MASTERS THESIS

A Comparison of Linear and Reverse Linear Periodised Programs with Equated Volume and Intensity for Endurance Running Performance

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I, **Duncan Bradbury**, certify that:

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Written consent has been received and archived for the research involving participant data reported in this thesis.

This thesis contains work prepared for publication, some of which has been co-authored.

[redacted]

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Declaration

This thesis contains work which has been submitted for publication, some of which has been co-authored. The work involved in designing the studies was performed primarily by Duncan Bradbury (candidate). The thesis outline and experimental design was planned and developed by the candidate, in consultation with Dr Grant Landers, Dr Nat Benjanuvatra and Dr Paul Goods (the candidate's academic supervisors).

All participant recruitment and management, was well as data analysis was carried out by the candidate. The candidate drafted the original thesis chapters as well as the paper arising from this thesis that has been prepared for future publication. Dr Grant Landers, Dr Nat Benjanuvatra and Dr Paul Goods provided guidance on data collection, data analysis and all drafts associated with the thesis until the examinable version was finalised.

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Executive Summary

Introduction

Endurance running encompasses some of the most competitive athletic events, and is also an important component in the training programs of many athletes from a wide variety of team sports. As such, the training program design is important in attaining the optimal performance. The planning of training goals and ordering of training sessions is known as periodisation. Traditionally, linear periodisation (LP) has been applied to endurance running programs. The LP method builds aerobic endurance through long lower intensity running bouts before increasing anaerobic threshold (AT) by increasing the proportion of higher intensity endurance training. Advocates for a less common periodisation method, reverse linear periodisation (RLP), argue that earlier development of AT and running economy (RE) may lead to superior longer distance training sessions and therefore better endurance race performance. Given the paucity of empirical research in this area, the purpose of this study was to investigate the LP and RLP methods as well as unregulated training regimes in recreational runners. Endurance performance was examined through regularly performed time trials (TT) throughout an endurance training program. Key variables (maximal oxygen uptake ($\dot{V}O_{2max}$), AT and RE) which account for high variance in endurance performance were also measured. This would allow group comparisons to be made for changes to performance over time as well as the physiological mechanisms responsible for any changes/group differences.

It was hypothesised that the RLP method would elicit greater improvements in AT and RE following a short period of training than the LP method and an unregulated group. It was further hypothesised that both periodisation methods would demonstrate greater

improvements than unregulated training in TT performance and measured physiological endurance parameters.

Methods

Thirty subjects with a 5000 m personal best of less than 25 minutes completed the study. Subjects were assigned to a linear periodised group (LPG), a reverse linear periodised group (RPG) and a control group (CG) (n = 10, in each group) using a block randomisation technique to ensure the groups were matched by gender and initial test results. Subjects attended a total of 3 testing periods: week 0 (pre-training), week 7 (mid-point) and week 14 (final). In weeks between testing periods (1 - 6, 8 - 13), LPG and RPG completed a total of 24 supervised training sessions and 12 unsupervised sessions. The CG completed self-run training. All unsupervised sessions were monitored through exercise diaries. Testing weeks included two sessions (weeks 0, 7 and 14). The first began with the collection of anthropometric data (height, mass and skinfolds). This was followed by treadmill tests inclusive of a submaximal test for RE (at 9 and 11 km.h^{-1}) and an incremental test to exhaustion for $\dot{V}O_{2max}$, velocity at $\dot{V}O_{2max}$ and AT. At least 48 h later, subjects completed a 5000 m TT on a 400 m grass track.

At supervised training sessions, subjects completed a standardised warm-up on arrival, the assigned training set and a standardised cool down. Training intensity was calculated as a percentage of 5000 m TT performance. Rate of perceived exertion was recorded at the conclusion of sessions using the modified CR-10 scale. Unsupervised training was recorded as distance, duration, heart rate and a CR-10 score. Training load was calculated as session duration (mins) multiplied the CR-10 score. The daily mean training load divided by the standard deviation was calculated as training monotony.

Results

No significant differences (p = 0.848) existed for between groups training volumes (km). However, significant differences were observed in training loads between groups (p <

0.001) during the high volume training block (LP weeks 1 – 6 and RLP weeks 8 – 13). This difference was found to be between LPG and CG ($p < 0.001$) and between LPG and RPG ($p = 0.015$). No between group differences were seen for the high intensity training block (LP weeks 8 – 13 and weeks RLP 1 – 6) ($p = 0.071$). Improvements for the 5000 m TT occurred following 12 weeks of training in LPG (5.5 ± 3.9 %), RPG (8.1 ± 5.5 %) and CG (0.1 ± 4.6 %). Greater improvements in the 5000 m TT were observed in the LPG ($p = 0.009$, $d = 1.27$), and the RPG ($p = 0.002$, $d = 1.51$) than the CG. In addition, time interaction improvements were observed in VO_{2peak} ($F_{(2, 54)} = 4.998$, $p = 0.010$), AT ($F_{(2, 54)} = 10.639$, $p < 0.001$), RE at 9 $km.h^{-1}$ ($F_{(4, 54)} = 9.795$, $p < 0.001$) and RE at 11 $km.h^{-1}$ ($F_{(4, 54)} = 5.999$, $p = 0.004$).

Summary

Periodisation is commonly used in all sport and has been shown repeatedly to elicit greater gains in performance than non-periodised training programs. Results from the present study concur with previous literature with improvements to 5000 m time trial performance for LPG and RPG, but not for CG. Training load was significantly different between groups with the LPG recording higher perceived rate of exertion scores during the high volume training block. These different training loads highlight the differences in physiological adaptations between the training methods. Higher training loads may have been the cause of greater improvements in the LPG group than the CG. The lower load of the RPG group may be due to improvements to lactic tolerance and buffering capacity following a high intensity training block. This training loads confirm the desired mechanism of the RLP method. However, differences in performance between the two periodised training groups were not apparent. This may be due to relatively short duration of the intervention (12 weeks training). In contrast, the differences between periodised groups and the CG highlight the importance of periodisation as well as training structure to maximise performance. Further, due to the success of the RPG, RLP has been shown

as a valid method of structuring an endurance running program for recreational level endurance athletes. However, the results cannot be generalised to other populations. Future research may seek to utilise different populations as well as perform longer training interventions while examining a wider range of physiological parameters.

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List of Abbreviations

ANOVA	Analysis of variance
AT	Anaerobic threshold
ATP	Adenosine triphosphate
BLa	Blood lactate
CG	Control group
DUP	Daily undulating periodisation
GAS	General adaptation syndrome
GXT	Graded exercise test
HIB	High intensity training block
HIIT	High intensity interval training
HR	Heart rate
HR_{max}	Maximum heart rate
HRR	Heart rate recovery
HVB	High volume training block
LP	Linear periodisation
LPG	Linear periodisation group
LT_1	Aerobic threshold
LT_2	Second point of inflection on lactate curve

NLP	Non-linear periodisation
OTS	Over-training syndrome
RE	Running economy
RLP	Reverse linear periodisation
RPE	Rate of perceived exertion
RPG	Reverse linear periodisation group
SD	Standard deviation
SE	Standard error
S8SF	Sum of 8 skinfolds
SPANOVA	Split-plot analysis of variance
TRA	Traditional periodisation
TT	Time trial
UP	Undulating periodisation
VO_2	Volume of oxygen
$\dot{V}O_{2max}$	Maximal oxygen uptake
$v\dot{V}O_{2max}$	Velocity at maximal oxygen uptake

CHAPTER 1

1. EXTENDED LITERATURE REVIEW

1.1 Introduction

The purpose of this review is to identify key concepts and current practices associated with periodisation. Periodisation is commonly used in all sport and has been shown repeatedly to elicit greater gains in performance than non-periodised training programs (43, 49, 51, 53-56, 61, 73, 76, 77, 88, 89, 95). While there are many definitions of periodisation offered in the literature (41, 42, 53-55, 73), the underlying principle of periodisation is based on a logical method of planning and developing training programs which applies established training principles to optimise results. Periodisation dictates the order through which fitness components are developed (88). Fitness components are targeted through manipulation of volume and intensity (88).

The development of periodisation can be followed through history. In Greece, there was a story of a boy called Milo who would regularly carry a young bull around on his shoulders. With age the bull grew and Milo became stronger (32, 82). This illustrates a gradual increase in training intensity, suggesting that ancient Greeks may have understood some training concepts associated with improving strength many years ago. From the available information it can be inferred Milo performed a type of progressive overload. The idea of training for improved performance was further exemplified by the Romans with their modification of Spartan training principles (5). This may be seen as the introduction of structured training. Since that time, the development of training principles has progressed through trial and error until the early 20th century.

Presently, periodisation methods are tailored to an athlete’s requirements by coaches and sport scientists. As most of the current knowledge related to periodisation has been derived from observational evidence, anecdotal data and inferences from related studies conducted over short durations (37, 88), there can be confusion between coaches from different sports. Additionally, terminologies relating to periodisation vary not only from country to country, but also within the strength and conditioning community. Traditional periodisation (TRA) is one of the most commonly utilised methods and is also referred to as ‘linear periodisation’ (LP) by some authors (31, 76, 77). Another popular method of training is non-linear periodisation (NLP), also often referred to as ‘undulating periodisation’ (UP) and ‘daily undulating periodisation’ (DUP) (6, 15, 31, 43, 54, 71). While some terms are used synonymously with each other in literature, other authors view them as different planning methods (23, 30, 75, 76, 88, 89).

One of the most common modes of exercise is endurance running. Performance in this area is also important in professional sport as well as general health and wellbeing. Many training methods which can be periodised have been shown to improve endurance running performance (9, 17, 28, 48, 50, 64, 83, 100).

1.2 Drivers of Endurance Running Performance

The aim of endurance training is to stimulate physiological changes in key factors of endurance running which will allow a person to exercise for longer and at a higher intensity. The primary physiological factors recognised in the literature as key factors in endurance development are maximal oxygen uptake ($\dot{V}O_{2max}$), anaerobic threshold (AT) and running economy (RE) (25, 27, 39, 52). $\dot{V}O_{2max}$ is the maximum volume of oxygen able to be consumed (measured in $ml.kg^{-1}.min^{-1}$) (25, 27, 48). It is a measure of a person’s capacity for aerobic work and can be a predictor of potential for endurance athletes (4). The AT is the point of second inflection on a lactate curve (LT_2) (39, 78, 85, 92). When running, AT may be the intensity where energy requirements can be met aerobically, any faster and metabolite production will occur at an exponential rate (39). Running economy is the energy cost of running at a specific intensity (25). These sub-qualities of endurance may be developed relatively independently with a small crossover in adaptation depending on the training utilised and the interplay between volume and intensity (25, 27).

1.2.1 Aerobic capacity

The most widely accepted measure of aerobic capacity is $\dot{V}O_{2max}$ which is commonly accepted as a prerequisite to be an elite endurance athlete (63). As aerobic capacity improves, a submaximal workload can be maintained for a longer period of time (48). In addition, improving aerobic capacity may enhance the rate of recovery during interval training. This occurs through supplementation of anaerobic energy during exercise and providing derived energy at a faster rate during recovery periods (46, 70).

With targeted endurance training the concentration of aerobic enzymes may be increased which allows for a greater rate of oxygen extraction (48, 91). The concentration, size and surface area of mitochondria may also increase displaying an improvement in oxidative function (94). There is a high correlation ($r = 0.93$) between mitochondrial size and number, and adenosine triphosphate (ATP) production (94). In addition, greater cardiac output, capillarisation and blood vessel vasodilation increases the supply of oxygen and the removal of carbon dioxide to and from working muscles (83). Waste removal is also increased following high intensity exercise (46, 70).

These adaptations result in lower reliance on anaerobic glycolysis and therefore reduces hydrogen ions and subsequent acidosis during high intensity interval training (46, 70). As more energy is produced aerobically, the proportion of aerobic energy increases, thus reducing the need for anaerobically derived energy. This reduces the rate of accumulation for lactate, H^+ and heat during high intensity exercise (64) which improves performance. The improvement of aerobic capacity may make it easier to train and improve the AT.

1.2.2 Anaerobic threshold

The AT is an intensity of exercise, involving a large muscle mass, where the measured oxygen uptake (aerobic energy production) cannot account for all of the required energy (39). It can also be referred to as LT_2 on the lactate curve (Figure 1). When the AT is exceeded, the proportion of energy produced through anaerobic metabolism rises resulting in increased metabolite production (byproducts of anaerobic energy production). These often negatively affect performance. One recognised metabolite is lactic acid (4). Lactic acid can be indirectly measured through blood lactate (BLa) (100) and graphed against running speed to ascertain AT (39). Many research papers have shown AT as critically important to endurance performance (38, 39, 62, 92). Further, trained runners exhibit lower BLa concentrations (greater AT) during matched running speeds than untrained individuals (36). Thus, development of a high AT as a percentage of $\dot{V}O_{2max}$ is often seen as a priority, and should be targeted to maximise performance in endurance athletes.

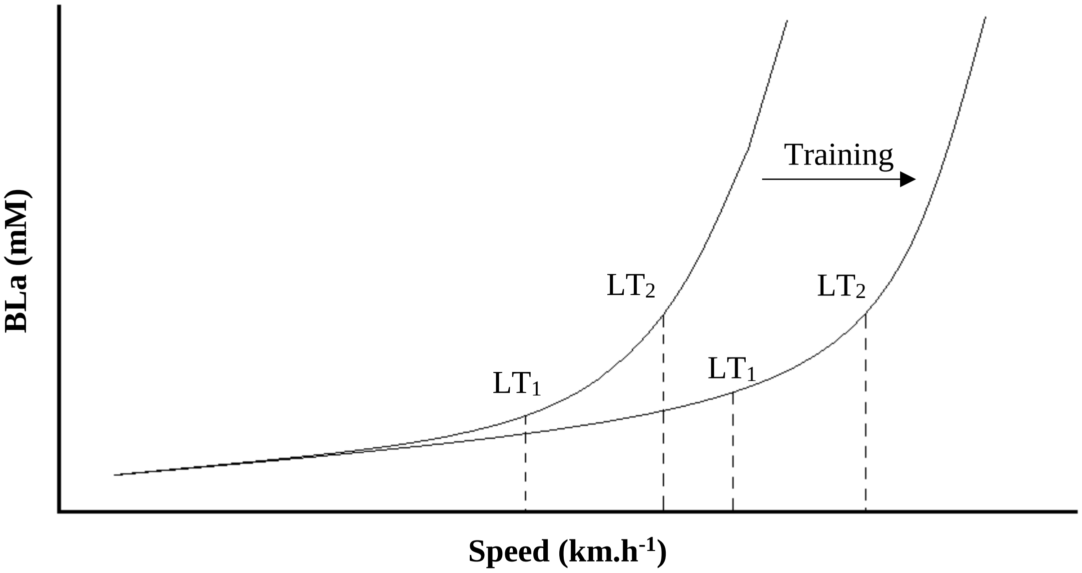

Figure 1. Blood lactate (BLa) plotted against running speed (km.h^{-1}). The aerobic threshold (LT_1) and anaerobic threshold (LT_2) are labelled and the impact of training shown [adapted from Faude, Kindermann and Meyer (29)].

When the aim is to improve AT, a coach may prescribe repeat intervals during which the running speed is higher than current AT (95). An improved AT results in the ability to run at higher speeds with less anaerobic energy contribution (38). As shown in Figure 1 this can be illustrated by the shift of an individual's lactic curve to the right. The AT is joined by another factor, aerobic threshold (LT_1) on the lactic curve. The aerobic threshold is the first intensity at which there is a sustained increase in BLa above resting levels (29). Both LT_1 and LT_2 account for large variances in endurance race performance indicating the importance of training AT (92).

Crossovers in training adaptations may be beneficial to endurance performance. Although long, slow distance training targets improvement of aerobic capacity it has been shown to improve AT (27). Further, concurrent improvements to endurance performance have been observed (27). A high correlation has been reported between AT and the oxidative capacity of the working muscles (78). This means AT is higher when the working muscles can utilise a greater volume of oxygen over a shorter period of time. Anaerobic threshold may also be improved through an increase in the rate of lactate transport from the muscles to the blood and the removal of lactate from the blood by the heart, liver and non-working muscles (36, 92). Individual AT may be increased as a result of a high buffering capacity of muscles and blood, and a high rate of oxygen transport to the working muscles (39, 92).

1.2.3 Running Economy (RE)

Running economy is the energy demand for a given velocity of submaximal running (25, 33). RE is determined by the efficiency at which individuals can transfer metabolic power into a given running velocity (24, 33). Runners with good RE use less energy and therefore less oxygen at the same velocity than runners with poor RE at the same velocity (24). Both physiological and biomechanical factors may affect and be responsible for changes to RE over time (26, 58, 79).

1.2.3.1 Modifying physiological factors to improve running economy

As a result of aerobic based exercise (25), physiological factors may be modified which can result in improvements to RE. At a cellular level factors may include increased size, number and surface area of mitochondria as well as higher concentrations of oxidative enzymes (25). In addition to changes on a cellular level, structural modifications to the cardiovascular system may occur which improve the myocardial oxygen supply (VO_2) and therefore $\dot{V}O_{2max}$ (26, 79). One such improvement is a more efficient combination of HR and stroke volume (a reduction in HR and an increase in stroke volume). This occurs largely due to increases in left ventricular size in the heart and increased blood volume (66) which results in reduced energy cost at submaximal intensity, leading to an improvement to overall RE (25, 34, 79).

VO_2 can also be improved through increases in haemoglobin concentration, greater plasma volume and blood volume (79). The transport of this extra oxygen to the working muscles is possible through increases in capillary densities within the trained muscles (3, 79). Research indicates an association between a higher percentage of slow twitch muscle fibres and a better RE (26, 33, 34), possibly due to the inherent lower contractile speeds and therefore energy costs of working slow twitch muscle fibres (47). However, the magnitude of muscle fibre type transition is restricted (72) and therefore should be of limited consideration when training athletes.

1.2.3.2 Modifying biomechanical factors to improve running economy

Some biomechanical factors which influence RE may be changed almost immediately, whereas others rely on changes to physiology from training which may take longer (33). Changeable biomechanical factors which impact RE include body fat, leg morphology, running kinematics, kinetics and use of elastic energy (33, 34, 79). Improving an athlete’s power to weight ratio through strength training or plyometric training improves RE, this requires muscular adaptation (69, 80). Body fat loss may also improve RE (4) as moving a lighter limb requires less work and therefore less energy to move than a heavy limb.

The enhancement of RE may occur rapidly through the kinematics of reducing unnecessary body movements (oscillation) (4), reducing knee angles during leg swing and increasing angular velocity of plantar flexion in the ankle during toe-off (4). In addition, reducing knee angles decreases torque around the hip joint as the lever (leg) length is reduced, this reduces energy cost (57). High angular velocities of plantar flexion during toe-off are closer to the preferred transition speeds of the gastrocnemius and soleus muscles and are therefore more efficient (4, 58, 67). In addition, kinetics (reaction rates) may be improved through lowering peak ground reaction forces to improve RE (69, 79).

Running economy, aerobic capacity and AT may all be improved depending on the level of the runner (22, 33). Novice runners can more easily and rapidly improve RE than elite level runners (22). Different training methods can be used to target these different drivers of endurance which determine endurance running performance.

1.3 Endurance Training Methods

There are two main methods of prescribing running training, continuous training and interval training (62). Both may be important in endurance running programs depending on the distance being trained for and the level of the athlete. When training for endurance running there is inevitably some crossover in physiological adaptations due to the principle of specificity (48, 62, 64). Specificity also limits the variation in volume and intensity as training will always be aimed at improving endurance running performance and therefore higher in volume than a sprint athlete (30, 62, 88, 89, 95).

1.3.1 Continuous training

Continuous training can be defined as an exercise bout without any rest intervals (45). An example of a continuous running session is an athlete running for 30 minutes without stopping (45). A continuous running session is performed at an intensity of 30-100% of $\dot{V}O_{2max}$, and can last until exhaustion (45). This training method is associated with improvements in aerobic capacity as it stimulates oxygen transport for extended periods of time (8, 62).

1.3.2 Interval training

Interval training involves a series of running bouts separated by passive or active recoveries (62). Bouts separated by active recovery periods are known as fartlek training (11). Interval training is commonly used as intermittent recovery periods enable athletes to perform a higher volume of high intensity work before exhaustion (65). Athletes can repeatedly enter oxygen debt in a session, the body adapts to this and becomes more efficient at working under higher concentrations of metabolites and lower pH levels (40, 62). Because of this, interval training is more effective at improving AT than continuous training (62).

The benefits of the above training methods are required to improve endurance performance, therefore a suitable program encompassing various continuous and interval sessions is often administered (62). Training sessions are often ordered differently due to competition dates (seasons) and differences in the endurance requirements and/or demands of different sports.

1.4 Periodisation

Periodisation can be defined as the process of planning training programs to achieve peak athletic performance at a specific time (88). Periodised programs often include variation of training through manipulation of volume and intensity (88). The principle of training variation to improve athletic performance has been established through previous research on human physiology (30). Some mechanisms of human physiology can be used to explain rates of athletic improvement or deterioration as a result of training (30, 81).

Variation of training can allow for optimised recovery and subsequent improvement to occur increasing peak performance at important competitions (6, 12, 15, 30, 88, 95).

1.4.1 General adaptation syndrome (GAS)

The human body has an intrinsic ability to adapt to the requirements of the external environment. This adaptation often comprises of changes to the structure and function of skeletal muscle as well as the cardiovascular system. Much of the knowledge on athletic adaptation was built on the research on GAS by Selye (81). Selye investigated how organisms respond to repeated instances of stress both acutely and chronically (81), and concluded that there are three phases to stress response: alarm phase, reaction/resistance development phase, and exhaustion phase (14, 81, 86, 87, 90).

1.4.1.1 Alarm phase

The alarm phase refers to the effects created by an unfamiliar stimulus or introduction to something new. For an endurance runner, this stimulus could be a new training program, sudden increase in training intensity or volume, life event, or a change in other variables or personal circumstances. When a new training stimulus is implemented and an alarm response occurs, there is often a decrease in performance and sometimes fitness (14, 90). The alarm response may seem like a negative event but it is needed to stimulate adaptation, and ultimately improvement in performance. According to Selye (81), if there is no training stimulus, there is no alarm response.

1.4.1.2 Reaction/resistance development phase

During the reaction/resistance development phase an organism adapts to the stress placed upon it (81). In training, any adaptation gained is specific to the stress which has been applied, this is known as the principle of specificity (75). An example is continuous running training improving oxygen transport to working muscles (62).

Different athletes and individuals may experience different reaction/resistance phases depending on their training history (12, 74, 97). Untrained individuals will improve at a greater rate than trained individuals when both are introduced to a training stress (22). In addition, retraining previously trained (detrained) individuals results in a greater rate of adaptation (22). Muscular adaptations such as size and strength can be retained and retrained within long periods, 30-32 weeks reported (22). This concept is essential when examining previous research as responses to training program are dependent on the training stimulus applied and the status of the individual and their physiological adaptive capabilities. This means athletes will respond to training differently to non-athletes. Consequently, athletes may adapt to the training program, but stagnate in performance more commonly than non-athletes (23, 54, 86). Improvements in an athlete’s performance can be reached through the addition of more stimuli or increasing the stimulus, which could range from introducing new training methods/exercises to increasing training volume or intensity.

1.4.1.3 Exhaustion phase

Overreaching occurs when the frequency, volume and/or intensity of training stressors are too high for complete recovery to occur between training bouts (35). Many structured training programs utilise phases of overreaching (functional overreaching) to provide various training stressors (35, 96). Overreaching is acute overtraining and can be recovered from in a few days (35). In addition, there is often a rebound (super-compensation); an increase in performance following recovery (2-5 weeks after the overreaching period) (90). If overreaching is sustained for an extended period or additional training stress is added, the exhaustion phase and overtraining syndrome (OTS) may occur (14, 90). Acute exhaustion in athletes may result in fractures, sprains, and lethargy (35, 96) while chronic exhaustion can lead to OTS (14, 90).

The exhaustion phase may also occur when an athlete has plateaued, the training program is no longer stimulating the athlete (16, 77, 90). This phase is often termed “monotonous training” and can lead to slight decrements in performance over time (59). Increasing training variation through volume and intensity can enable and athlete to progress past the plateau (13, 59).

It is difficult to ascertain whether a prescribed stimulus is having the desired effect or if it is exceeding an athlete’s level of tolerance. This makes OTS difficult to predict and is therefore often diagnosed too late (19, 96). However, when periodisation is utilised appropriately it reduces overtraining potential and assists with the achievement of desired performance gains (12, 60). This is because a periodised training program appropriately mixes training stress with periods of recovery (12, 88, 89).

1.4.2 Fitness-fatigue paradigm

Another underlying concept crucial to periodisation can be found in the Fitness-fatigue paradigm (7). The Fitness-fatigue paradigm (Figure 2) illustrates that when fitness exceeds fatigue, the preparedness of the athlete increases (18).

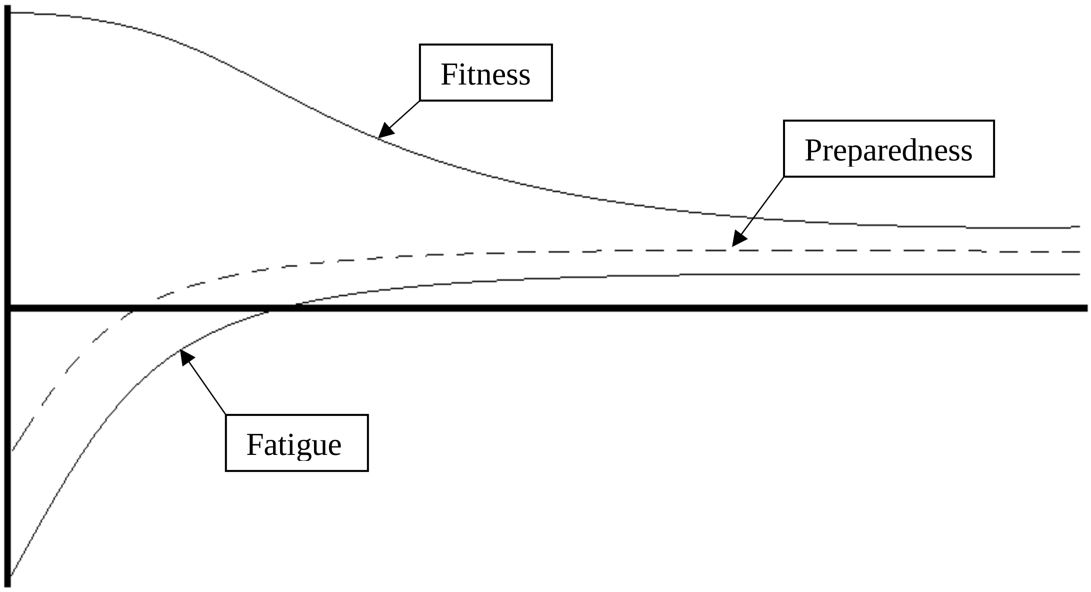

Figure 2. A simplified fitness-fatigue paradigm graphing fitness against fatigue which result in preparedness [adapted from Plisk and Stone (73) and Zatsiorsky (99)].

This concept of the fitness-fatigue paradigm is based on the interaction of a negative factor (fatigue) which hinders performance and a positive factor (fitness) which improves performance (18, 90). The interaction of these two factors influences an athlete's ability to perform. The difference between fatigue and fitness level is termed "preparedness" (90, 99). In the short term, as training progresses there are improvements to fitness, but they are exceeded by fatigue which lead to acute decreases in preparedness (18, 99). During rest, fatigue dissipates at a greater rate than fitness resulting in improvements to preparedness (99). In practice, structuring periods of recovery after periods of intense training increases preparedness (following the dissipation of fatigue). The balance of fatigue and fitness is one of the key aspects of periodisation. Use of appropriate training variation will assist in fatigue management thereby increasing athlete preparedness.

1.4.3 Types of periodisation

The aim of periodisation is to achieve the best possible performance at the most important competition or race of the season (12, 73). Periodisation involves breaking a training season into smaller units and sub-units referred to as macrocycles, mesocycles and microcycles, each target specific fitness and technical goals (37). Typically a macrocycle will refer to a year and mesocycles 4 ± 2 week blocks as this allows sufficient time for adaptation (56, 73, 90). Microcycles are often one week (73).

According to Bompa and Haff (12), one way to plan a training year is to divide it into 3 phases: preparatory, competitive and transition. Training during the preparatory phase is used for building a fitness foundation allowing for later phases to be completed to a higher standard (12). In practice, the preparatory phase cannot be shorter than the time it takes to produce an acceptable level of fitness. The preparatory phase may also be split into general and specific phases, the general phase focuses on the building blocks and the specific phase is a transition from pre-season to the competitive season (12, 37). The competitive phase is where basic fitness achieved in previous cycles is converted into competition performance. Peaking strategies should also be implemented here by ensuring athletes have achieved sufficient recovery from previous mesocycles before beginning the next one (12, 37). Depending on the periodisation method, a mesocycle may focus on a specific fitness component (37).

An essential consideration for the periodisation of training is the development of the specific fitness components required by the specific athlete. These components typically include: strength, speed, endurance and power. In most periodised programs, the development of certain components precede the development of others (37). Each mesocycle should be building on the previous while moving towards more competition specific fitness goals. Many coaches disagree on the sequence of required development (37, 43, 73) and as result there are many different methods of periodisation which may be applied.

Traditionally, endurance athletes will progress from aerobic endurance training, through to AT and interval training (43). This approach has been designed from anecdotal observations and principles of physiology observed through acute research rather than applied periodisation studies (37). Typically, a coach may utilise periodisation through linear periodisation (LP), reverse linear periodisation (RLP), traditional periodisation (TRA) or undulating periodisation (UP) while individuals may not utilise periodisation (31, 76, 77).

1.4.3.1 Linear periodisation

When training for an endurance running event, continuous training or low intensity interval training is traditionally introduced first so as to improve maximum aerobic capacity (43). An improved ability to utilise oxygen results in a greater energy production (ATP resynthesis) through aerobic respiration which reduces the build-up of metabolites such as hydrogen ions which impair the function of muscle (98). For example, a three week (70-80% $\dot{V}O_{2max}$) continual training intervention has been shown to reduce blood lactate concentration without affecting ventilation in previously untrained individuals (36). This improvement in aerobic ATP resynthesis enables runners to run at higher intensities for longer during intervals as recovery is enhanced (93).

As the training program progresses the training volume is decreased and the running speed is increased. When sessions are performed above AT, oxygen demand becomes higher than the oxygen supplied, lactic acid and other metabolites begin to accumulate (39, 75, 77). Sessions performed above AT are generally interval sessions, this is because an athlete can't perform above AT for an extended period of time (85). Recovery periods are given between intervals to allow an athlete to run for longer above AT than they would in a continuous running session. When utilised, LP results in these AT-based sessions to be performed at a higher intensity as increased ATP resynthesis increases the proportion of energy provided through aerobic respiration which improves the rate of recovery (48, 91). Having the ability to perform high intensity training more frequently and for longer during a competition phase will result in greater improvements to AT and therefore endurance performance.

1.4.3.2 Reverse linear periodisation

The objective of RLP for endurance running is to improve AT prior to the introduction of continuous and/or longer interval training (21). This is often achieved through the completion of high intensity interval training (HIIT) prior to the introduction of continuous or long interval training. In order to effectively improve AT, the running speed during training should be greater than AT (39). Training above AT is more effective than lower intensity continuous training or low intensity interval training for the development of AT (39). Denadai and colleagues found that when a 4 week higher intensity HIIT training protocol utilising 100% velocity at maximal oxygen uptake ($v\dot{V}O_{2max}$) was introduced to well-trained athletes, there were significant improvements in 5000 m time trial (TT), 1500 m TT, $v\dot{V}O_{2max}$ and RE (27). A slightly lower intensity (95% $v\dot{V}O_{2max}$) only elicited improvements over the 5000 m TT (27). Improvements in $v\dot{V}O_{2max}$, RE and 1500 m TT performance only occurred in the higher intensity training group (27). Improvements to AT and changes in muscle recruitment patterns resulting in improved RE may have accounted for the difference between the two groups (44).

Training which activates large numbers of motor units may induce changes to intra- and inter- muscle coordination thereby improving running mechanics and therefore RE. It has previously been established that acute changes to muscle recruitment patterns occur with increases in running velocity (68). There is a shift for rectus femoris activity from knee extension to hip flexion, gastrocnemius activity also increases prior to foot contact (68). Anecdotally, increasing running speeds to above anaerobic threshold in early training may improve activation and synchronisation of muscles around the hip and lower leg resulting in improved RE at lower running speeds. This has previously been demonstrated with maximal intensities and with both plyometric exercises and strength training (10, 17, 84). A similar principle can been applied to strength training where within 2 weeks of starting, athletes are capable of lifting more weight with no changes to muscle size (2, 20). Improvements in intra and inter-muscle efficiency occur through changes to motor unit activation patterns which translate to improvements in speed of movement (1, 21).

One recent study examined ten week reverse linear and block periodised programs for middle distance running performance (21). Early improvements in the reverse linear group were attributed to neural adaptation leading to increases in agonist activation and antagonist relaxation (21). The findings from a previous study suggest that as motor patterns vary depending on running speed (44). Anecdotally, HIIT should be implemented early in running training programs to maximise motor recruitment thereby training muscle coordination and improving synchronisation. At the conclusion of the ten weeks of training the RLP group showed significantly greater improvements over a 400 m TT and a 1000 m TT than the block periodised group (21). The researchers attributed the differences in TT performance to improved aerobic and anaerobic energy derivation, muscle acid buffering capacity and lactate tolerance (21). This supports the strategy of managing lactate through training tolerance followed by clearance.

An improved AT and RE can be utilised to increase the speed which continuous or long interval training sessions can be performed (38). This may result in greater improvements in aerobic capacity. It may also be logical to include higher volume training at the conclusion of a program as the duration is closer to endurance race demands. Practicing similar distances at training may assist with race preparation due to similar exercise durations and intensities.

1.5 Summary

It has been well established that endurance running performance is predominantly determined by the interaction between an individual's $\dot{V}O_{2max,}$ AT and RE (25, 27, 39, 52). These components may be improved through training where different combinations of volume and intensity can be utilised to stimulate improvement in a target fitness component (30, 62, 88, 89, 95). Due to the co-dependence of endurance variables there is often a crossover where varying degrees of improvement can be observed across accompanying components (25, 27). This co-dependence is pivotal to the principle of periodisation as it suggests that when a subsequent element is targeted, improvements may be attained at a greater rate.

When designing an endurance training program, there are many changeable factors. This has resulted in the common use of several different periodisation models including but not limited to the traditional model of LP and a less conventional model in RLP. Both models are based upon the same physiological principles with LP building aerobic capacity first and using it to enhance AT training. In contrast, RLP aims to develop aerobic capacity through an improved AT and RE. Due to the limited research comparing periodisation methods for running, there is rationale to explore the changes in physiological mechanisms involved in endurance performance across differently periodised training programs. Any differences could influence coaches' future training program design.

The aim of the present study was to investigate the effectiveness of two periodisation methods and unregulated training regimes on endurance time trial performance and the factors which determined that performance. It was hypothesised that:

a. A reverse linear periodised endurance training program would be more effective than a linear periodised endurance program at improving anaerobic threshold and running economy following 12 weeks of running training.
b. Both periodisation methods would demonstrate greater improvements than unregulated training across all measured performance variables.

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CHAPTER 2

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2. THE PAPER

A Comparison of Linear and Reverse Linear Periodised Programs with Equated Volume and Intensity for Endurance Running Performance

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2.0 Abstract

This investigation examined the effectiveness of two periodisation methods on endurance running performance. Thirty recreational runners (25.2±7.4 y; 175.4±8.1 cm; 69.0±9.8 kg) were randomly assigned to three groups based on pre-intervention test results: linear periodisation (LPG, n=10), reverse linear periodisation (RPG, n=10), and control group (CG, n=10). The LPG and RPG completed 3 training sessions (2 supervised, 1 unsupervised) per week in two 6-week blocks. The LPG undertook a high-volume training program while the RPG performed higher intensity, lower volume training in the initial block. Training volume and intensity was reversed in the second 6-week training block. All subjects completed pre-training (week 0), mid-point (week 7) and post-training (week 14) testing which included anthropometric measurements (body mass and sum of 8 skinfolds), treadmill tests for running economy (RE) and $\dot{V}O_{2max}$, and a 5000 m time trial (TT) on a 400 m grass track. Greater improvements in the 5000 m TT were observed in the LPG (76.8±55.8 s, p=0.009, *d*=1.27), and the RPG (112.8±83.4 s, p=0.002, *d*=1.51) than the CG (3.6±59.0 s). No significant differences in 5000 m TT were found between the LPG and RPG (p=0.321, *d*=0.51). No between-group differences were found for $\dot{V}O_{2peak}$ (p=0.955) or RE at 9 km.h^{-1} (p=0.329) or 11 km.h^{-1} (p=0.558). However, significant improvements were seen in these variables following training: $\dot{V}O_{2peak}$ (p=0.010), RE 9 km.h^{-1} (p<0.001), RE 11 km.h^{-1} (p=0.004). These results do not support linear periodisation or reverse linear periodisation as a superior method of endurance running training. However, periodised training elicited greater improvements in endurance performance than non-periodised training, highlighting the importance of planned training structure.

Key words: Running Economy; $\dot{V}O_{2max}$; Time Trial; Training Load; Linear periodisation

2.1 Introduction

Periodisation is the process of planning a training program that considers all factors that influence the overall performance of an individual (4, 30, 34). Fitness variables that govern performance are often ordered within a training program to achieve peak performance for a specific event or competition (24, 34, 35, 38). This is done whilst considering the interrelationship between the key performance variables (32). As such, the achievement of a specific training goal may enable other training goals to progress, resulting in improvement in the overall performance (12, 19, 28, 29). As a result, periodisation is widely regarded as the principle method of developing an athlete's peak performance (15, 20, 24, 30). Crucial to periodisation is the inverse relationship between volume and intensity (24).

While most agree with the concept of periodisation and the manipulation of training volume and intensity, there is debate on how the structure of a training plan should be organised to deliver the optimal performance (20). There are a number of periodisation models that have been utilised in many sports including linear periodisation and reverse linear periodisation (31). The optimal structure is dependent on a number of factors including the type of sport or level of athletes. For example, when preparing an athlete for an endurance event, the commonly utilised method of periodisation is linear periodisation (32).

The typical linear periodised program aims to build aerobic capacity first through a period of high-volume/low-intensity training before increasing the proportion of high-intensity training (23). The logic of this approach is to ensure sufficient level of aerobic capacity so the athlete can better tolerate high intensity work in later training. The increase in aerobic respiration reduces the need for anaerobically derived energy which reduces metabolite accumulation and enables athletes to exercise at higher intensity for longer

(39) but also enhances the rate of recovery between high intensity bouts during interval training sessions (37). This improves the consistency of high intensity training efforts in the latter half of a linear periodised program.

In contrast, reverse linear periodisation is less common, but has been used in short to middle distance track events (6) and begins with a period of high intensity training. The primary purpose of the high intensity work early on is to enhance anaerobic threshold (AT), lactate buffering and lactate tolerance (6). An investigation by Cantos, Liedtke and Palomo-Vélez (6) showed reverse linear periodisation to be more effective than block periodisation for improving middle distance performance. They also suggested that high intensity running training innervates more muscle fibres and therefore elicits improvements in running economy (RE) (6). Continuous training or long intervals are then gradually introduced to further the development of aerobic capacity (24). Advocates for reverse linear periodisation argue that beginning an endurance training program with shorter efforts will allow subsequent longer training efforts to be performed faster due to an improved AT and RE (6). In addition, longer intervals performed at a greater speed may be more specific to the demands of competitive endurance racing and therefore be more appropriate later in preparatory phases (18).

While linear periodisation traditionally has been used in endurance training programs (31), there is a lack of empirical research supporting a particular periodisation method for endurance running performance (20). Consequently, within the coaching community there is reliance on past experience and anecdotal evidence to guide the planning process (20). Therefore the purpose of the present study was to investigate the effectiveness of two periodisation methods (linear periodisation and reverse linear periodisation) and unregulated training regimes on endurance TT performance and the physiological factors which determined that performance. It was hypothesised that in recreational endurance runners: (a) reverse linear periodisation would elicit greater improvements in AT and RE following a short period of training than linear periodisation and an unregulated group; (b) both periodised training methods would demonstrate greater improvements than unregulated training across all examined performance measures.

2.2 Methods

2.2.1 Experimental Approach to the Problem

A 3 (group) x 3 (time period) repeated measures design with a controlled sample was used to examine the effects of linear periodisation, reverse linear periodisation and non-regulated endurance training program on 5000 m running performance. Thirty subjects were randomly assigned to either the control group (CG), the linear periodised group (LPG) or the reverse linear periodised group (RPG). Groups were matched based on gender, $\dot{V}O_{2max}$ and 5000 m TT results. Subjects in LPG and RPG performed the assigned training program 3 times per week (2 supervised and 1 unsupervised sessions), whereas subjects assigned to the CG continued with their own training. Endurance running performance was monitored via changes in TT performance as well as key physiological variables: $\dot{V}O_{2max}$, AT and RE. Assessments occurred prior to commencing (Week 0), at the end of the first 6-week training block (Week 7) and at the end of the second training block (Week 14). All subjects were instructed to record any unsupervised training in exercise diaries throughout the training intervention.

2.2.2 Subjects

Thirty five recreational runners, male (n = 26) and female (n = 9) (25.2 ± 7.4 y; 175.4 ± 8.1 cm; 69.0 ± 9.8 kg) with no less than 2 y running experience and a 5000 m personal best less than 25 min (22.5 ± 2.1 min) were recruited from local sporting clubs and social running groups. Subjects were also required to have run at least 15 km per week without complete discontinuation for more than two consecutive weeks, for 2 y or more (14). They were assigned to one of three groups, LPG (n = 11), RPG (n = 11) and CG (n = 13), using a block randomisation technique to ensure the groups were matched by gender, 5000 m TT performance and $\dot{V}O_{2max}$. Five subjects (1 from LPG, 1 from RPG and 3 from CG) withdrew from the study due to illness. Thus, only data from the 30 remaining subjects (n = 10 in each group) who completed the entire study were used in the analyses. The investigation was conducted in accordance with the National Statement on Ethical Conduct in Human Research and was approved by the University of Western Australia Ethics Committee (RA/4/1/8738) prior to recruitment of subjects (Appendix C). Subjects were informed of the benefits and risks of participation before the start of the study (Appendix A). All subjects gave written consent (Appendix B).

2.2.3 Procedures

All subjects attended 3 testing sessions, at week 0 (pre-training), week 7 (mid-point, separating two training blocks) and week 14 (post-training). In the weeks between testing periods (1 - 6, 8 - 13), the LPG and RPG completed 6-week training blocks which consisted of two supervised training sessions and one unsupervised training session per week (Table 1). Subjects in the CG were asked to continue with their regular training independently. Investigators monitored the unsupervised training of all participants through training diaries (Appendix F).

2.2.3.1 Testing Orientation

During each testing period, the following tests were conducted: Submaximal test for RE, incremental treadmill test to exhaustion and a 5000 m TT. Both the submaximal test for RE and the incremental treadmill test to exhaustion were conducted on a calibrated treadmill (H/P Cosmos, Quasar 3p Medical treadmill, Nussdorf-Traunstein, Germany) at a gradient of 1%, in a climate-controlled laboratory (22°C, 50-60 % relative humidity). The incremental treadmill test to exhaustion was used to determine the $\dot{V}O_{2max}$, velocity at the maximal oxygen uptake ($v\dot{V}O_{2max}$) and AT for each participant. The 5000 m TT was conducted on a 400 m grass track 48 h after laboratory tests. Subjects were instructed to refrain from unsupervised training and alcohol in the 24 h before a test and caffeine 3 h prior to testing sessions. Subjects were instructed to record dietary intake in the first testing week and replicate it in the second and third testing weeks. At the beginning of each testing period, subject anthropometric data (height, mass and sum of 8 skinfolds) was collected. All subsequent testing sessions were completed at the same time of day.

2.2.3.2 Training Sessions

Each subject attended two supervised training sessions per week at a minimum of 48 h apart. At supervised training sessions, subjects completed a standardised warm-up (2 km at 60-70% of previously determined maximum heart rate (HR_{max})) before commencing their assigned training set (Table 1). Training intensity was determined based on the 5000 m TT performance and the rate of perceived exertion (RPE) was recorded at the conclusion of sessions using the modified CR-10 scale (5).

Each subject was also required to perform one unsupervised training session (prescribed by researchers) each week during the intervention period. Subjects were instructed to undertake the prescribed training session on flat ground. For these sessions, the target work intensity was based on the subject's HR_{max} determined during the graded exercise test (GXT). Subjects were required to record running distance, duration, average heart rate (HR) and CR-10 RPE scores.

To calculate training load, session duration in minutes was multiplied by the corresponding CR-10 RPE score. Session loads were then summated to determine weekly training loads (17). The daily mean and standard deviations of training load were also calculated for the week (including zero load days). The daily mean was divided by the standard deviation to determine training monotony (16).

Table 1: Linear Periodised Training program

Week	Session 1	Session 2
0 (testing)	Treadmill test	5000 m time trial
1	10x800 m 85% TT 2 min rest	5x1600 m 80% TT 2 min rest
2	10x800 m 85% TT 2 min rest	5x1600 m 80% TT 2 min rest
3	10x700 m 90% TT 2 min rest	6x1200 m 85% TT 2 min rest
4	10x700 m 90% TT 2 min rest	6x1200 m 85% TT 2 min rest
5	10x600 m 95% TT 2 min rest	6x1000 m 90% TT 2 min rest
6	10x600 m 95% TT 2 min rest	6x1000 m 90% TT 2 min rest
7 (testing)	Treadmill test	5000 m time trial
8	10x500 m 105% TT 2 min rest	6x800 m 100% TT 2 min rest
9	10x500 m 105% TT 2 min rest	6x800 m 100% TT 2 min rest
10	10x400 m 115% TT 2 min rest	7x600 m 105% TT 2 min rest
11	10x400 m 115% TT 2 min rest	7x600 m 105% TT 2 min rest
12	10x300 m 125% TT 2 min rest	9x400m 115% TT 2 min rest
13	10x300 m 125% TT 2 min rest	9x400m 115% TT 2 min rest
14 (testing)	Treadmill test	5000 m time trial

*RPG began at week 14 and finished at week 0.

2.2.3.3 Anthropometric Assessment

Body mass was measured with a digital platform scale (Model ED3300; Sauter Multi-Range, Ebingen, West Germany ± 10 g) with subjects wearing as little clothing as possible. Skinfold thickness at eight body landmarks (triceps, biceps, subscapulare, supraspinale, iliocristale mid-abdominal, anterior thigh, & medial calf) was measured using Slim Guide® spring-loaded calipers to the nearest 0.5 mm on the right side of the body (Creative Health Products, Plymouth, Michigan, USA). If the difference between duplicate measures exceeded 4% for skinfolds, a third measurement was taken but only after the full profile had been completed in duplicate. The median of duplicate anthropometric measurements was used for subsequent analysis (33).

2.2.3.4 Measurement of Running Economy

Running economy was defined as the steady state oxygen consumption in mL.kg^{-1}.min^{-1} obtained at each workload (8). Prior to the test, participants warmed up at a running speed of 8 km.h^{-1} for 10 min then rested for 5 min. Subjects then completed two bouts of continuous running on the treadmill, one at 9 km.h^{-1} and another at 11 km.h^{-1}. These speeds were selected to be submaximal as a 25 min 5000 m TT equates to 12 km.h^{-1}. Previous literature has used speeds between 8 km.h^{-1} and 21 km.h^{-1} (1, 40). Each workload was undertaken until steady state was reached and lasted for a minimum of 3 min. The two running bouts were separated by a 5 min passive rest period. A 10 min rest period was given at the conclusion of the 11 km.h^{-1} trial prior to commencement of the graded exercise test. Steady state was defined as an increase of <100 mL O_2 utilised determined through expired gas over the final minute of both stages. Respiratory exchange ratio (RER), mL.kg^{-1}.min^{-1} and HR were averaged over 15 s intervals from steady state of each stage. Rate of perceived exertion was also taken through use of the Borg 6-20 RPE scale (5). Prior to testing, subjects were familiarised with the RPE scale and received standardised instructions on how to implement the scale. The scale was in full view of each subject during the RE test.

2.2.3.5 Graded Exercise Test

Following the completion of the RE test the graded exercise test commenced. The initial speed was set at 10 km.h^{-1} for 3 min and then increased 1 km.h^{-1} every 3 min until volitional exhaustion. Each stage of the test was followed by a 1 min rest period to allow determination of blood lactate concentration via a capillary blood sample from the earlobe. Throughout each test, pulmonary gas exchange was determined breath-by-breath (Universal ventilation meter, VacuMed, Ventura, California, USA). Before each test, the oxygen and carbon dioxide analysis system was calibrated with and validated by a 1-L calibration syringe (Model 5540: Hans Rudolph, Kansas City, MO) in accordance with manufacturer's instructions. Expired oxygen and carbon dioxide concentrations were analysed using Ametek gas analysers (Applied Electrochemistry, SOV S-3A11 and COV CD-3A, Pittsburgh, PA, USA), and calibrated immediately before and verified after each test using a certified gas mixture of known concentrations (BOC Gases, Chatswood, Australia). Heart rate was monitored continuously throughout the tests and recorded in the last 15 s of each stage (Polar Electro Oy Professorintie, Kempele, Finland). Earlobe capillary samples were analysed for blood lactate (mmol.L^{-1}) through a Lactate Pro 2 portable blood lactate analyser (Arkray, KDK, Kyoto, Japan). The $\dot{V}O_{2max}$ is defined as the sum of the highest 4 consecutive 15 s VO_2 values reached during the incremental test (expressed as mL.kg^{-1}.min^{-1}). To have reached $\dot{V}O_{2max}$ a subject fulfilled at least 2 of the following criteria: a respiratory exchange ratio of greater than 1.10, a blood lactate reading above 8 mmol.L^{-1} and a peak HR at least equal to 90% of age predicted maximum (36). The $v\dot{V}O_{2max}$ is defined as the minimum velocity at which $\dot{V}O_{2max}$ occurred (3). Individual AT was calculated via the D-max method (9). The D-max was identified as the point on the polynomial regression curve that yielded the maximal distance to the straight line formed by the two end data points (41).

2.2.3.6 Time Trial

At TT sessions, subjects completed a standardised warm-up (1 km at 60-70% of HR_{max}) followed by a 5 min passive rest. Each subject individually completed a 5000 m TT on a 400 m grass surface track. Subjects were instructed to run at 5000 m race pace and given verbal encouragement throughout the trial. The time taken to run the 5000 m was recorded using a manual chronometer. Heart rate was recorded immediately after completion of the TT and 60 s later heart rate recovery (HRR) was recorded. In an attempt to control factors which could influence HR and HRR, subjects were asked to sit passively, and remain still for the duration of the recovery period (22).

2.2.4 Statistical Analysis

2.2.4.1 Time trial performance

A 3 (group) x 3 (time point) split-plot analysis of variance (SPANOVA) was used to determine any significant effects of training conditions at different time points. Subsequent two-way repeated measures analysis of variances (ANOVA) located any between group differences. Post hoc paired sample *t*-tests were used to identify any differences at specific time points. Cohen's *d* effect sizes were also calculated where the following descriptors were used; 0-0.2 (trivial); 0.2-0.5 (moderate); >0.8 (large), with only moderate to large effect sizes reported (11).

2.2.4.2 Training Response

Comparisons were made for equivalent training weeks where LPG and CG weeks 1 – 6, 8 – 13 were compared to RPG weeks 13 – 8, 6 – 1. A one-way ANOVA was used to locate any significant differences between groups for both block and weekly training volume, load and monotony. Post hoc paired sample *t*-tests were used to identify the source of any differences.

2.2.4.3 Physiological determinants of endurance performance

A 3 (group) x 3 (time point) SPANOVA was used to locate any significant effects for $\dot{V}O_{2peak}$, AT, RE at 9 $km.h^{-1}$, RE at 11$km.h^{-1}$ and sum of 8 skinfolds. Subsequent two-way repeated measures analysis of variances (ANOVA) located any between group differences. Post hoc paired sample *t*-tests identified the source of any differences.

2.3 Results

2.3.1 Training Compliance

All subjects (LPG and RPG) were required to attend a minimum of 90% of supervised training sessions to be included in the analysis. Subject compliance was 94.0 ± 3.4%.

2.3.2 Time Trial Performance

A significant time x group interaction ($F_{(4, 54)} = 5.423$, p = 0.003) was found in the 5000 m TT performance. Post hoc analyses found that both LPG and RPG had significantly greater improvements in the 5000 m than CG ($F_{(2, 36)} = 6.705$, p = 0.009, *d* = 1.27 & $F_{(2, 36)} = 8.801$, p=0.002, *d* = 1.51, respectively). No significant differences existed between the LPG and RPG groups ($F_{(2, 36)} = 1.172$, p = 0.321, *d* = 0.51).

Figure 3 displays the improvements in 5000 m TT performance which occurred in LPG (76.8 ± 55.8 s, 5.5 ± 3.9 %), RPG (112.8 ± 83.4 s, 8.1 ± 5.5 %) and CG (3.6 ± 59 s, 0.1 ± 4.6 %) following 12 weeks of training.

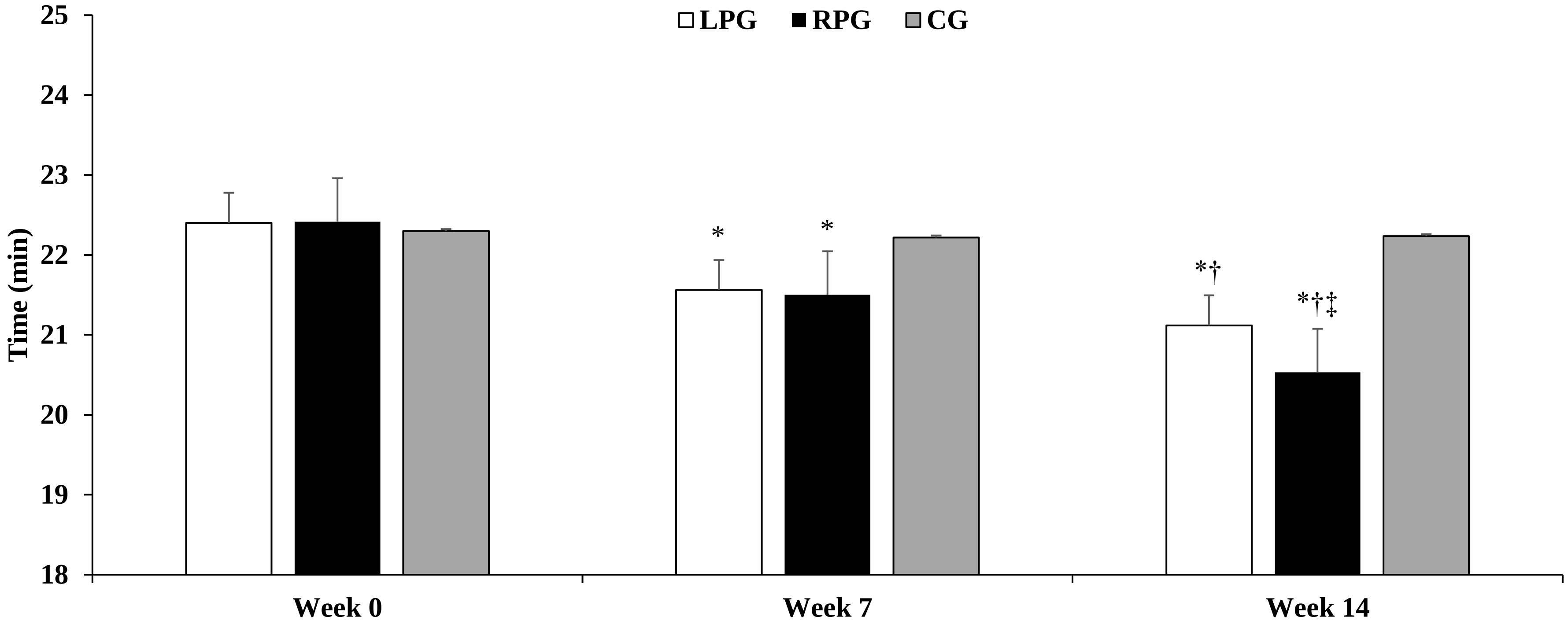

Figure 3. Mean ± (SE) 5000 m time trial times between the linear periodised group (LPG), reverse linear periodised group (RPG), and control group (CG) recorded in week 0, week 7 and week 14 of the training intervention.

* Significantly different to week 0 value ($p<0.05$)

† Significantly different to week 7 value ($p<0.05$)

‡ Significantly different to CG ($p<0.05$)

2.3.3 Training Response

Significant differences were detected in training volume and load between groups in training weeks (1 – 6, 8 – 13) (Figure 4).

A significant difference in training load ($F_{(2, 29)} = 12.535$, $p < 0.001$) resulted between the three groups for total training load during the high volume training block (HVB). The LPG had a significantly higher total training load than both the RPG ($p = 0.015$, $d = 1.59$) and the CG ($p < 0.001$, $d = 1.91$). The significant differences in loads was located within HVB in weeks 1 – 5 (Table 2).

Significantly higher training loads were found in the HVB than the high intensity training block (HIB) within both the LPG ($p < 0.001$, $d = 3.52$) and the RPG ($p < 0.001$, $d = 2.21$).

No significant differences were found between groups for training monotony in the HVB ($F_{(2, 29)} = 1.121$, $p = 0.341$) or the HIB ($F_{(2, 29)} = 0.671$, $p = 0.519$).

No significant differences were found between LPG (24.59 ± 2.49 km), RPG (25.23 ± 2.48 km) or CG (24.26 ± 5.56 km) for mean weekly training volumes ($F_{(2, 29)} = 0.166$, $p = 0.848$).

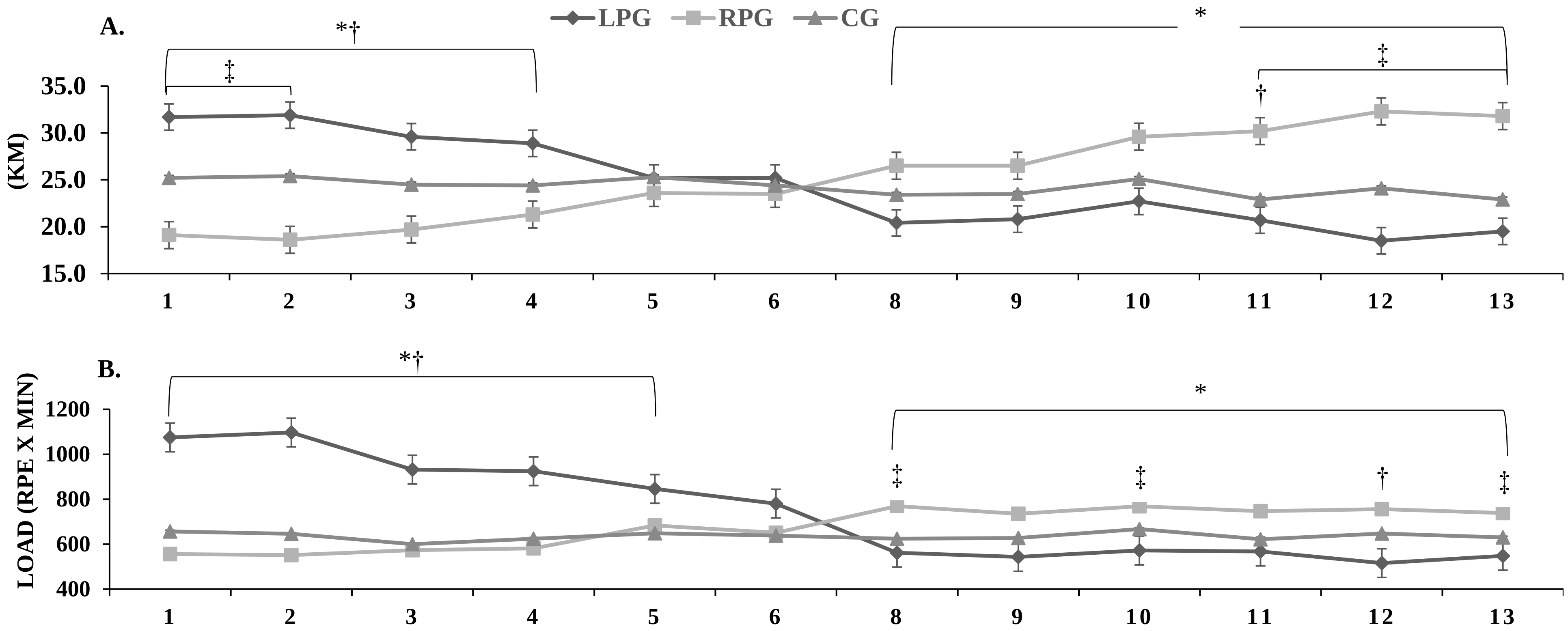

Figure 4. Mean ± (SE) weekly training volume (A) and weekly training load (B) for the linear periodised (LPG), reverse linear periodised (RPG) and control (CG) groups during training weeks (1 – 6, 8 – 13).

* Significant differences between LPG and RPG ($p < 0.05$)

† Significant differences between LPG and CG ($p < 0.05$)

‡ Significant differences between RPG and CG ($p < 0.05$)

Table 2. Mean ± (SD) weekly training load, weekly training monotony and weekly training volume (km) for the linear periodised (LPG), reverse linear periodised (RPG) and control (CG) groups.

			High Volume training block (weeks)						**High Intensity training block (weeks)**					
	Group		**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Training Volume (km)	**LPG**	*Mean*	31.70*	31.90*	29.60	28.89	25.20	25.20	20.40	20.80	22.70	20.70	18.50*	19.50*
		(SD)	(3.86)	(4.04)	(3.34)	(3.17)	(4.52)	(4.52)	(5.60)	(3.33)	(2.59)	(2.42)	(3.07)	(2.51)
	RPG	*Mean*	31.80*	32.30*	30.20	29.60*	26.50	26.50	23.50	23.60	21.30	19.70	18.60*	19.10*
		(SD)	(3.97)	(3.89)	(4.14)	(3.17)	(4.20)	(4.20)	(5.21)	(3.08)	(2.81)	(1.58	(2.11)	(2.42)
	CG	*Mean*	25.20	25.40	24.50	24.40	25.30	24.40	23.40	23.50	25.10	22.90	24.10	22.90
		(SD)	(7.35)	(7.31)	(7.20)	(5.27)	(6.02)	(6.74)	(5.66)	(4.38)	(5.80)	(6.38)	(6.38)	(3.63)
Training Load	**LPG**	*Mean*	1075*	1097*	931*	925*	846*	780	562	543	572	567	516*	548
		(SD)	(188)	(187)	(159)	(163)	(181)	(170)	(113)	(79)	(55)	(73)	(85)	(68)
	RPG	*Mean*	739†	756†	747†	769†	735	769	651	683†	582	573	551	556
		(SD)	(93)	(90)	(95)	(85)	(100)	(115)	(125)	(79)	(77)	(78)	(75)	(78)
	CG	*Mean*	657	646	600	624	648	638	624	628	667	621	647	630
		(SD)	(216)	(210)	(198)	(132)	(122)	(197)	(145)	(124)	(149)	(108)	(134)	(112)
Training Monotony	**LPG**	*Mean*	0.89	0.95	0.88	0.79	0.86	0.81	0.80	0.79	0.92	0.89	0.90	0.95
		(SD)	(0.17)	(0.24)	(0.12)	(0.13)	(0.17)	(0.13)	(0.14)	(0.09)	(0.12)	(0.10)	(0.15)	(0.13)
	RPG	*Mean*	0.97	1.00	0.97	0.94	0.93	0.92	0.89	0.95	0.93	0.88	0.92	0.92
		(SD)	(0.18)	(0.18)	(0.17)	(0.12)	(0.15)	(0.15)	(0.14)	(0.12)	(0.13)	(0.11)	(0.13)	(0.13)
	CG	*Mean*	0.90	0.90	0.85	0.87	0.91	0.87	0.83	0.87	0.93	0.87	0.90	0.87
		(SD)	(0.16)	(0.16)	(0.17)	(0.19)	(0.16)	(0.21)	(0.13)	(0.11)	(0.13)	(0.14)	(0.15)	(0.12)

* Significantly different to CG ($p < 0.05$)

† Significantly different to LPG ($p < 0.05$)

2.3.4 Physiological Determinants of Endurance Performance

For the graded exercise test, no significant time x group interactions were observed for $\dot{V}O_{2peak}$ ($F_{(4, 54)}$ = 0.166, p = 0.955) and AT ($F_{(4, 54)}$ = 0.680, p = 0.609). However, time interaction improvements were observed in VO_{2peak} ($F_{(2, 54)}$ = 4.998, p = 0.010) and AT ($F_{(2, 54)}$ = 10.639, $p < 0.001$, *d* = 0.64).

For the RE tests, no significant interaction effects were found for the speeds 9 km.h^{-1} ($F_{(4, 54)}$ = 1.183, p = 0.329) or 11 km.h^{-1} ($F_{(4, 54)}$ = 0.757, p = 0.558). However, significant time effects for RE at 9 km.h^{-1} ($F_{(4, 54)}$ = 9.795, $p < 0.001$, *d* = 0.69) and 11 km.h^{-1} ($F_{(4, 54)}$ = 5.999, p = 0.004) indicate improvements at both speeds.

No interaction was found between groups and time for skinfolds ($F_{(4, 54)}$ = 1.312, p = 0.283). A significant time effect was found ($F_{(2, 54)}$ = 31.961, $p < 0.001$) indicating a reduction within groups in the sum of 8 skinfolds measurement. Significant decreases were seen in all three groups (Table 3).

Table 3. Mean ± (SD) $\dot{V}O_{2peak}$, anaerobic threshold (AT), running economy at 9 km.h^{-1} (RE$_{9km.h^{-1}}$), running economy at 11km.h^{-1} (RE$_{11km.h^{-1}}$) and sum of 8 skinfolds (S8SF) for the linear periodised (LPG), reverse linear periodised (RPG) and control (CG) groups recorded in week 0, week 7 and week 14 of the training intervention.

Variable		**LPG**			**RPG**			**CG**		
		Week 0	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
$\dot{V}O_{2peak}$	Mean	59.46	60.36	62.09	59.95	61.29	62.52	59.57	61.51	61.07
(mL.kg^{-1}.min^{-1})	*(SD)*	(7.58)	(7.03)	(4.70)	(7.13)	(6.71)	(6.15)	(7.13)	(4.57)	(5.20)
AT	Mean	13.67	14.00	14.53*	13.13	13.87*	14.02*	13.33	13.55	13.83
(km.h^{-1})	*(SD)*	(1.27)	(1.51)	(1.23)	(1.30)	(1.14)	(0.67)	(1.28)	(1.64)	(1.12)
RE$_{9km.h^{-1}}$	Mean	39.07	36.40*	36.51*	40.54	36.68*	37.43	39.78	39.80	38.23*
(mL.kg^{-1}.min^{-1})	*(SD)*	(3.23)	(2.67)	(3.16)	(5.02)	(2.32)	(3.98)	(2.18)	(3.76)	(3.49)
RE$_{11km.h^{-1}}$	Mean	44.57	43.27	42.44*	44.33	43.38	43.27	45.21	46.24	43.93*
(mL.kg^{-1}.min^{-1})	*(SD)*	(2.25)	(2.76)	(3.81)	(3.89)	(3.49)	(3.81)	(4.13)	(4.44)	(3.74)
S8SF	Mean	90.6	83.0*	78.4*	96.1	89.9*	79.1*†	88.1	85.6	78.6*†
(mm)	*(SD)*	(36.3)	(33.7)	(27.2)	(31.6)	(27.9)	(25.3)	(28.8)	(31.9)	(26.2)

* Significantly different to week 0 value ($p<0.05$)

† Significantly different to week 7 value ($p<0.05$)

2.4 Discussion

To the best of our knowledge, this is the first study to examine the effect of different periodised training models on endurance running performance (in recreational runners). The results suggest no between-group differences in the key performance measures: $\dot{V}O_{2peak}$, RE, AT and body composition. Consequently, the hypothesis that recreational endurance runners in the RPG would elicit greater improvements in AT and RE following a short period of training than the LPG and CG was not supported. With regards to $\dot{V}O_{2peak}$, subject training history may have placed them close to their physiological upper limits of oxygen consumption (2). The current group of subjects already had high $\dot{V}O_{2peak}$ scores as demonstrated at initial tests. Therefore, limited increases to $\dot{V}O_{2peak}$ could be expected, reducing the potential for between group differences. As these measures have been shown to account of a large portion of inter-individual variance in endurance performance (12, 13, 21, 26), it is likely that improvements in these sub-qualities accounted for a significant proportion of the improvements to 5000 m TT performance.

The hypothesis that both periodised groups would be more effective in improving 5000 m TT performance than the CG was confirmed. This concurs with previous research which suggests that a structured training plan is better than unstructured exercise (7, 25, 28). Training under supervision 3-5 times per week for 20-30 min has been shown to improve $\dot{V}O_{2peak}$ and AT (7). Increasing training intensity and moving to an interval training format has been shown to induce greater improvements in endurance performance than moderate continuous running over an 8 week period in recreational runners (25). This may be due to the anaerobic nature of intervals and the subsequent improvement to the important AT. A structured program can also combine running training with resistance training to attain even greater improvements to endurance performance (28).

The underlying purpose of periodisation is to split the training program into specific objectives, focusing on one objective before moving on the next (20). An advantage of splitting training into objectives is gaining the ability to utilise periods of high load training as they may be followed by optimised recovery periods (4, 20). This will result in improvements to performance. Further, the manipulation or variation of training can reduce the likelihood of training stagnation, monotony and boredom (4, 27). In contrast, the CG had relatively constant week to week training loads for entirety of the intervention.

Differences between training responses in periodised and non-periodised training groups may have occurred as a result of training history. In a practical sense, coaches must take the level of the athlete in consideration when developing a training program because training experience can dictate the response to a training stimulus (27). Athletes may stagnate more quickly than untrained people when exposed to new training stimuli (10). As subjects in this study all had a minimum of 2 y training experience, it can be assumed that subjects in the present study would stagnate without appropriate training variation. This is due to the likely repetitive nature of training in recreational runners which is highlighted in the weekly training loads of the CG. The training structure and variation of volume and intensity likely prevented stagnation in the LPG and RPG, whereas the CG performed relatively constant loads throughout the training period. This principle may be responsible for differences in 5000 m TT performance between the periodised groups and the CG. Further, there were a lack of significant differences between total group training volumes indicating training structure was likely responsible for group differences. This highlights the importance in the role of the coach, and subsequent training program and session design which appear crucial in improving key endurance parameters and subsequent running performance (7, 25, 28).

Although there were no significant differences between LPG and RPG 5000 m TT results the differences between programs was evident with significant differences in weekly training volume and weekly training load in training weeks (1 – 6, 8 – 13). Further, the different mechanisms of linear periodisation and reverse linear periodisation were evident as session equivalent RPE scores were lower in the RPG than LPG for HVB sessions. While the LPG relied on the introduction of high volume training early to improve aerobic capacity thereby improving HIB repetition consistency and interval recovery (4), the RPG introduced high intensity training first which may have induced improvements in lactic acid buffering and tolerance (peripheral adaptation). This is one possible reason for the lower RPE scores seen in the RPG high volume training sessions (1). A previous investigation which demonstrated reverse linear periodisation to be more effective than block periodisation for short/middle distance running attributed the success of reverse linear periodisation to the principle of managing lactate through training tolerance followed by clearance (7). Authors also advocated early introduction of high intensity interval training to maximise motor recruitment thereby training muscle coordination and improving synchronisation (7). In contrast, the LPG had higher RPE scores than the CG and RPG which suggest a greater training stimulus. This highlights that while there were no significant differences between the LPG and RPG for TT results, the mechanisms which allowed significant improvement are different.

There were some limitations to the present study which are worth noting. There was a high inter-subject variability across all performance variables which may have impaired the ability to detect statistical significance. However, groups were matched on pre-training test results allowing for group comparisons. Due to the moderate effect size between the linear and reverse periodised groups for TT performance, it is possible that more subjects would have brought about significance. Additionally, as periodisation generally refers to time periods of a season or more, it may be logical for future research to use longer time periods so that differences following each training block can become more pronounced. This would allow the first trained key performance variable to have a larger effect on subsequent training, therefore having a greater impact on other interrelated variables which may also have a greater impact on performance.

In conclusion, structured endurance running training was superior in improving endurance TT performance compared with unregulated training, which shows the importance of training periodisation and session structure. Although no differences existed in between-group training volumes, differences existed in training loads which may indicate variances in physiological adaptations. These differences suggest the order of equated (volume and intensity) training sessions does have an impact on physiological adaptations, but is also important in preventing stagnation.

2.4.1 Practical Applications

From the results, the present study may be used to support previous research showing structured training will improve endurance running performance compared to training load matched unstructured training. The RPG improved by the same magnitude as the LPG with lower training RPE scores. This confirms the desired mechanism of reverse linear periodisation and it is therefore a valid method of structuring an endurance running program for recreational level endurance athletes.

2.5 References

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CHAPTER 3

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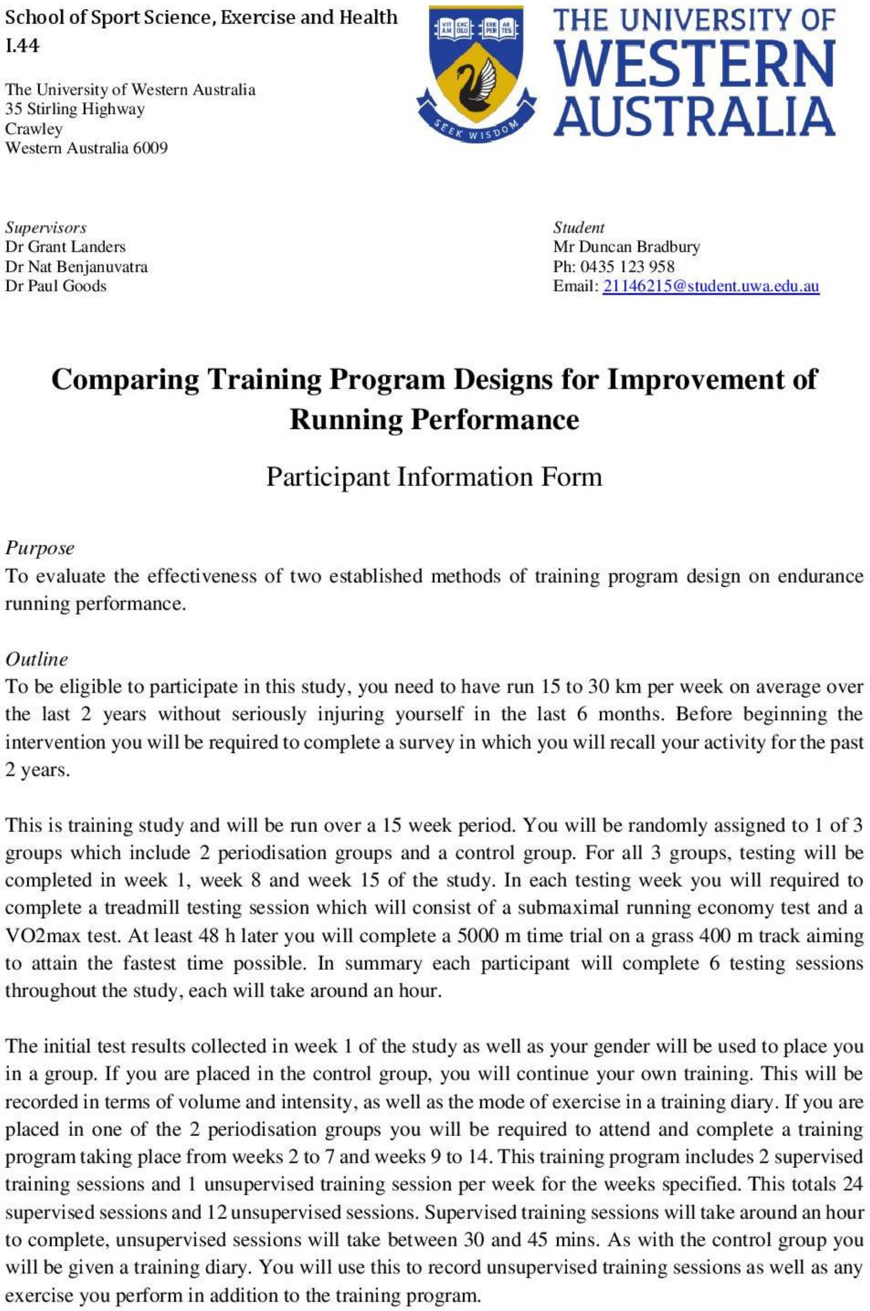
3. APPENDICES

Appendix A: Subject Information Sheet



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Supervisors
Dr Grant Landers
Dr Nat Benjanuvatra
Dr Paul Goods

Student
Mr Duncan Bradbury
Ph: 0435 123 958
Email: 21146215@student.uwa.edu.au

Comparing Training Program Designs for Improvement of Running Performance

Participant Information Form

Purpose
To evaluate the effectiveness of two established methods of training program design on endurance running performance.

Outline
To be eligible to participate in this study, you need to have run 15 to 30 km per week on average over the last 2 years without seriously injuring yourself in the last 6 months. Before beginning the intervention you will be required to complete a survey in which you will recall your activity for the past 2 years.

This is training study and will be run over a 15 week period. You will be randomly assigned to 1 of 3 groups which include 2 periodisation groups and a control group. For all 3 groups, testing will be completed in week 1, week 8 and week 15 of the study. In each testing week you will required to complete a treadmill testing session which will consist of a submaximal running economy test and a VO2max test. At least 48 h later you will complete a 5000 m time trial on a grass 400 m track aiming to attain the fastest time possible. In summary each participant will complete 6 testing sessions throughout the study, each will take around an hour.

The initial test results collected in week 1 of the study as well as your gender will be used to place you in a group. If you are placed in the control group, you will continue your own training. This will be recorded in terms of volume and intensity, as well as the mode of exercise in a training diary. If you are placed in one of the 2 periodisation groups you will be required to attend and complete a training program taking place from weeks 2 to 7 and weeks 9 to 14. This training program includes 2 supervised training sessions and 1 unsupervised training session per week for the weeks specified. This totals 24 supervised sessions and 12 unsupervised sessions. Supervised training sessions will take around an hour to complete, unsupervised sessions will take between 30 and 45 mins. As with the control group you will be given a training diary. You will use this to record unsupervised training sessions as well as any exercise you perform in addition to the training program.

Procedures

During testing weeks (1, 8, 15) you will be required to complete a combined VO_{2max} and running economy test at the Sport Science Exercise Physiology Laboratory. Dry nude body mass will be taken at the beginning of this session. Following this, the position of the mouthpiece used for gas analyses will be adjusted for your comfort during treadmill testing. You will then complete a submaximal running economy test on a treadmill. You will be warmed up at a running speed of 8 km/h for 10 min then run again for 6 min at 10 km/h and 12 km/h. You will be given a 5 min rest period between trials. Following this, you will be given a 10 min rest before beginning the VO2max test. For the test result to be meaningful, you must reach a 'steady' running state, in the event that this does not occur, the trial may need to continue for another 30 s.

For the measurement of VO2max the initial speed of the treadmill will be set at 10km/h for 3 min. The speed of the treadmill will be increased by 1 km/h every 3 min until you can no longer continue. All stages of the test will be separated by a 1 min rest period. During this time and earlobe capillary blood sample will be collected. The treadmill will also be set to a 1% gradient to simulate air resistance.

At least 48 hours later, a 5000 m time trial will be performed on the grass 400 m track at McGillivray oval. The aim of this time trial is to run the distance as fast as possible.

Training

For the periodisation groups, training volume per week will not exceed 30 km spread over the 3 weekly prescribed training sessions. Minimum training volume will not fall below 15 km per week. Training volume includes the standardised warm-up and cool-downs which are 2 km and 1 km at 60-70% of maximum heart rate respectively. Your maximum heart rate will be attained during the VO2max testing session.

Your supervised training intensity will be administered as a percentage of the pace seen in your 5000 m time trial. These sessions will also occur a minimum of 48 hours apart. Unsupervised training intensity may be administered as a percentage of 5000 m time trial pace or at a percentage of maximum heart rate. For unsupervised training you are asked to record the duration of exercise as well as the distance, time of day you completed the session and your rate of perceived exertion. Heart rate may also be recorded if it was measured. Any additional exercise may be recorded here inclusive of mode. Examples include swimming or cycling.

Because the aim of the study is to evaluate training methods, completion of sessions is important. Therefore participants who miss 4 or more training sessions out of 36 will be removed from analyses. You will be asked to abstain from alcohol in the 24 hour period and caffeine 3 hours prior to all testing sessions.

THIS STUDY INVOLVES

RISKS

The blood samples collected (average of 18 per participant) during this investigation may cause you some local discomfort; however, all efforts will be made to minimise this through the use of well-trained blood collectors and a small, retractable lancet will be used to pierce the skin. Additionally, carrying out a maximal treadmill test for the measurement of VO_{2max} may feel difficult due to the high intensity as well as the wearing of a mouthpiece. This is completely normal and common practice amongst athletes, however should you at any stage feel dizzy, light headed or excessively uncomfortable in any way, please let the researcher know, and you may immediately cease the trial. The prescribed training and 5000 m time trial may also result in local muscle soreness in the following days. However, this should not be greater than any training session that you perform in your regular program.

BENEFITS

For participating you will receive the data from your 3 VO_{2max} tests and 3 5000 m time trials, this includes your VO_{2max} as a quantifiable number and your time recorded for the time trial. In addition, the VO_{2max} protocol will also provide your running economy and anaerobic threshold. These are some of the key areas for endurance performance. The test mentioned above is normally very expensive and only experienced by elite athletes, it is the gold standard. The results will allow you some insight into how suited your body is to endurance activity and how you react to endurance training over time. The program you will be following is quantified and should improve your fitness level, it has been written by a coach with accreditation in numerous areas, an understanding of fitness variables and how to improve them.

CONFIDENTIALIATY

All personal data recorded will be kept secure and will not be accessed by anyone other than the researcher, unless external auditing is necessary.

SUBJECT RIGHTS

Participation is voluntary and you are free to withdraw from the study at any time without prejudice. You can withdraw for any reason, and you do not need to justify your decision. If you withdraw from the study and you are an employee or student at the University of Western Australia (UWA) this will not prejudice your status and rights as employee or student of UWA. Data may be retained, but only if you agree otherwise all recorded data will be destroyed. Your participation in this study does not prejudice any right to compensation that you may have under statue of common law.

If you have any questions feel free to ask, call or e-mail either myself Grant Landers, Nat Benjanuvatra or Paul Goods at any time (contact details below).

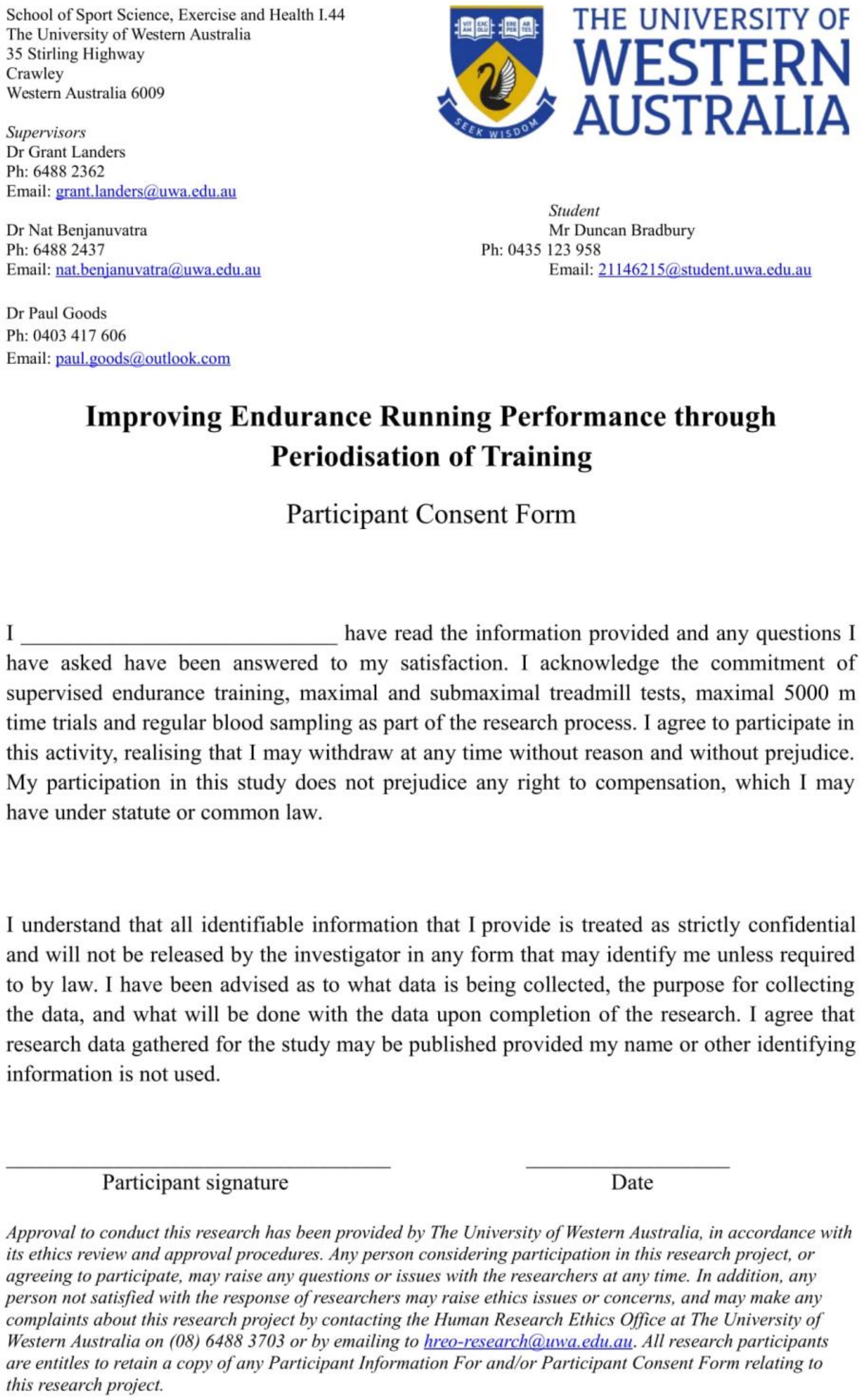
Contact Details

Mr Duncan Bradbury: 0435 123 958, 21146215@student.uwa.edu.au

Supervision team: Dr Grant Landers, Dr Nat Benjanuvatra, Dr Paul Goods – contact details available upon request.

Approval to conduct this research has been provided by The University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time. In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Research Ethics Office at The University of Western Australia on (08) 6488 3703 or by emailing to hreo-research@uwa.edu.au. All research participants are entitles to retain a copy of any Participant Information For and/or Participant Consent Form relating to this research project.

Appendix B: Consent Form



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THE UNIVERSITY OF WESTERN AUSTRALIA

Improving Endurance Running Performance through Periodisation of Training

Participant Consent Form

I ___________________________ have read the information provided and any questions I have asked have been answered to my satisfaction. I acknowledge the commitment of supervised endurance training, maximal and submaximal treadmill tests, maximal 5000 m time trials and regular blood sampling as part of the research process. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice. My participation in this study does not prejudice any right to compensation, which I may have under statute or common law.

I understand that all identifiable information that I provide is treated as strictly confidential and will not be released by the investigator in any form that may identify me unless required to by law. I have been advised as to what data is being collected, the purpose for collecting the data, and what will be done with the data upon completion of the research. I agree that research data gathered for the study may be published provided my name or other identifying information is not used.

__________________________________ Participant signature

__________________ Date

Approval to conduct this research has been provided by The University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time. In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Research Ethics Office at The University of Western Australia on (08) 6488 3703 or by emailing to hreo-research@uwa.edu.au. All research participants are entitles to retain a copy of any Participant Information For and/or Participant Consent Form relating to this research project.

Appendix C: UWA Human Ethics Approval

THE UNIVERSITY OF WESTERN AUSTRALIA

Human Ethics

Office of Research Enterprise

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E humanethics@uwa.edu.au
CRICOS Provider Code: 00126G

Our Ref: RA/4/1/8738

15 November 2016

Dr Grant Landers
School of Sport Science, Exercise and Health
MBDP: M408

Dear Doctor Landers

HUMAN RESEARCH ETHICS APPROVAL - THE UNIVERSITY OF WESTERN AUSTRALIA

Comparison between Linear and Reverse Linear Periodisation: Effects on Endurance Time Trial Performance, Running Economy and VO2max

Ethics approval for the above project has been granted in accordance with the requirements of the *National Statement on Ethical Conduct in Human Research* (National Statement) and the policies and procedures of The University of Western Australia. Please note that the period of ethics approval for this project is five (5) years from the date of this notification. However, ethics approval is conditional upon the submission of satisfactory progress reports by the designated renewal date. Therefore initial approval has been granted from 15 November 2016 to 14 November 2017.

You are reminded of the following requirements:

1. The application and all supporting documentation form the basis of the ethics approval and you must not depart from the research protocol that has been approved.
2. The Human Ethics office must be approached for approval in advance for any requested amendments to the approved research protocol.
3. The Chief Investigator is required to report immediately to the Human Ethics office any adverse or unexpected event or any other event that may impact on the ethics approval for the project.
4. The Chief Investigator must submit a final report upon project completion, even if a research project is discontinued before the anticipated date of completion.

Any conditions of ethics approval that have been imposed are listed below:

Special Conditions

None specified

The University of Western Australia is bound by the *National Statement* to monitor the progress of all approved projects until completion to ensure continued compliance with ethical principles.

The Human Ethics office will forward a request for a Progress Report approximately 30 days before the due date.

If you have any queries please contact the Human Ethics office at humanethics@uwa.edu.au.

Please ensure that you quote the file reference – RA/4/1/8738 – and the associated project title in all future correspondence.

Yours sincerely

Caixia Li

Dr Caixia Li
Manager, Human Ethics

Name	***Faculty / School***	***Role***
Dr Grant Landers	School of Sport Science, Exercise and Health	Chief Investigator
Dr Nataphoom Benjanuvatra	School of Sport Science, Exercise and Health	Co-Investigator
Mr Paul Goods	School of Sport Science, Exercise and Health	Co-Investigator

Student(s): Duncan Bradbury - Masters - 21146215

Appendix D: Borg RPE Scale (15 point)

Rating	**Description**
6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Borg GA. *Borg's perceived exertion and pain scales.* Human kinetics, 1998.

Appendix E: Borg modified CR-10 scale

Rating	Description
0	Nothing at all
0.5	Very, very light
1	Very light
2	Fairly light
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Very, very hard

Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, Doleshal P, and Dodge C. A new approach to monitoring exercise training. *The Journal of Strength and Conditioning Research* 15: 109-115, 2001.

Appendix F: Exercise Diary

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Exercise Diary

Date	Mode of Exercise	Duration	Distance	Heart rate (if measured)	Time of day	RPE (difficulty 1-10)	Other details (if relevant)
12/03	Running	45 min	7500 m	140-155 bpm	5.30 am / [✓ pm]	6	
/		min	m	bpm	am / pm		
/		min	m	bpm	am / pm		
/		min	m	bpm	am / pm		
/		min	m	bpm	am / pm		
/		min	m	bpm	am / pm		
/		min	m	bpm	am / pm		
/		min	m	bpm	am / pm		
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/		min	m	bpm	am / pm		
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/		min	m	bpm	am / pm		
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/		min	m	bpm	am / pm		
/		min	m	bpm	am / pm		
/		min	m	bpm	am / pm		

Example: a 7500m run taking 45 minutes run starting at 5.30pm on the12th of March where heart rate ranged between 140 and 155. RPE = rate of perceived exertion. Difficulty of the session 6/10.

If you have any questions, do not hesitate to contact me:
Duncan Bradbury: 21146215@student.uwa.edu.au, 0435123958

Appendix G: Raw Data

Table 4. Body mass (kg) recorded at the beginning of each testing period in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	61.70	61.70	61.80	58.10	58.60	58.00	60.50	60.05	58.88
2	78.35	79.45	76.45	68.10	67.40	67.10	65.80	67.40	66.80
3	63.30	62.50	63.05	71.10	72.25	69.10	77.55	76.35	76.20
4	61.70	62.90	62.45	58.70	58.10	58.20	74.50	72.70	72.60
5	74.75	74.10	72.85	81.55	81.25	80.00	55.45	54.82	53.75
6	66.05	68.70	66.40	48.62	48.98	49.70	72.30	71.70	73.85
7	70.40	70.30	71.00	59.38	57.34	55.75	65.45	64.70	65.10
8	68.45	70.25	70.90	83.90	84.70	83.60	65.25	65.75	63.50
9	62.85	60.50	61.90	83.15	84.55	83.95	75.45	74.25	75.95
10	69.30	68.35	66.65	70.25	69.50	68.95	63.65	64.30	63.30
Mean	67.69	67.88	67.35	68.29	68.27	67.44	67.59	67.20	66.99
SD	5.69	6.07	5.20	12.08	12.52	12.12	7.13	6.71	7.56

Table 5. Sum of 8 skinfolds (mm) recorded at the beginning of each testing period in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	38.5	39.0	37.0	54.0	54.5	47.0	105.5	108.0	85.5
2	143	131.5	115.0	96.5	99.0	88.5	54.5	51.0	52.0
3	73	66.5	69.5	112.5	97.5	72.5	93.0	81.5	84.0
4	104.5	94.0	91.0	131.0	122.5	124.0	61.0	53.0	49.0
5	120	113.0	99.0	108.0	96.0	88.0	116.0	107.0	91.5
6	67.5	62.0	64.0	46.5	42.5	42.0	66.5	61.0	58.5
7	64.0	60.5	56.0	144.0	128.5	104.0	92.5	84.5	86.0
8	61.5	57.5	58.0	84.0	79.0	72.0	137.0	140.0	121.0
9	88.5	69.5	73.5	74.0	71.5	59.5	103.5	119.0	111.5
10	145.0	136.5	120.5	110.0	108.0	93.5	51.0	50.5	47.0
Mean	90.55	83.00	78.35	96.05	89.90	79.10	88.05	85.55	78.60
SD	36.33	33.70	27.16	31.59	27.92	25.59	28.79	31.88	26.17

Table 6. Running Economy 9 km.h^{-1} (VO$_2$·kg^{-1}·min^{-1}) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	37.75	35.35	35.32	43.40	38.98	42.07	34.75	N/A	32.77
2	35.81	35.99	36.95	49.93	34.87	35.08	39.63	36.73	37.27
3	40.68	42.30	41.54	39.95	36.73	45.43	38.26	35.97	36.70
4	42.96	35.95	41.52	34.08	33.76	33.58	40.21	33.80	36.87
5	37.14	34.38	34.32	35.72	37.32	34.45	40.17	43.53	38.03
6	38.36	38.36	36.58	44.17	39.00	40.20	39.67	41.99	42.60
7	40.02	34.98	37.00	37.95	33.52	34.15	42.41	44.36	40.85
8	45.53	37.97	36.46	38.45	36.84	37.01	39.89	38.21	34.18
9	36.77	32.48	31.26	36.36	35.38	34.40	40.25	40.60	39.18
10	35.69	36.27	34.16	45.36	40.40	37.97	42.57	43.01	43.82
Mean	39.07	36.40	36.51	40.54	36.68	37.43	39.78	39.80	38.23
SD	3.23	2.67	3.16	5.02	2.32	3.98	2.18	3.76	3.49

Table 7. Heart rate at 9 km.h^{-1} (bpm) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the training intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	114	123	118	133	129	145	133	120	132
2	118	128	125	133	129	133	169	155	164
3	149	157	156	185	170	174	127	120	123
4	135	132	146	133	143	148	118	105	107
5	127	121	119	154	137	143	158	161	140
6	141	133	127	153	138	145	124	136	129
7	142	120	130	156	168	167	161	151	142
8	161	148	137	143	128	127	174	155	147
9	136	131	136	139	123	116	176	170	175
10	163	166	142	166	161	143	154	158	153
Mean	138.6	135.9	133.6	149.5	142.6	144.1	149.4	143.1	141.2
SD	16.4	15.8	12.2	16.9	17.5	17.1	21.9	21.6	19.9

Table 8. Perceived rate of exertion (6-20) at 9 km.h^{-1} in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the training intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	9	9	8	9	8	9	11	11	10
2	10	10	10	8	8	10	11	12	12
3	13	9	10	11	11	8	10	9	9
4	8	10	11	11	12	9	10	11	11
5	11	11	7	11	11	10	10	10	11
6	11	10	9	9	10	9	11	10	11
7	10	9	9	8	10	11	10	10	11
8	12	10	10	10	10	9	9	11	12
9	11	9	11	11	9	11	10	8	10
10	10	10	11	9	8	9	10	11	10
Mean	10.5	9.7	9.6	9.7	9.7	9.5	10.2	10.3	10.7
SD	1.4	0.7	1.4	1.3	1.4	1.0	0.6	1.2	1.0

Table 9. Running Economy 11 km.h^{-1} ($VO_2 \cdot kg^{-1} \cdot min^{-1}$) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	44.96	44.51	38.42	51.22	46.36	46.13	36.79	N/A	37.62
2	42.39	42.32	40.75	44.73	39.33	40	45.93	44.99	42.41
3	46.73	48.25	48.5	47.59	46.74	50.38	43.21	43.32	41.06
4	45.86	47.16	48.31	38.01	38.82	39.62	42.51	36.99	40.26
5	42.86	43.43	40.84	43.67	43.77	40.75	45.67	50.19	44.61
6	45.57	41.66	44.05	47.48	49.13	48.35	47.01	50.57	48.76
7	44.27	42.59	41.56	41.53	40.21	40.60	52.34	50.94	49.69
8	48.74	42.91	44.48	43.00	42.96	42.08	44.15	44.86	44.28
9	41.32	39.29	37.54	40.35	41.13	40.70	45.40	46.13	44.65
10	42.99	40.58	39.98	45.70	45.31	44.08	49.14	48.18	45.99
Mean	44.57	43.27	42.44	44.33	43.38	43.27	45.21	46.24	43.93
SD	2.25	2.76	3.81	3.89	3.49	3.81	4.13	4.44	3.74

Table 10. Heart rate at 11 km.h^{-1} (bpm) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the training intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	131	132	122	158	144	164	150	142	163
2	138	139	133	148	145	144	175	168	173
3	167	172	169	199	182	174	140	130	137
4	153	151	158	144	156	161	139	120	124
5	139	136	129	177	158	156	177	172	154
6	149	144	138	170	157	165	147	149	140
7	155	144	143	170	178	167	174	165	156
8	167	161	156	163	145	141	180	174	167
9	164	142	155	154	135	132	181	184	186
10	183	177	166	172	170	158	169	167	170
Mean	154.6	149.8	146.9	165.5	157.0	156.2	163.2	157.1	157.0
SD	16.0	15.3	16.2	16.0	15.6	13.2	17.1	20.9	18.8

Table 11. Perceived rate of exertion (6-20) at 11 km.h^{-1} in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the training intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	11	11	10	11	10	11	12	13	11
2	14	14	12	12	11	13	13	15	13
3	15	13	13	14	13	9	11	12	11
4	11	12	12	13	13	11	11	12	13
5	13	14	11	14	13	13	12	12	12
6	13	12	11	12	12	11	12	11	12
7	12	11	12	13	13	12	14	14	13
8	13	12	11	13	11	11	12	13	14
9	12	10	11	13	12	12	13	11	13
10	14	13	12	11	10	12	12	11	12
Mean	12.8	12.2	11.5	12.6	11.8	11.5	12.2	12.4	12.4
SD	1.3	1.3	0.9	1.1	1.2	1.2	0.9	1.4	1.0

Table 12. $\dot{V}O_{2peak}$ ($VO_2 \cdot kg^{-1} \cdot min^{-1}$) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	68.56	69.9	65.96	73.74	73.32	70.97	49.36	N/A	53.84
2	57.05	59.71	59.27	61.16	63.61	65.74	66.22	69.64	69.37
3	63.75	70.81	67.26	51.71	55.13	61.91	62.08	60.7	58.71
4	61.7	60.81	65.84	54.07	57.98	54.22	60.58	61.15	62.58
5	51.23	57.71	59.48	59.18	57.53	57.13	57.98	57.84	64.74
6	70.73	64.20	66.47	64.66	67.95	66.06	64.8	65.50	64.45
7	58.59	63.94	65.73	50.85	50.10	52.45	64.54	63.23	62.74
8	63.38	54.59	59.51	63.66	61.13	65.86	49.46	55.22	57.18
9	51.91	51.18	53.78	55.55	60.26	62.44	51.87	56.64	53.14
10	47.73	50.75	57.61	64.88	65.89	68.43	68.84	63.63	63.99
Mean	59.46	60.36	62.09	59.95	61.29	62.52	59.57	61.51	61.07
SD	7.58	7.03	4.70	7.13	6.71	6.15	7.13	4.57	5.20

Table 13. v$\dot{V}O_{2peak}$ (km.h^{-1}) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	17	17	17	17	18	18	13	14	14
2	15	16	17	16	18	18	16	17	17
3	16	17	17	13	13	15	16	16	17
4	16	16	16	16	16	15	18	19	19
5	14	16	16	15	16	16	14	14	15
6	18	18	18	17	17	17	16	14	17
7	16	17	17	14	14	15	14	15	15
8	15	17	17	17	17	17	13	14	15
9	14	15	16	16	17	18	13	14	14
10	12	13	14	17	17	18	17	17	17
Mean	15.3	16.2	16.5	15.8	16.3	16.7	15.0	15.4	16.0
SD	1.7	1.4	1.1	1.4	1.6	1.3	1.8	1.8	1.6

Table 14. Respiratory exchange ratios recorded during graded exercise tests in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	1.05	1.07	1.12	1.02	1.05	1.08	1.06	N/A	1.06
2	1.01	1.07	1.10	1.07	1.08	1.06	1.07	1.01	1.08
3	1.02	1.02	1.12	1.07	1.09	1.09	1.10	1.09	1.07
4	1.00	1.09	1.02	1.05	1.03	1.15	1.01	1.07	1.07
5	1.02	1.05	1.13	1.09	1.08	1.05	1.08	1.03	1.12
6	1.04	1.01	1.17	1.06	1.06	1.14	1.03	1.13	1.15
7	1.04	1.05	1.15	1.02	1.05	1.14	1.03	1.16	1.04
8	0.98	1.01	1.17	1.08	1.08	1.16	1.07	1.17	1.05
9	1.05	1.06	1.15	1.01	1.13	1.16	1.05	1.15	1.03
10	1.03	1.11	1.00	1.16	1.11	1.11	1.04	1.18	1.04
Mean	1.02	1.05	1.11	1.06	1.08	1.11	1.05	1.11	1.07
SD	0.02	0.03	0.06	0.04	0.03	0.04	0.03	0.06	0.04

Table 15. Maximum heart rate (bpm) recorded during graded exercise tests in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	182	196	187	203	201	206	192	180	195
2	178	182	182	186	200	192	198	194	201
3	200	214	214	204	202	207	180	175	178
4	194	187	196	196	195	201	188	192	181
5	167	184	175	207	208	201	198	198	193
6	196	193	190	200	204	200	191	192	186
7	198	191	188	192	198	197	194	191	188
8	200	202	202	202	191	192	202	197	195
9	182	179	185	188	190	191	202	200	205
10	202	199	202	202	198	202	202	204	206
Mean	189.9	192.7	192.1	198.0	198.7	198.9	194.7	192.3	192.8
SD	11.8	10.6	11.5	7.2	5.6	5.7	7.2	8.9	9.6

Table 16. Anaerobic threshold (km.h^{-1}) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	15.5	16.6	16.5	14.3	15.3	14.2	12.9	12.4	13.7
2	13.9	12.2	14.4	13.0	14.6	14.6	13.6	14.9	14.4
3	14.0	14.4	15.7	10.1	11.9	13.6	15.8	15.6	14.4
4	14.8	14.7	14.8	13.5	13.5	13.2	14.7	16.1	15.8
5	12.8	14.8	14.7	13.8	14.8	13.5	12.5	11.5	12.5
6	14.5	14.5	15.0	13.7	12.8	14.7	13.3	13.4	14.5
7	13.5	14.1	14.0	11.8	12.4	12.9	12.7	13.3	13.2
8	13.0	13.7	14.6	13.2	14.5	14.2	11.4	12.0	13.0
9	13.7	14.0	13.8	13.3	14.6	14.7	12.3	11.8	12.1
10	11.0	11.0	11.8	14.5	14.3	14.6	14.2	14.5	14.6
Mean	13.67	14.00	14.53	13.13	13.87	14.02	13.33	13.55	13.83
SD	1.24	1.51	1.23	1.30	1.14	0.67	1.28	1.64	1.12

Table 17. Time trial performances (min) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	19.92	19.55	19.45	22.33	21.46	19.87	22.72	22.62	22.13
2	23.43	22.20	21.31	19.69	19.52	19.10	19.53	19.71	19.60
3	21.96	21.60	21.53	25.27	23.57	20.40	20.45	21.12	20.78
4	24.41	22.07	22.11	22.27	23.25	22.11	19.92	19.48	19.83
5	21.18	20.96	20.38	24.17	22.43	21.23	24.82	24.51	24.05
6	18.28	18.22	18.67	22.69	19.78	20.08	21.03	21.45	23.55
7	23.89	22.43	21.45	25.44	24.45	23.85	23.86	23.55	23.16
8	22.12	21.46	20.37	21.57	20.75	19.96	25.18	24.85	24.45
9	23.17	21.98	21.58	21.14	20.45	19.88	24.24	23.56	23.55
10	25.66	25.13	24.34	19.60	19.35	18.84	21.24	21.34	21.24
Mean	22.40	21.56	21.12	22.42	21.50	20.53	22.30	22.22	22.23
SD	2.20	1.82	1.56	2.06	1.83	1.50	2.12	1.89	1.78

Table 18. Heart rate at conclusion of time trial (bpm) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	182	169	194	192	192	191	184	186	184
2	175	165	182	197	184	180	206	197	196
3	215	201	211	194	196	190	176	174	172
4	186	188	190	190	182	189	179	180	181
5	185	176	175	208	206	187	195	190	193
6	190	188	186	181	196	195	182	183	194
7	176	177	190	188	189	190	188	194	190
8	193	191	195	196	194	196	190	191	190
9	176	180	179	187	186	189	194	192	195
10	192	194	191	196	194	201	189	187	188
Mean	187.0	182.9	189.3	192.9	191.9	190.8	188.3	187.4	188.3
SD	11.9	11.4	10.0	7.3	7.0	5.7	8.8	6.9	7.5

Table 19. Heart rate recovery (1 min) at conclusion of time trial (bpm) in linear periodised (LPG, n = 10), reverse linear periodised (RPG, n =10) and control (CG, n = 10) groups in week 0, week 7 and week 14 of the intervention.

	LPG			**RPG**			**CG**		
Subject	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**	**Week 0**	**Week 7**	**Week 14**
1	41	51	54	56	58	59	37	38	40
2	44	47	38	40	45	42	51	54	50
3	33	46	58	19	28	32	45	42	39
4	34	39	40	50	42	55	42	44	45
5	43	48	50	30	37	39	35	36	40
6	54	53	54	35	57	45	42	43	44
7	34	37	46	28	32	34	37	43	45
8	37	41	47	43	45	46	22	24	29
9	36	41	41	39	44	48	34	35	34
10	23	24	30	48	48	51	47	46	47
Mean	37.9	42.7	45.8	38.8	43.6	45.1	39.2	40.5	41.3
SD	8.3	8.4	8.6	11.2	9.6	8.7	8.2	8.0	6.3

Table 20. Time (min), rate of perceived exertion (RPE) and load for training sessions completed in weeks 1 - 6 in the linear periodised group (LPG).

		Week 1					**Week 2**					**Week 3**					**Week 4**					**Week 5**					**Week 6**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 1	**Time**	52	69	31			52	69	31			40	64	31			104	40				51	36	31			51	36	31		
	RPE	6	6	5			5	6	5			5	5	5			6	7				6	7	5			6	7	5		
	Load	314	416	155	314		262	416	155			201	320	155			621	282				305	253	155			305	253	155		
Subject 2	**Time**	59	76	36			59	76	36	38		45	73	20	36		45	73	36			58	41	36			58	41	36		
	RPE	6	6	5			6	6	5	7		6	6	5	4		6	6	5			6	6	5			6	6	5		
	Load	352	454	182			352	454	182	268		273	440	101	146		273	440	182			347	244	182			347	244	182		
Subject 3	**Time**	56	73	34	24		56	73	34			43	70	34			43	70	34			55	37	39			55	37	39		
	RPE	6	7	5	5		6	7	5			6	6	5			6	6	5			6	7	5			6	7	5		
	Load	336	511	171	122		336	511	171			260	417	171			260	417	171			329	261	194			329	261	194		
Subject 4	**Time**	60	77	38	20	43	60	77	38	21	43	47	76	44	16	38	47	76	39	45		60	42	38	27		60	42	38	27	
	RPE	5	6	5	7	8	5	6	5	7	6	6	6	5	4	6	6	7	6	4		6	7	6	8		6	7	6	9	
	Load	302	464	190	142	342	302	464	190	149	258	281	456	218	62	228	281	532	236	181		359	293	228	215		359	293	228	244	
Subject 5	**Time**	55	72	33	28		55	72	33	29		42	67	21	33		42	67	2	33		53	38	33	25		53	38	25		
	RPE	5	5	6	7		6	5	6	7		6	6	6	7		5	6	8	6		6	6	6	7		6	6	5		
	Load	273	358	198	198		328	358	198	201		253	405	127	230		211	405	169	198		320	227	198	178		320	227	127		

		Week 1					Week 2					Week 3					Week 4					Week 5					Week 6				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 6	**Time**	49	66	28			49	66	28			38	60	28			38	60	28			48	34				48	34			
	RPE	6	6	4			6	6	4			7	6	4			6	6	6			6	7				6	7			
	Load	297	399	114			297	399	114			265	358	114			227	358	170			285	239				285	239			
Subject 7	**Time**	59	76	37			59	76	37			46	75	37			46	75	37			59	41				59	41			
	RPE	7	6	6			7	6	6			7	6	6			7	6	6			6	8				6	8			
	Load	416	459	223			416	459	223			323	448	223			323	448	223			353	329				353	329			
Subject 8	**Time**	56	73	34			56	73	34			44	70	44			70	34	44			70	34	55			39	34	55		
	RPE	6	6	7			6	6	7			7	5	6			7	6	6			7	7	6			7	7	6		
	Load	338	440	241			338	440	241			305	350	261			489	206	261			489	241	331			273	241	331		
Subject 9	**Time**	58	75	36	27		58	58	75	36	26	45	73	21	36		45	73				57	40	36	24		57	40	24		
	RPE	6	5	4	6		6	5	4	6	6	6	5	5	5		6	5				6	6	6	5		6	6	5		
	Load	349	376	144	160		349	291	301	216	157	270	364	103	180		270	364				344	242	216	122		344	242	120		
Subject 10	**Time**	63	80	40			63	80	40			49	79	40			49	79	40			62	43	40			62	43	40		
	RPE	7	8	6			6	7	6			6	6	6			6	6	7			7	7	6			7	7	6		
	Load	438	637	239			376	557	239			292	476	239			292	476	279			436	304	239			436	304	239		

Table 21. Time (min), rate of perceived exertion (RPE) and load for training sessions completed in weeks 8 - 13 in the linear periodised group (LPG).

		Week 8					**Week 9**					**Week 10**					**Week 11**					**Week 12**					**Week 13**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 1	**Time**	29	30	21			29	30	21			24	26	21			24	26	21	21		20	23	21			20	23	21		
	RPE	7	7	6			7	7	6			8	7	6			8	7	6	6		8	8	6			8	8	6		
	Load	201	208	123			201	208	123			192	182	123			192	182	123	123		160	182	123			160	182	123		
Subject 2	**Time**	31	23				31	23	24			26	28	24			26	28	24			21	24	24	18		21	24	23	24	
	RPE	7	7				7	7	6			8	7	6			8	7	6			8	8	6	5		8	8	6	5	
	Load	218	162				218	162	142			206	196	142			206	196	142			170	195	142	89		170	195	137	118	
Subject 3	**Time**	31	32				31	32	23			25	27	23			25	27	23			21	24	23			21	24	23		
	RPE	7	7				7	7	6			8	7	6			8	7	6			8	8	6			8	8	6		
	Load	214	222				214	222	138			203	192	138			203	192	138			168	192	138			168	192	138		
Subject 4	**Time**	31	32	23			31	32				26	28	27			26	28	27			21	24	27	27		21	24	27	27	
	RPE	7	6	6			7	6				8	6	6			8	6	6			8	7	6	6		8	7	7	5	
	Load	217	193	139			217	193				206	167	162			206	167	162			169	170	162	164		169	170	188	137	
Subject 5	**Time**	30	31	49			30	31	23			25	27	23			25	27	49			21	24				21	24	23	17	
	RPE	7	7	6			7	7	6			8	7	6			8	7	6			8	8				8	8	6	6	
	Load	210	218	291			210	218	139			200	189	139			200	189	293			165	189				165	189	135	101	

		Week 8					**Week 9**					**Week 10**					**Week 11**					**Week 12**					**Week 13**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 6	**Time**	28	28	19			28	28	23			23	25	23	20		23	25	20			19	22	20			19	22	20		
	RPE	7	6	6			7	6	6			7	6	6	5		7	6	6			8	8	6			8	7	7		
	Load	193	171	115			193	171	137			162	149	139	99		162	149	119			155	175	119			155	154	139		
Subject 7	**Time**	31	33	24			31	33	23			26	28	23	23		26	28	23			21	24	23			21	24	23		
	RPE	7	7	6			7	7	6			8	7	6	5		8	7	6			8	8	6			8	8	8		
	Load	220	228	142			220	228	137			208	197	139	113		208	197	139			171	196	139			171	196	185		
Subject 8	**Time**	39	34				31	32				31	32	25			27	22	25			27	22	21			24	22	21		
	RPE	8	7				8	7				8	7	6			8	7	6			8	8	6			8	8	7		
	Load	312	241				244	221				244	221	152			219	155	152			219	177	125			191	177	146		
Subject 9	**Time**	31	32	23	24		31	32	24			26	28	24	23		26	28	24	23		21	24	24	18		21	24	24	18	
	RPE	6	7	6	5		7	7	5			8	7	6	4		8	7	6	4		8	8	5	4		8	8	6	4	
	Load	186	225	139	121		217	225	121			205	194	145	93		205	194	145	93		169	194	121	72		169	194	145	72	
Subject 10	**Time**	34	35	26			34	35	26			28	30	27			28	30	27			23	26	27			23	26	27		
	RPE	8	8	6			8	8	6			9	7	6			9	7	6			8	8	6			8	8	6		
	Load	271	281	159			271	281	156			250	211	159			250	211	159			181	209	159			181	209	159		

Table 22. Time (min), rate of perceived exertion (RPE) and load for training sessions completed in weeks 1 - 6 in the reverse periodised group (RPG).

		Week 1					**Week 2**					**Week 3**					**Week 4**					**Week 5**					**Week 6**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 1	**Time**	49	51	35			49	51	35			43	45	34	35		43	45	34	35		37	38	34	34		37	38	34	34	
	RPE	4	5	4			4	5	4			5	5	5	4		6	5	5	4		7	6	5	4		8	6	6	4	
	Load	197	257	138			197	257	138			213	227	170	138		256	225	170	138		257	229	168	138		292	227	202	138	
Subject 2	**Time**	46	48	31	20	26	46	48	31	20	26	40	42	31	20	26	40	42	31	20		34	36	31	20		34	35	31	20	
	RPE	5	5	5	6	4	5	5	5	6	4	6	6	5	4	6	6	6	5	7		7	6	5	6		8	6	5	6	
	Load	229	239	154	122	105	229	239	154	122	105	239	253	154	80	155	239	251	154	141		241	214	154	121		274	212	154	121	
Subject 3	**Time**	53	55	38			53	55	38			46	49	38			46	48	38			39	41	38			39	40	38		
	RPE	5	5	5			5	5	6			6	6	6			6	8	6			7	6	6			8	7	7		
	Load	264	277	191			264	277	230			274	292	230			274	386	230			275	245	230			312	283	268		
Subject 4	**Time**	52	55	38	24		52	55	38	24		45	48	38	24		45	48	38	24		39	40	37	24		39	40	37	24	
	RPE	5	5	6	5		5	5	6	5		6	6	5	5		6	6	5	5		7	6	6	5		7	6	6	5	
	Load	262	274	227	121		262	274	227	121		272	289	189	121		272	287	189	121		272	242	225	119		270	240	225	119	
Subject 5	**Time**	51	53	36			51	53	36			44	47	36			44	46	36			38	39	36			38	39	36		
	RPE	5	5	6			5	5	6			6	6	6			6	6	6			7	7	7			7	7	7		
	Load	254	266	219			254	266	219			264	281	219			264	279	219			265	275	255			264	273	255		

		Week 1					**Week 2**					**Week 3**					**Week 4**					**Week 5**					**Week 6**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 6	**Time**	46	48	32	33		46	48	32	33		40	43	32	33		40	42	32	33		35	36	32	32		35	36	32	32	
	RPE	4	5	4	7		4	5	4	7		5	5	5	4		5	6	5	4		6	6	6	4		7	6	6	4	
	Load	185	241	128	229		185	241	128	229		201	213	161	131		201	254	161	131		208	216	190	128		242	214	190	128	
Subject 7	**Time**	54	57	40			54	57	40			47	50	39			47	50	39			40	42	39			40	42	39		
	RPE	5	6	5			5	6	5			6	6	5			6	6	6			7	7	7			7	8	7		
	Load	272	342	199			272	342	199			282	301	196			282	298	235			282	293	274			280	333	274		
Subject 8	**Time**	48	50	34			48	50	34	22		42	44	34			42	44	34			36	37				36	37			
	RPE	5	5	5			5	5	5	6		6	6	5			6	7	6			8	7				7	7			
	Load	239	250	169			239	250	169	133		250	265	169			250	307	202			287	261				250	259			
Subject 9	**Time**	47	49	33			47	49	33			41	44	33			41	43	33			36	37	33			35	37	33		
	RPE	5	5	5			5	5	5			6	6	5			6	6	5			7	6	6			7	6	6		
	Load	237	247	166			237	247	166			247	262	166			247	260	166			249	221	199			247	219	199		
Subject 10	**Time**	45	47	31	20		45	47	31	20		40	42	31			40	42	31			34	35	46			34	35	46		
	RPE	4	4	5	8		4	4	5	8		5	5	5			6	5	5			6	5	5			7	6	6		
	Load	182	190	157	163		182	190	157	163		198	210	157			237	208	157			205	177	232			238	211	279		

Table 23. Time (min), rate of perceived exertion (RPE) and load for training sessions completed in weeks 8 - 13 in the reverse periodised group (RPG).

		Week 8					**Week 9**					**Week 10**					**Week 11**					**Week 12**					**Week 13**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 1	**Time**	32	32	22	34		32	32	22	34		26	28	22			26	28	22			21	25	22			21	25	22		
	RPE	7	7	5	4		7	7	5	4		7	7	5			8	7	5			8	8	6			8	8	6		
	Load	226	227	109	138		226	227	109	138		181	196	109			207	196	109			170	200	131			170	200	131		
Subject 2	**Time**	30	30	19	52		30	30	19	52		24	26	19	20		24	26	20			20	23	20			20	23	20		
	RPE	7	7	5	6		8	7	5	6		8	7	5	5		9	7	5			8	8	6			8	8	6		
	Load	208	209	97	312		238	209	97	312		193	182	97	101		217	182	100			161	187	120			161	187	120		
Subject 3	**Time**	35	35	26			35	35	26			28	30	26			28	30	26			23	27	26			23	27	26		
	RPE	7	8	6			7	8	6			8	8	6			9	8	6			8	8	7			9	9	7		
	Load	245	282	158			245	282	158			223	242	158			251	242	158			181	215	184			204	241	184		
Subject 4	**Time**	32	32	22	22		32	32	22	22		26	28	22	22		26	28	22	22		21	25	22	23		21	25	22	23	
	RPE	7	7	5	8		7	7	5	8		8	7	5	8		8	7	5	8		8	8	6	8		8	8	6	8	
	Load	225	227	112	176		225	227	112	176		207	196	112	176		207	196	112	176		170	200	135	180		170	200	135	180	
Subject 5	**Time**	34	34	24			34	34	24			27	29	24			27	29	24			22	26	24			22	26	24		
	RPE	8	7	6			8	8	6			8	8	6			9	8	6			8	8	7			8	8	7		
	Load	272	239	145			272	274	145			217	236	145			244	236	145			177	209	169			177	209	169		

		Week 8					**Week 9**					**Week 10**					**Week 11**					**Week 12**					**Week 13**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 6	**Time**	33	33	23	34		33	33	23	34		26	28	23	34		26	28	23			21	25	23	22		21	25	23	22	
	RPE	9	7	5	4		7	6	5	4		7	7	5	5		8	7	5			8	8	5	6		8	8	5	6	
	Load	293	229	116	138		228	197	116	138		183	198	116	171		209	198	116			172	202	116	130		172	202	116	130	
Subject 7	**Time**	35	35	25			35	35	25			28	30	25			28	30	25			23	27	25			23	27	25		
	RPE	7	7	6			7	7	6			8	8	6			9	8	6			9	8	6			9	8	6		
	Load	247	248	152			247	248	152			224	243	152			252	243	152			205	215	152			205	215	152		
Subject 8	**Time**	32	32				32	32	22			25	27	22			25	27	22			21	25	22	20		21	25	22	20	
	RPE	7	7				8	7	5			7	7	5			8	7	5			8	8	5	6		8	8	5	6	
	Load	221	222				252	222	111			178	192	111			203	192	111			168	196	111	122		168	196	111	122	
Subject 9	**Time**	31	31	21			31	31	21	17		25	27	21	18		25	27	21	18		21	24	21			21	24	21		
	RPE	7	7	5			7	7	5	2		8	7	5	6		8	7	5	6		8	8	6			8	8	6		
	Load	218	219	107			218	219	107	35		201	190	107	105		201	190	107	105		166	194	128			166	194	128		
Subject 10	**Time**	30	30	20			30	30	20	20		24	26	20			24	26	20			20	23	20			20	23	20		
	RPE	7	6	5			7	6	5	9		8	7	5			8	7	5			8	8	5			8	8	5		
	Load	208	179	101			208	179	101	183		193	182	101			193	182	101			160	186	101			160	186	101		

Table 24. Time (min), rate of perceived exertion (RPE) and load for training sessions completed in weeks 1 - 6 in the control group (CG).

		Week 1					Week 2					Week 3					Week 4					Week 5					Week 6				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 1	**Time**	65	52	37			65	29	37			52	29	37			65	29	37			65	52	37			65	37			
	RPE	5	5	5			5	5	5			5	5	5			5	5	5			5	5	5			5	5			
	Load	324	262	187			324	147	187			262	147	186			324	146	187			324	262	187			324	187			
Subject 2	**Time**	45	20	20			45	20	20			52	25	20			52	25	20			52	25	20			52	25	20		
	RPE	5	4	4			5	4	4			5	4	4			5	4	5			5	4	5			5	5	6		
	Load	225	80	82			225	80	82			260	102	80			259	101	100			259	101	100			260	127	121		
Subject 3	**Time**	73	47	48	21		72	47	48	21		74	45	47	21		73	47	21			58	40	34	21		74	45	47	21	
	RPE	6	5	5	6		6	5	5	6		6	5	5	6		6	5	6			5	5	6	6		5	6	6	7	
	Load	438	236	240	125		432	235	239	124		445	227	234	127		439	237	127			292	199	202	125		371	272	281	148	
Subject 4	**Time**	57	33	32	46	16	57	33	32	46	16	53	26	26	39	16	53	33	26	39	16	53	33	26	39	16	53	54	26	39	16
	RPE	5	5	5	6	2	5	5	5	6	2	5	5	5	6	2	5	5	5	6	3	5	5	5	5	3	5	5	6	5	3
	Load	284	164	160	275	31	284	164	160	275	31	266	129	132	232	32	264	164	132	233	47	264	164	132	194	47	264	271	158	194	47
Subject 5	**Time**	41	42	14	25		41	42	14	25		41	42	14	25		48	41	14	25		48	41	14	33		48	41	14	25	
	RPE	5	6	3	4		5	6	3	4		5	6	3	4		5	6	3	4		5	5	3	4		5	5	3	4	
	Load	204	250	42	101		204	250	42	101		204	252	42	100		242	245	42	101		242	204	42	131		242	204	42	101	

		Week 1					**Week 2**					**Week 3**					**Week 4**					**Week 5**					**Week 6**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 6	**Time**	60	21	22			60	21	22			60	22	22			60	22	21			60	22	22			60	22	21		
	RPE	5	5	4			5	5	4			5	5	4			5	7	4			5	6	6			5	6	6		
	Load	300	107	87			300	107	87			301	108	88			301	151	85			301	129	131			301	129	127		
Subject 7	**Time**	63	31	32	31		63	31	32	31		63	31	31			63	39	31			67	39	31			67	31			
	RPE	5	6	5	5		5	6	5	5		5	6	5			5	6	5			5	6	5			5	6			
	Load	316	185	161	154		316	187	161	154		317	184	157			315	235	155			334	235	155			334	185			
Subject 8	**Time**	49	26	26			49	26	26			49	25	25			49	26	25			49	26	25			49	26	25		
	RPE	5	5	5			5	5	5			5	5	5			5	5	5			5	6	6			5	6	6		
	Load	245	128	130			245	128	130			246	127	127			245	129	127			245	154	152			245	154	152		
Subject 9	**Time**	31	32	32			32	32	31			31	32				40	31	25			32	32	31			32	32	31		
	RPE	5	5	5			5	5	5			5	5				5	5	5			6	6	6			6	5	6		
	Load	156	159	158			162	160	157			156	160				199	156	123			194	191	188			194	160	188		
Subject 10	**Time**	47	22	22	17	8	47	22	22	17	8	47	22	22	17	8	47	22	22	17	14	47	22	22	17	8	47	22	22	17	8
	RPE	5	5	4	5	8	5	5	4	5	8	5	5	4	5	8	5	5	4	5	9	5	6	6	3	8	5	6	6	3	8
	Load	234	108	87	83	62	234	110	87	86	61	235	111	86	84	60	235	108	88	83	128	234	132	131	51	58	234	132	131	51	58

Table 25. Time (min), rate of perceived exertion (RPE) and load for training sessions completed in weeks 8 - 13 in the control group (CG).

		Week 8					**Week 9**					**Week 10**					**Week 11**					**Week 12**					**Week 13**				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 1	**Time**	65	29	37			64	29	37			64	29	23	43		64	29	23	18		64	44	23	18		64	44	23		
	RPE	5	6	5			5	6	7			5	6	7	5		5	6	7	3		5	5	7	3		5	5	6		
	Load	323	175	186			322	175	258			322	175	162	217		322	175	162	54		322	221	162	54		322	221	139		
Subject 2	**Time**	52	25				52	25	20			52	25	20			52	25	20			52	25	20			52	25	20		
	RPE	5	6				5	5	5			5	5	4			5	5	6			5	5	6			5	5	6		
	Load	261	153				260	127	100			261	127	79			260	127	121			260	127	121			258	126	119		
Subject 3	**Time**	75	49	22			60	27	16			60	27	16	27		60	27	16	27		60	27	16	27		49	27	16		
	RPE	5	6	7			5	5	8			5	6	8	4		5	6	8	5		5	6	8	5		5	6	8		
	Load	377	292	151			300	134	131			301	164	130	107		301	164	130	134		301	164	130	134		243	163	130		
Subject 4	**Time**	52	32	25	15		52	32	25	15		52	43	25	25		52	43	25	25		52	43	25	25		52	43	38		
	RPE	5	6	6	3		5	6	6	3		5	5	6	6		5	5	6	6		5	5	6	6		5	5	5		
	Load	258	192	151	46		258	191	149	45		258	215	152	149		258	215	151	149		258	215	151	149		258	215	189		
Subject 5	**Time**	48	40	14	25		47	40	14	25		47	40	14	25		47	48				47	48				48	47	41		
	RPE	5	5	3	4		5	5	3	4		5	5	3	4		5	5				5	5				5	5	5		
	Load	238	201	42	100		237	201	41	99		237	201	41	99		233	239				233	239				238	235	206		

		Week 8					Week 9					Week 10					Week 11					Week 12					Week 13				
Session		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Subject 6	**Time**	61	22	22			61	22	22			61	22	22			61	22	22			61	22	22			61	22	22		
	RPE	5	6	6			5	6	6			5	6	6			5	6	6			5	6	6			5	6	6		
	Load	306	131	133			306	131	130			306	131	130			306	131	130			306	131	130			305	132	129		
Subject 7	**Time**	62	39	30	39		62	39	31	38		62	39	31	38		39	31	38			54	39	31	38		54	43	31	38	
	RPE	5	6	4	6		5	6	4	6		5	6	4	6		6	6	6			5	6	4	6		5	5	6	5	
	Load	312	232	122	231		312	232	124	227		312	232	124	227		232	187	227			272	232	124	227		272	217	187	189	
Subject 8	**Time**	48	25	25	14		48	25	25			48	25	25			48	25	25			48	25	25			48	25	25		
	RPE	5	6	6	3		5	6	6			5	6	6			5	6	6			5	6	6			5	6	6		
	Load	241	152	149	42		241	151	150			241	151	150			241	151	150			241	151	150			241	151	150		
Subject 9	**Time**	39	30	24			39	31	24			39	31	24			39	31	24			39	31	24			39	31	24		
	RPE	5	6	7			5	6	7			5	6	7			5	6	7			5	6	7			5	6	7		
	Load	193	182	168			194	183	167			194	183	167			194	183	167			194	183	167			194	183	167		
Subject 10	**Time**	47	35	17			47	35	22	28		47	35	22	28		47	35	22	27		47	35	22	27		47	35	22	27	
	RPE	5	6	3			5	6	3	7		5	6	4	7		5	6	4	7		5	6	4	7		5	6	4	7	
	Load	235	210	50			236	211	65	193		236	211	86	193		233	212	86	190		233	212	86	190		233	212	86	190	