen consumption, power output, ratings of perceived exertion, maximal heart, red blood cells and haemoglobin. However, both groups were not significantly different in the 20 km time trials. Finally, we concluded that physiological adaptations among the junior cyclists are evidenced following the reduction in training load protocol that was performed. The reduction in training load can induce physiological adaptation with reduced volume of training but maintaining at the same time intensity of training.

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