ACCURACY OF THE PREDICTION OF IRONMAN PERFORMANCE: RELATIONSHIP TO TRAINING HISTORY, MUSCLE PAIN AND RELATIVE PERCEPTION OF EFFORT DURING, AND RECOVERY AFTER THE RACE

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DECLARATION

I, Ronel Spijkerman, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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(Date)

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LIST OF ABBREVIATIONS

RPE…………………………………………	Relative perception of effort
CHO…………………………………………	Carbohydrates
FVC…………………………………………	Forced vital capacity
FEV1…………………………………………	Forced Expiratory Volume in 1 Second
FEF…………………………………………..	Forced Expiratory Flow
MVV…………………………………………	Maximum Voluntary Ventilation
VO_{2max}..	Maximal oxygen consumption

THESIS OUTLINE

With regards to swimming, cycling and running, several studies have investigated the physiological and genetic contribution of performance in athletes, different training programs and athletes' adaptation to these programs. Other studies have investigated levels of pain and relative perception of effort (RPE) and the athlete's ability to recover after endurance races. No studies have examined whether there is a relationship between any of these factors. Furthermore, few studies have investigated the triathletes' ability to predict swimming, cycling, running and overall times accurately.

The aim of this thesis is to review the literature which discusses the background to the questions outlined above (Chapter 2), followed by a study which attempts to answer these questions (Chapter 3). The aim of the study was to establish whether the training methods in preparation for the Ironman were related to subjective pain and perception of effort during the race, and the recovery time after the race. The study was designed to establish whether there were differences in these variables between triathletes who predicted their finishing time accurately compared to those triathletes who under- or over-predicted their performance.

Subjects were recruited at the 2006 South-African Ironman. All the subjects completed a questionnaire at registration which recorded a full biographical training and tapering history as well as a prediction of their swimming, cycling, running and overall performance in the 2006 Ironman. We limited the tapering history to one week before the race. It would have been desirable getting more information with regards tapering, but there was a limitation with time and therefore we tried to get as much information as possible in the time we had allocated for the administration of the questionnaire. Subjects were instructed to shout their RPE and pain scores at each of the 7 data collection points distributed throughout the course. All subjects were contacted daily for the first seven days after the race and thereafter they were contacted weekly for the next seven weeks for their pain scores. Final total Ironman times and the individual swimming, cycling and running times were obtained from the Ironman website after the race.

Data from the 117 subjects were included in the study. 16 Subjects completed the race in a faster time than predicted (group = FASTER), 85 subjects completed the race in a slower time than predicted (group = SLOWER) and 16 subjects completed the race in a similar time than predicted (group = ACCURATE). When examining the training history, FASTER trained less days per week than SLOWER or ACCURATE (5.4 ± 0.9 vs. 5.9 ± 0.8 and 6.1 ± 0.6 days respectively). The FASTER group ran less per week than the ACCURATE group (distance and time) ($P < 0.02$). The FASTER group also ran less per week than the SLOWER group (distance and time). At station 2 (approximately 27% of race duration), the FASTER group's pain and RPE was lower than the ACCURATE and SLOWER groups respectively, and at station 4 (approximately 61% of race duration) only the FASTER group's RPE, was lower than the ACCURATE and SLOWER groups respectively. These data can be interpreted in three ways. Firstly, the FASTER group trained less, but at a higher intensity than ACCURATE or SLOWER and therefore incurred adaptations which translated into them going faster than predicted. Secondly the FASTER group may have done more multi-block training than the other groups and were better prepared for the race. A third interpretation is that FASTER group trained optimally which meant they were slightly more rested before the race, compared to SLOWER and ACCURATE groups and therefore on the day of the race they performed better than expected. Further research is needed to distinguish the different interpretations. When examining the level of pain after the race (in the first week and for the next 7 weeks), no significant differences were found between the three groups. Athletes started training and even competing in other races within 2 weeks after the Ironman Triathlon. This might indicate that they felt ready to train and compete, even though previous research shows that on a microscopic level their muscles have not regenerated and that they are not yet ready to train and compete. This premature training and racing can lead to long term detrimental effects.

In summary, the data from this study shows that the triathletes who trained less (measured as days and hours) performed better than expected and perceived their effort to be less, than triathletes who trained more. There was no difference between the three groups regarding recovery after the race and most of the participants had started training and competing in other races within 2 weeks of the Ironman.

CHAPTER 1

INTRODUCTION AND SCOPE OF THESIS

Triathlon is defined as an endurance sport that comprises a sequential swim, swim-to-cycle transition, cycle, cycle-to-run transition and run (Margaritis, 1996). The distances vary from the sprint triathlon (750 m swimming, 20 km cycling and 5 km running), to an Olympic distance triathlon (1500 m swimming, 40 km cycling and 10 km running), and to an Ironman Triathlon (3.8 km swimming, 180 km cycling and 42 km running). When the components of swimming, cycling and running are combined into one event the physiological demands of the event are different from the demands of the individual sports of swimming, cycling and running. It is possible that these different physiological characteristics of the triathlon, which have not been well described, may make some athletes more suited to compete in triathlons, compared to single discipline sports (O'Toole and Douglas, 1995). Another interpretation is that these physiological characteristics required to meet the demands of the triathlon can be acquired with training, because as the experience of the triathlete increases, the mechanical and physiological alterations which occur during transition from cycling to running decrease (Millet et al., 2000; Zderic et al., 1997).

A combination of genetics, training, environment, lifestyle and social factors influence performance in endurance events (Lambert and Noakes, 2000). It is generally accepted that training for ultra-endurance events such as the Ironman, has a predominant effect on performance compared to any of the other factors which are associated with endurance performance. It is logical to assume that the many hours of training which are required before competing in the Ironman provide the necessary cues which assist with pacing during the event (St Clair Gibson et al., 2006). Precise pacing, in accordance with the triathlete’s ability and training status, should allow the triathlete to compete with minimal discomfort during the event. Furthermore, it can also be argued that the recovery of the triathletes who pace themselves appropriately, will be faster after the race when compared to triathletes who over exert themselves by racing too fast. A consequence of accurate pacing is the ability to predict race time before the event. The ability of triathletes to predict performance times in the Ironman Triathlon accurately has also not been studied closely. Furthermore, no relationships have been established between the ability of triathletes to predict performance times accurately, their training programs, perception of pain and RPE levels during the race and recovery time after the race. The following review of the literature will attempt to summarize the research on the individual sports (swimming, cycling and running) and also these sports combined into the triathlon, with particular emphasis on the background to pacing, perception of effort and recovery after the race.

CHAPTER 2

LITERATURE REVIEW

EVENTS COMPRISING THE TRIATHLON

Swimming

To date, little research has focused on the swimming aspect of a triathlon. It has been suggested that a reason for this is that the duration of the swim is relatively short (approximately 12-15%) and has little relationship to the overall race time (Dengel et al., 1989). Furthermore, it has been suggested that a 3000 m swim in 8 highly trained ultra-endurance triathletes, has no significant effect on the power output of a subsequent three hour cycling ride (Laursen et al., 2000). However, an earlier study on 9 well trained, male triathletes, reported a 17% decrease in cycling power output after an 800 m swim, relative to the power output achieved during an isolated cycling bout (Kreider et al., 1988). Another study showed that swimming at an intensity below that of a maximal time trial effort of 750 m (the researchers used a swimming speed of 80% and 90% of the swim time trial times respectively), significantly improves subsequent cycling and overall triathlon performance in nine highly trained triathletes (Peeling et al., 2005). The difference in the findings of these studies might be due to different intensities of the swim trials as well as the different distances over which the swim trial took place (3000 m, 800 m and 750 m) (Kreider et al., 1988; Laursen et al., 2000; Peeling et al., 2005).

The role of circulating lactate concentrations in the development of muscle fatigue and in regulation of muscle metabolism during intense exercise can be examined by performing exercise with other muscle groups after fatigue has developed (Bangsbo et al., 1996). Such an exercise regime has been used in several studies and a reduction in performance has been observed when exercise is performed with “unfatigued” muscle groups after exercise which caused fatigue in other muscle groups (Bangsbo et al., 1996). In the same context, it has been reported that intense arm exercise, that increases circulating lactate concentrations, can impair subsequent leg exercise (Bangsbo et al., 1996). Bangsbo et al. (1996) also showed in a group who did arm exercises that the arterial blood lactate concentration was approximately 11 times higher during leg exercise compared to a control group which did leg exercise but not the prior arm exercise. Collectively, these findings support the theory that cycling in the triathlon after the swim will be more strenuous and different physiological responses will be experienced by the athlete due to the prior swim. The seemingly contradiction regarding the effects of swimming prior to cycling, could be due to the different intensities and distances over which the swim leg took place.

Swimming appears to be a highly specific activity with the adaptations resulting from swimming training not gaining from, nor providing benefits to other activities (i.e. cycling and running). This is in contrast to cycling and running where cross-transfer training effects occur in elite triathletes (Millet et al., 2002).

In the Ironman Triathlon competition, triathletes are allowed to wear wetsuits during the swim leg. Research by Tomikawa et al. (2007), suggests that the benefits of wearing a wetsuit contribute to an improvement in swimming performance and propulsion efficiency, and reduce gross energy consumption in the swimming portion of triathlon races. It is certainly conceivable that the energy sparing effect of swimming with a wetsuit can be beneficial to the triathlete in both the cycling and the running leg of the Ironman.

<u>Cycling</u>

<u>Drafting</u>

The conditions under which the cycling leg takes place in the Ironman influences not only the athlete’s final cycling time, but also the running time. In most sprint and Olympic distance triathlons, the athletes are allowed to draft, i.e. cycle behind a cyclist, in the slipstream, thereby gaining a mechanical advantage. Drafting however, is not permitted in the cycling leg of the Ironman. Instead, the cycling leg is raced as an individual time trial, where drafting is not allowed. The time trial is more strenuous and energy consuming compared to a similar distance where drafting is allowed and the intensity varies because of "jumping the bunch" to break away from the group (Hausswirth et al., 1999; McCole et al., 1990).

The effect of cycling cadence, the swim leg and swim training in triathlon

Bernard et al. (2003), investigated the effect of cycling at three cadences (60, 80 and 100 rpm during a 20 minute cycle bout) on a subsequent 3000 m track running performance in 9 well trained triathletes. This study showed there was a significant effect of the prior cycling exercise on subsequent middle distance running performance (stride rate and running speed). Their cycle cadence did not have any additional effect (Bernard et al., 2003).

Whyte et al. (2000) investigated the relationship between physiological profiles and cycling performance in ultra-endurance triathletes. They found that the more conditioned triathletes maintained a higher cardiac output during prolonged cycling than the less conditioned triathletes. They also found that the longer duration swim (time wise), prior to the cycling component, impacted upon cycle performance in the less conditioned triathletes.

Studies of arm movements suggest that interference with motor learning occurs when multiple tasks are practiced in sequence, or with short interim periods, and that muscle recruitment might be less developed in triathletes than in cyclists matched for cycling training loads. This suggests that multi-discipline training may interfere with adaptation of the neuromuscular system to cycling training in triathletes (Chapman et al., 2007(a)). This study investigated muscle recruitment in highly trained triathletes, who swim, cycle and run sequentially during training and competition. Comparisons were made to highly trained and novice cyclists, i.e. between trained multi-discipline, trained single-discipline and novice single-discipline athletes, to investigate adaptations of muscle recruitment that occur in response to ongoing multitask, or multi-discipline, training. Electromyographic (EMG) activity of five leg muscles were recorded during cycling and differences were found between trained triathletes and trained cyclists in recruitment of all muscles. Patterns of muscle recruitment in trained triathletes were similar to those recorded in novice cyclists. Modulation of muscle activity decreased with increasing cadence (i.e. the amplitude and duration of muscle activity was greater at higher movement speeds) in both triathletes and novice cyclists but modulation of muscle activity was not influenced by cadence in trained cyclists. These findings imply that control of muscle recruitment is less developed in triathletes than in cyclists matched for cycling training loads. This suggests that multi-discipline training may interfere with adaptation of the neuromuscular system to cycling training in triathletes.

Running

Running after cycling

Various factors which influence running after cycling have been investigated. For example the energy cost of running was higher after the cycle-to-run transition in triathlon, compared to that of the individual sport of running (Hue et al., 1998; Vallier et al., 2003). Stride length, which is an important biomechanical parameter associated with running performance, was also investigated. Stride length during running after cycling was shorter than stride length during running alone (Hausswirth et al., 1997; Candau et al., 1998; Nicol et al., 1996). When ventilatory responses were investigated, it was found that the transition from cycling to running was more strenuous on the respiratory system, than was running alone (Guezennec et al., 1996; Millet et al., 2000).

Chapman et al. (2007)(b) found that short periods of cycling do not influence running kinematics in elite triathletes. However, there is evidence that leg muscle activity during running is influenced by cycling in elite triathletes despite their years of training. This influence is not related to kinematic variations and is unlikely related to fatigue, but may be a direct effect of cycling on the motor commands of running.

Summary

From the above discussion, it is clear that there are remarkable differences in the demands of the single sports of swimming, cycling and running compared to the sports performed in combination during the triathlon. The differences are not as remarkable in the novice athlete, but the more elite the athlete becomes, the more important the differences and the ability of the athlete to adapt to the next discipline becomes.

FACTORS INVESTIGATED IN THIS STUDY

In the next section the different training protocols and the adaptations associated with endurance training will be discussed. There will also be a discussion on the relevance of ratings of RPE and pain scores during and after the race. This will be followed by a brief discussion on the anatomical and physiological changes resulting from the race and the recovery thereafter.

Training

Training programmes for triathlon

There are many different training programs which differ in the mode of training (for example interval training or single discipline training), intensity, specificity, frequency, rest between sessions and recovery time. Many training methods are largely a product of the trial-and-error approach used by coaches of successful athletes and teams, or based on training schedules of current world class athletes (Adrian et al., 2006). Although the trial-and-error approach has probably advanced the overall effectiveness of the training programs given to athletes, many of the common methods employed have received little scientific support (Tabata et al., 1997). Basing training programs on the programmes used by world class athletes is also problematic, because these athletes possess specific genotypes and phenotypes and the ability to adapt which are not the characteristic of the average competing athlete (Keul et al., 1996).

The optimal training dose

There is a lack of existing data quantifying athletic performance and training load, however, intra-individual differences in the effect of exercise training on physical fitness-related measures are well known (Bouchard and Rankinen, 2001). It has been shown that there is a two-fold difference in training volume and performance of similarly matched elite Two Oceans runners matched for performance (Lambert and Keytel, 2000).

Gratze et al. (2005) hypothesised that for each individual, there could be a narrow range of an appropriate level of training, for any given training state. A study done on training and bioenergetic characteristics in elite male and female Kenyan runners (10 km), showed that the type of training is associated with different physiological characteristics of the runners (Billat et al., 2003). They also showed that the running speed at the VO_{2max} is the main factor predicting the variance of the 10-km performance both in men and women, and that high-intensity training (training speeds faster than the speed at VO_{2max}) contributes to this higher VO_2max among men (Billat et al., 2003).

A study by Zarkadas et al. (1995) showed that proper placement of training volume during taper is a key factor in optimizing performance for a specific competition and a high volume of training in the immediate days preceding an event may be detrimental to physical performance. According to Gulbin and Gaffney (1999), less training is required for non-elite competitors to finish an Ironman than has been previously reported in studies that have primarily focused on elite competitors. Additionally, training distances appear to be a more important factor for competitive success than training intensity (Gulbin and Gaffney, 1999).

The individual effects of training

There are wide individual variations in training (distance and intensity) for each of the three activities of the Ironman Triathlon. A study by O'Toole (1989) showed that peak weekly swim distances ranged from 1.7 to 34.0 km, with an average weekly distance of 12.2 km. Peak weekly cycling distances ranged from 26 to 740 km with an average of 386 km. Run distances ranged from 7 to 179 km per week with an average of 77 km per week. There was little or no systematic difference in training between males and females. Younger triathletes, however, tended to train greater distances at faster paces. Faster finishers (less than 10.5 h in the Hawaii Ironman Triathlon) tended to average greater training distances at faster paces than slower finishers. There was, however, a great deal of overlap in training practices according to finish time. Faster finishers in the Hawaii Ironman Triathlon were able to maintain their training paces throughout all three activities of the triathlon. According to this study, training distances appear to be more important than training paces in preparation for an ultra-endurance triathlon (O'Toole, 1989).

The effect of multi-block training

Multi-block training, where short bouts of repeated swim, cycle and run bouts are done in combination, is a common training strategy amongst triathletes. A study by Hue et al. (2002), demonstrated that although 6 weeks of multi cycle-run training does not improve cycle-run performance in triathletes more than normal training (single bout training), it induces greater ability and adaptation to the cycle-run transition as well as greater technical adaptation to the next phase. It was concluded that further research is needed to specify the physiological and performance responses induced by longer-term multi-block training (Hue et al., 2002). This study shows that it is clear that the type, amount and timing of training have an important contribution to the success of the triathlete. This raises the question of whether triathletes who followed an optimal training program (with regards to type, amount and timing of training), will perform better and have a different perception of effort and pain during, and after the race, compared to those triathletes who did not train optimally.

Relative perception of effort (RPE)

Borg stated that the RPE is the "*single best indicator of physical strain*" and that the perceived exertion rating "*integrates various information, including the many signals elicited from the peripheral working muscles and joints, from the central cardiovascular and respiratory functions, and from the central nervous system*" (Borg, 1982). RPE is not merely an indicator of physical strain, but also incorporates cognitive and psychological processes, and may be influenced by the subject's knowledge or expectations of task duration (Borg, 1982). Walster and Aronson (1967) hypothesized that perceptions or sensations of fatigue are suppressed until near the end of a task to avoid premature discomfort and termination of exercise. Studies have also shown that expectations of task duration and anticipation of an endpoint influence subjective ratings of perceived exertion (Rejeske and Ribisl, 1980). A study by Baden et al. (2005), showed that physiological demands of a running task did not change at the same stage as which changes in RPE was observed. This supports Borg's statement that RPE is not only an indicator of physical strain, but that cognitive and psychological processes are involved as well.

The cognitive and psychological contribution to RPE

Mental cognitive function includes the level of motivation at the time of the activity, memory of prior exercise sessions and an associated decision-making component based on the relationship between the current sensorimotor input and memory of previous events (St Clair Gibson et al., 2003). Previous experience and planning of current activity are also important components of the sensation of fatigue during exercise. Previous memory of fatigue allows one to estimate one's reserves and tolerance levels, and allow decision-making to occur about whether to continue, reduce activity or halt the physical activity (St Clair Gibson et al., 2003). Noakes et al. (2007) hypothesised that fatigue in any form of exercise may form part of a regulated, anticipatory response co-ordinated in the subconscious brain with the ultimate goal of preserving homeostasis in all physiological systems during exercise. According to these theories the effect of training is to improve the precision of this regulation so that homeostasis can be maintained at higher exercise intensities than occurred prior to training. It follows from this that training contributes to the ability to adopt a better pacing strategy to ensure that the imminent onset of fatigue is delayed for as long as possible. It is a reasonable assumption that better trained triathletes will be able to predict their pace (and therefore their race time) better than less trained competitors.

The effect of lower intensity exercise on RPE

Peeling et al. (2005) showed that subjects who completed the 1500 m swim leg of the triathlon in a slower time than their maximal ability, perceived their physical status as more comfortable (as measured by RPE), during the swim-cycle combination. A relationship exists between thoughts, perception of exertion, and athletic performance (Baudoin et al., 1998). Therefore it is possible that the lower swim intensity allowed more positive thoughts about the ability to perform throughout the remainder of the race.

The influence of personality type on RPE

Dishman et al. (2001) investigated the effect of different personality types, particularly Type A Behaviour Pattern on ratings of RPE, during exercise testing. They hypothesized that exercise tolerance during graded stress testing is overestimated in males showing the Type A Behaviour

Pattern because of high motivation and suppressed RPE. However, they showed no relationship existed between RPE and several self-report measures of Type A Behaviour Pattern. Groups did not differ on maximal test performance or RPE at any stage of the test, even after adjusting RPE for small group variations in % VO_{2peak} and ventilatory equivalent for oxygen, which are strong correlates of RPE during incremental exercise. It was shown that there is no basis for the view that the Type A Behaviour Pattern affects cycling performance or ratings of perceived exertion during standard exercise testing in young men (Dishman et al., 2001).

The influence of carbohydrate ingestion on RPE

Backhouse et al. (2007), investigated the effects of ingesting a CHO solution on the RPE during prolonged, intermittent, high-intensity exercise. Seventeen male soccer players completed a prolonged intermittent high-intensity exercise protocol for 90 minutes on two occasions, separated by at least 7 days. RPE was maintained in the last 30 minutes of exercise but carried on increasing in the placebo trial. Therefore, CHO ingestion during prolonged high-intensity exercise appears to elicit an enhanced perceived activation profile that may impact upon task persistence and performance.

RPE consists of a cognitive as well as physical component, therefore all of the above mentioned factors might contribute to a difference between being able to predict performance accurately or not as well. No studies could be found which examined the relationship between RPE and predicting splits and overall times, performance and recovery time in the Ironman Triathlon.

Recovery after an endurance event

Previous research has also shown that endurance training and racing causes acute and chronic muscle damage to the participating athlete and that a period of recovery from this damage is necessary (Hikida et., 1983; Warhol et al., 1987). The range in rate of recovery varies widely (Chambers et al.,1998) and may be associated with endurance training (Thoden, 1991).

Physiological aspects of training and recovery

A wide range of physiological responses to exercise and the recovery after endurance events has been studied. For example, the autonomic and hemodynamic parameters (i.e. heart rate, stroke index, systolic blood pressure, diastolic blood pressure, total peripheral resistance index and baroreceptor reflex sensitivity) only returns to baseline levels 3 days after an Ironman competition in highly trained triathletes (Gratze et al., 2005). In a study where endurance-trained males (n = 22) ran at 100% of their ventilatory threshold on a treadmill until volitional fatigue, cortisol and prolactin (stress hormones) returned to baseline levels after 90 minutes and even dropped below baseline levels after 24 hours (Daly et al., 2004). Other studies have also shown that serum levels of catecholamines and cortisol are elevated for several hours after the triathlon (Rogers et al., 1986) and that free testosterone concentration is significantly reduced for several days after the competition (Urhausen and Kindermann, 1987). Hill et al. (1991), concluded that vital capacity, flow rates at mid-lung volumes, and inspiratory muscle strength declined as a consequence of participation in an Ironman Triathlon. Measurements in this study were taken the afternoon before the event, after each segment and the following morning. Following completion of the triathlon, statistically significant declines occurred in FVC (7.1%), FEV1 (8.4%), FEF25-75% (15.2%), and FEF50% (18.6%), but not in MVV. On the morning after the triathlon, only FEV1 remained significantly below baseline (Hill et al., 1991).

From the studies discussed above, it is clear that a wide range of physiological aspects are influenced by endurance events, including an Ironman Triathlon. An interesting question which has not been addressed is how does the triathlete perceive these physical and physiological aspects, during and after the race?

Muscle damage due to endurance training

Prolonged, exhaustive endurance exercise results in both acute (Hoppeler, 1986) and chronic (Kuipers et al., 1989) alterations to the z-discs, such as z-disc streaming, smearing, broadening, disruption, and dissolution. Warhol et al. (1985), found that the gastrocnemius muscle of marathon runners showed sequential ultrastructural changes of cellular injury and repair. The severity of damage differed in the individuals, as the runners were of different age, running speed and training levels. In contrast to other studies, no evidence of inflammatory reactions were found. Evidence of the regenerative process in muscle biopsies were still evident 10-12 weeks after the marathon, at which point the experiment ended (Warhol et al., 1987).

Case studies have shown an association between long term high volume endurance training and racing, acquired training intolerance and chronic skeletal muscle pathology (Grobler et al., 2004). A muscle biopsy of a 28 year old international runner with a history of a high volume of training showed pathological changes in the vastus lateralis muscle while the structure of his triceps muscle was normal (St Clair Gibson et al., 1998). They interpreted this finding as being a consequence of repetitive bouts of damage/regeneration which would have occurred in the vastus lateralis muscles, and not in the triceps muscles of the runner. Derman et al. (1997), described a group of athletes with a history of high volume endurance training and racing, a precipitous decline in running performance that was not related to ordinary aging and an inability to tolerate and adapt to previously accustomed exercise training loads. On investigation, structural and ultra structural abnormalities of the skeletal muscle typical of exercise induced muscle degeneration/regeneration were noted. The z-disc appears to be the structure that is most susceptible to exercise induced muscle damage (Appell et al., 1992). Collectively these studies show that endurance events (training and racing) cause muscle damage, the symptoms which seem to manifest differently in different athletes.

Predicting Ironman performance:

No studies could be found investigating the ability of the triathletes to predict their Ironman splits and overall times. The only studies were those in which laboratory tests, using physiological parameters, were used to predict field performance, and studies using laboratory tests to predict sprint and standard distance triathlon performance.

Schabort et al. (2000), investigated the physiological variables which accurately predicted triathlon race time in the standard distance triathlon. The five most significant predictors of triathlon performance in this study were blood lactate concentrations measured during steady-state cycling, blood lactate while running, peak treadmill running velocity, VO_{2peak} during cycling and peak sustained power output during swimming. No training history was mentioned in the study, but all the subjects were Olympic-distance National level triathletes. The results of this study show that race time for top triathletes competing over the Olympic distance can be accurately predicted from the results of maximal and submaximal laboratory measures. Miura et al. (1997), also demonstrated that a larger VO_{2max} during maximal exercise tests and smaller increment of VO_2 during a simulated laboratory test triathlon, indicating good economy, were good predictors to determine the Olympic distance triathlon.

Van Schuylenbergh et al., (2004), investigated whether sprint triathlon performance can be adequately predicted from laboratory tests. Subjects underwent two graded maximal exercises tests, one on a treadmill and the other on either an exercise bike or on their own bike mounted on an ergo meter, to determine their peak oxygen consumption. Subjects then participated in two to three 30 minute constant-load tests in swimming, cycling and running to establish their maximal lactate steady state in each exercise mode. It was shown that running speed and swimming speed at maximal lactate steady state, together with blood lactate concentration in running at maximal lactate steady state, yielded the best prediction of performance. The results indicate that exercise tests aimed to determine maximal lactate steady state in running and swimming allow for a precise estimation of sprint triathlon performance.

Summary

The discussion above shows that the triathlon comprises of a sequential swim, cycle and run. This combination of events imposes different physical and physiological demands on the triathlete compared to the single sports. Research has been done in various fields to investigate the training regimes, performances, athlete's perception of effort, recovery and prediction of performance of elite and sedentary athletes in endurance events. These studies show that there are many different training protocols with controversy about the optimal program. Perception of effort during endurance exercise is more than a perception of physical effort with emotional and cognitive factors also contributing to the overall perception of effort score. Multiple factors, including training history, play a role in the athlete's ability to predict performance accurately. Although there are no data to support this, it stands to reason that the ability to recover after endurance exercise depends on the pacing and the training history of the athlete.

A practical question relating to performance in the Ironman and which has not been addressed is;

> Are there differences between the training history, relative perception of effort during the Ironman race and the recovery time after the Ironman race, in triathletes who predicted their individual and overall times accurately (i.e. were able to adopt an accurate pacing strategy during the race) compared to triathletes who over- or under-predicted their Ironman race performance? The hypothesis of this thesis states; Triathletes who are able to accurately predict their performance times will have conducted more training, will experience a lower RPE and will recover quicker from an Ironman Triathlon compared to those triathletes who are unable to make accurate performance predictions

The next section of the dissertation (Chapter 3) will attempt to answer this question and test this hypothesis.

CHAPTER 3

ACCURACY OF THE PREDICTION OF IRONMAN PERFORMANCE: RELATIONSHIP TO TRAINING HISTORY, MUSCLE PAIN AND RELATIVE PERCEPTION OF EFFORT DURING, AND RECOVERY AFTER THE RACE

ABSTRACT:

Introduction: The aim of this study was to establish how accurately triathletes could predict their performance and how this relates to training, muscle pain and RPE as well as recovery after the race. **Methods**: Subjects consisted of volunteers (n = 117) from all the participants (n = 948) in the 2006 Ironman Triathlon (South Africa). Training history and other applicable information were obtained from a questionnaire which the triathletes completed at registration. Final total Ironman times and the split times were obtained from the Ironman website after the race and triathletes were divided into three groups, FASTER (n = 16), SLOWER (n = 85) and ACCURATE (n = 16) (defined by being within 1% of their predicted time). **Results**: FASTER trained less days per week than SLOWER or ACCURATE for the 15 weeks before the race (5.4 ± 0.9 vs. 5.9 ± 0.8 and 6.1 ± 0.6 days; FASTER vs. SLOWER and ACCURATE respectively). The FASTER group ran less distance and time per week than the ACCURATE group ($P < 0.02$). At station 2 (cycling leg, approximately 27 % total duration), FASTER had lower pain than SLOWER and ACCURATE. At Station 4 (cycling leg, approximately 61% total duration) FASTER had a lower RPE score than ACCURATE and SLOWER. There were no differences in pain scores between groups immediately after the race and up to 7 weeks later. **Conclusion**: The RPE increased linearly with race duration. The triathletes who trained less days and hours in the 15 weeks prior to the race performed better and perceived their effort as less, compared to the triathletes who trained more days and hours during this period. There are three possible interpretations of these data: The "less trained" group (i) trained at higher intensities than the "higher trained" group, (ii) did more multi-block training, or (iii) trained optimally and did not

have symptoms of fatigue which may have impaired performance. The rate of recovery was similar in all groups. Most subjects had started training again within 2 weeks of the Ironman.

INTRODUCTION

The individual sports of swimming, cycling and running have been studied extensively, whereas the combination of these sports into the triathlon has received less attention. Various studies have investigated the contribution to endurance performance of physiological (O'Toole and Douglas, 1995) and genetic (Bosch et al., 1990) factors as well as the influence of different training programs (Adrian et al., 2006) and the athlete's adaptation to these programs (Keul et al., 1996). Studies have also investigated the levels of pain and relative perception of effort (RPE) during the event (Rejeske and Ribisl, 1980; Baden et al., 2005) and the athlete's ability to recover after endurance races (Thoden, 1991; Chambers et al., 1998). However, no studies have focussed on Ironman triathletes, particularly how their training prior to the race is associated with their ability to predict their swimming, cycling, running and overall times. Furthermore, there are no studies relating training for the event to their pain and perception of effort during the race and in the recovery period after the race.

The aim of this study was to establish whether there was a relationship between training methods in preparation for the Ironman and subjective pain and perception of effort during the race, and the recovery time after the race. The study was designed to establish whether there were differences in these variables between triathletes who predicted their finishing time accurately compared to those triathletes who under- or over-predicted their performance. The information derived from this study is novel and has the potential to assist triathletes in training correctly for a predetermined time goal that they have set themselves.

METHODS

Subjects

All entrants of the 2006 Ironman race in Port Elizabeth, South Africa (n = 948) were invited to participate in the study. There were no inclusion or exclusion criteria beyond the prerequisite that subjects had to have entered the race and volunteered to record their subjective scores during and after the race. The data of subjects were only included for analysis if they completed the race.

Subjects were recruited at the registration of the Ironman by the researcher. All participants were fully informed of the procedures and risks involved in participating in the study. The protocol was approved by the Research and Ethics Committee of the University of Cape Town. Written informed consent was obtained from all participants. Subjects were allowed to withdraw from the study at any stage and for any reason.

Questionnaire

All the subjects completed a questionnaire at registration which asked for biographical information and questions on their training history, previous participation in various races, tapering strategies in the week before the race and prediction of their swimming, cycling, running and overall performance in the 2006 Ironman (Appendix A).

Subjective assessment of pain and relative perception of effort

The researcher provided the subjects with pamphlets describing the ratings for RPE (Table 3.1) and pain (Table 3.2) which were going to be used in the study. This allowed them to familiarise themselves with these scores before the race.

Table 3.1 Rating scores for relative perception of effort (RPE) (Borg, 1982)

Score	**Description**
6	
7	Very very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very very hard
20	Maximal exertion

Table 3.2 Rating scores for pain

Score	**Description**
0	Nothing at all
1	Very very slight
2	Very slight
3	Slight
4	Mild
5	Moderate
6	Moderate-severe
7	Severe
8	Very severe
9	Very very severe
10	Maximal pain

The pain and RPE scales were given and explained to the participants at the registration, and they were invited to ask questions about the study. All the contact details of the subjects, including their e-mail addresses, were obtained for future correspondence. Each subject was given a yellow band for easy recognition during the race. Subjects were required to wear the band on their right wrists. Subjects were informed of the exact locations of all the research stations on the route. They were instructed to shout their RPE score to the researchers first, followed by their pain score at each data collection point, as they perceived it at that specific point in time.

Two researchers were used per data collection point with another researcher based 50 m before the station to warn the participants of the upcoming station. Written posters as well as verbal prompts were used to warn subjects about the upcoming data recording point. At each research station, posters with the RPE and pain scales were displayed at a clearly visible point. Researches used pre-printed documentation sheets to record the scores which were verbally given by the participants as they passed the station.

Data collection points were situated along the race course, with the first station between the two swim laps, at 1.9 km (which participants passed once), the second station 5 km before the end of the cycle lap (which participants passed 3 times), and the third station 5 km after the start of the run lap (which participants passed 3 times). In total seven recordings of RPE and pain was taken at the different stations. A summary of these collection points is shown in Table 3.3

Table 3.3 A summary of the location of the data collection points and the duration of the three disciplines

The % distance of the mode represents the % of the distance for swimming (3.8 km), cycling (180 km) and running (42 km). The % of total duration represents the estimate of the duration.*

Station	Mode	Distance (km)	% Distance of the mode	% of Total Time*
1	Swim	1.9	50	6
2	Cycle	55	31	27
3	Cycle	115	64	44
4	Cycle	175	97	61
5	Run	5	12	67
6	Run	19	45	80
7	Run	32	76	91

**This calculation is based on the assumption that the average swim time for all competitors was 90 minutes, the average cycle time was 409 minutes and the average run time was 296 minutes. These estimates were made from the group average. The estimate is also based on the assumption that the energy was expended evenly over the course.*

All subjects were emailed on a daily basis for the first seven days after the Ironman to prompt them for their pain scores. Thereafter they were contacted weekly for the next seven weeks for their pain scores.

Final total Ironman times and the individual swimming, cycling and running times were obtained from the Ironman website after the race. The total times and the individual times for the three disciplines were compared to the predicted times the triathletes provided in the questionnaire before the race.

Statistics

The descriptive data are presented as the mean and standard deviation (X $\pm$ SD). The subjects were classified into 3 groups based on the difference between their predicted total time and actual total time for the race. A 1% difference was defined as a “meaningful difference” in performance. This decision was based on the study which showed that a 1% difference in cycling represented a “meaningful difference” (Paton and Hopkins, 2001). We have assumed that this calculation also translates into overall triathlon performance. Therefore the three groups were described as;

1. Faster than predicted (> 1%) (FASTER)
2. Slower than predicted (< 1%) (SLOWER)
3. Accurate predicting (1%) (ACCURATE)

A one way analysis of variance was used to determine differences between groups for the parametric data. When a difference existed in the F value, a Scheffe’s post hoc test was used to identify the differences between groups. A Friedman analysis of variance was used for the non-parametric data (RPE and pain scores) when comparing days. A Kruskal-Wallis analysis of variance test compared groups for the non-parametric variables. A Pearson product moment correlation was used to determine relationships between variables. Statistical significance was accepted as $P < 0.05$.

RESULTS

Of the 948 athletes who finished the Ironman, a total of 160 athletes volunteered for the study. Data were incomplete on 43 subjects and it was decided to exclude their data from further analysis. Of the remaining 117 triathletes, 99 were male, and 18 were female athletes. Incomplete data were due to subjects not completing the questionnaires fully, subjects not giving pain and RPE scores at the research stations and subjects not completing the race. The data from the remaining 117 subjects were included in the study for analysis. 16 Subjects completed the race in a faster time than predicted (group = FASTER), 85 subjects completed the race in a slower time than predicted (group = SLOWER) and 16 subjects completed the race in a similar time than predicted (group = ACCURATE). The relationship between actual time and predicted overall time is shown in Figure 3.1. In the FASTER group, 3 subjects were female and 13 male. In the ACCURATE group 4 subjects were female and 12 male and in the SLOWER group 11 subjects were female and 74 male. The descriptive data of the subjects in these three groups involving their race time are shown in Table 3.4.

Table 3.4 A summary of the general characteristics of the three groups

	FASTER (n = 16)	**SLOWER** (n = 85)	**ACCURATE** (n = 16)	**F (df)**	**P value**
Age (years)	35.8 ± 6.7	38.0 ± 9.7	39.0 ± 7.4	0.54 (2.110)	0.58
Mass (kg)	76.0 ± 10.4	73.8 ± 10.6	73.9 ± 13.2	0.28 (2,107)	0.75
Stature (cm)	177.9 ± 8.2	178.0 ± 8.0	178.1 ± 9.8	0.003 (2,102)	1.00
Swim time (min)	92 ± 11	90 ± 16	84 ± 17	1.14 (2,114)	0.32
Cycle time (min)	408 ± 32	410 ± 41	406 ± 31	0.08 (2,113)	0.93
Run time (min)	284 ± 49	302 ± 55	277 ± 36	2.10 (2,113)	0.13
Overall time (min)	784 ± 80	800 ± 98	770 ± 69	0.84 (2,114)	0.44
Predicted time (min)	843 ± 85	734 ± 83	772 ± 73	12.25 (2,114)	0.00002

There were no differences between the means of the three groups (FASTER, SLOWER and ACCURATE), for either age, mass, stature, the final swim, cycling and run time, the final overall time or the predicted overall time.

The relationship between the actual total race time and predicted race time is shown on Figure

3.1. The correlation coefficient (r = 0.77) was significant (P < 0.0001).

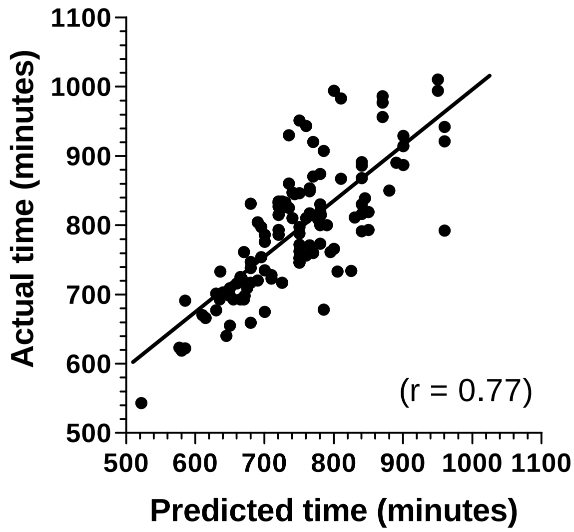

Figure 3.1 Relationship between predicted and actual time (minutes) for the Ironman Triathlon (n=117)

Training and racing history

The training and racing history of the groups are shown in Table 3.5. FASTER trained fewer days per week (in the 15 weeks before the race) compared to the SLOWER and ACCURATE groups (P < 0.05).

Table 3.5 Days per week trained in the 15 weeks before the Ironman Triathlon by the three different groups

	FASTER (n = 16)	**SLOWER** (n = 85)	**ACCURATE** (n = 16)	**F (df)**	**P**	**COMPARISON**
Days trained	5.4 ± 0.9	5.9 ± 0.8	6.1 ± 0.6	3.90 (2.110)	0.02	FASTER *less than* SLOWER FASTER *less than* ACCURATE

*The P value represents the level of significance for the ANOVA. The column headed "**COMPARISON**" describes the post-hoc results. "Less than" implies P < 0.05. N/S represents "not significant". This format is used in all the tables.*

A summary of the swim training is shown in Table 3.6. The training are displayed as the average distance and training time in the 15 weeks preceding the race, and the distance in the week before the race. The taper rate% (taper distance as a % of average 15 week distance) is also shown in the table There were no differences between groups in any of the parameters which defined volume of swim training.

Table 3.6 A summary of the swim training per week history in the 15 weeks before the Ironman Triathlon

SWIM	**FASTER** (n = 16)	**SLOWER** (n = 85)	**ACCURATE** (n = 16)	**F (df)**	**P**	**COMPARISON**
15 Week distance (km) per week	4.93 ± 2.77	6.78 ± 3.17	6.90 ± 3.19	2.45 (2,107)	0.09	N/S
15 Week time (min) trained per week	150 ± 44	191 ± 109	190 ± 73	1.10 (2,108)	0.34	N/S
Week before distance (km)	0.162 ± 0.135	0.95 ± 0.67	0.35 ± 0.19	0.17 (2,109)	0.84	N/S
Taper rate%	29 ± 21	44 ± 100	47 ± 26	0.23 (2,104)	0.79	N\S

A summary of the cycle training history is shown in Table 3.7. There were no differences between groups for any of the training or tapering variables. There were also no differences in the relative intensity between the 3 groups during the cycling section of the race.

Table 3.7 A summary of the cycle training history in the 15 weeks before the Ironman Triathlon and the relative intensity during the cycling section of the race

CYCLE	**FASTER** (n = 16)	**SLOWER** (n = 85)	**ACCURATE** (n = 16)	**F (df)**	**P**	**COMPARISON**
15 Week distance (km) per week	204 ± 73	222 ± 85	225 ± 55	0.38 (2,107)	0.69	N/S
15 Week time (min) trained per week	439 ± 154	520 ± 235	522 ± 108	1.01 (2,108)	0.37	N/S
Week before distance (km)	59.9 ± 3.9	53.1 ± 4.2	77.5 ± 4.3	2.08 (2,108)	0.13	N/S
Week before time (min) trained per week	138 ± 92	137 ± 110	184 ± 80	1.31 (2,108)	0.27	N/S
Taper rate%	35 ± 28	35 ± 23	30 ± 58	0.09 (2,106)	0.91	N/S
Race speed (%)*	84 ± 10	90 ± 10	84 ± 12	2.20 (2,94)	0.17	N/S

** calculated as a percentage of their average speed achieved in their fastest race over 80 km in the preceding 15 weeks.*

A summary of the training for running is shown in Table 3.8. The total training distance and time spent training in the last 15 weeks before the race were not different between groups. There were also no differences in the relative intensity between the 3 groups during the running section of the race. However, the FASTER group trained less distance per week and spent less time training per week in the last 15 weeks before the Ironman Triathlon than the ACCURATE group (P= 0.05). The rate of taper was similar between groups.

Table 3.8 A summary of the run training history in the 15 weeks before the Ironman Triathlon and the relative intensity during the running section of the race

RUN	**FASTER** (n = 16)	**SLOWER** (n = 85)	**ACCURATE** (n = 16)	**F (df)**	**P**	**COMPARISON**
15 Week distance (km) per week	45.3 ± 14.8	48.0 ± 17.9	53.4 ± 20.5	0.86 (2,106)	0.43	N/S
15 Week time (min) trained per week	345 ± 114	295 ± 125	315 ± 77	1.21 (2,106)	0.30	N/S
Week before distance (km)	8.6 ± 7.8	11.3 ± 9.7	17.5 ± 10.5	3.71 (2,109)	0.03	FASTER *less than* ACCURATE
Week before time (min) trained	47 ± 38	67 ± 57	102 ± 49	4.32 (2,109)	0.02	FASTER *less than* ACCURATE
Taper rate%	23 ± 20	33 ± 20	18 ± 15	2.71 (2, 205)	0.07	NS
Race speed (%)*	80 ± 13	79 ± 13	74 ± 12	1.35 (2,79)	0.27	N/S

** calculated as a percentage of their average speed achieved in their fastest 42.2km race in the preceding 15 weeks.*

The frequency distribution of the finishers in the Ironman triathlon, based on whether they under or over predicted their finishing time (%) is shown in Figure 3.2. The data are shown for the (a) overall time, (b) swim time (c) cycle time and (d) running time.

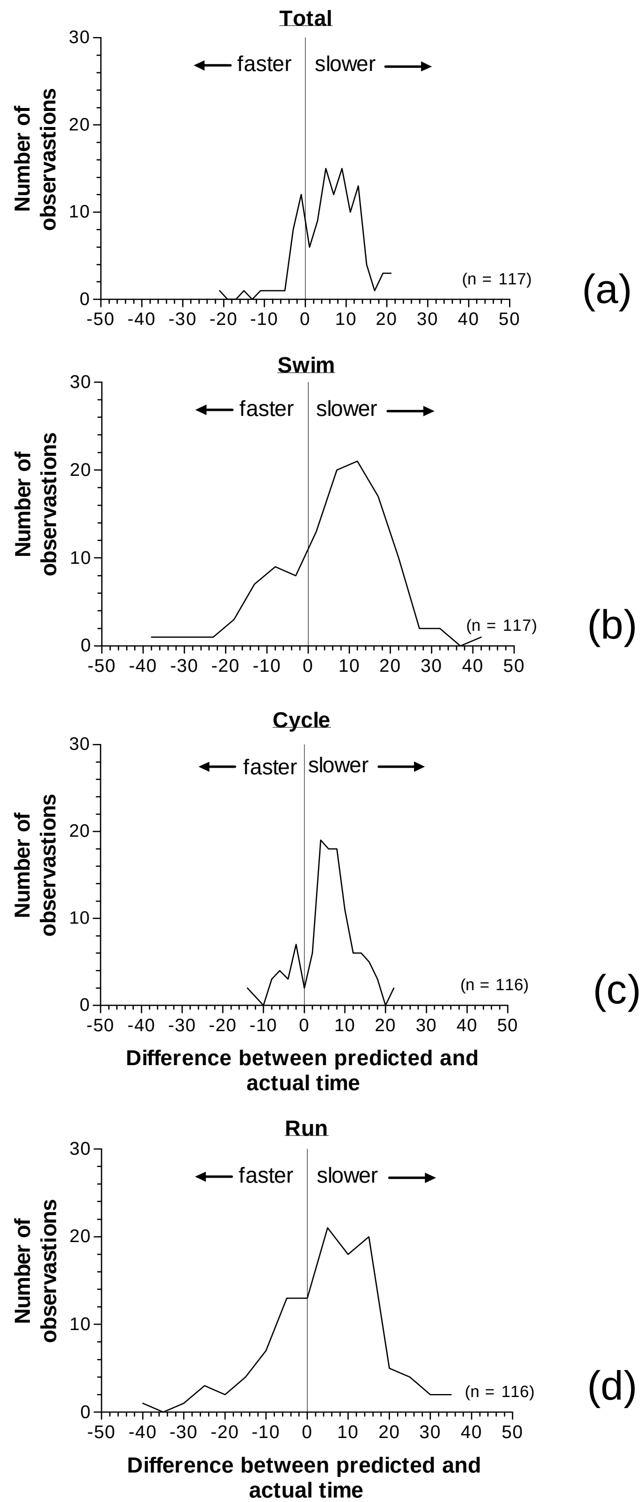

Figure 3.2: *The frequency distribution of the finishers in the Ironman triathlon, The data are shown for the (a) overall time, (b) swim time (c) cycle time and (d) running time.*

There was no relationship between experience, defined by the number of previous Ironman Triathlons and the performance in the race or sections of the race; i.e number of Ironman Triathlon races vs overall time (r = 0.13, N/S); vs swimming time (r = 0.14, N/S); vs. cycling time (r = 0.07, N/S) and vs. running time (r = 0.13, N/S). Of the 49 participants who were doing the race for the first time 11 went faster than predicted, 11 predicted their time accurately, and 27 went slower than predicted. This can be compared to the participants who had raced once or more (4 FASTER, 4 ACCURATE and 46 SLOWER) (*data missing on 15*). Therefore 55% of the novices went slower compared to 85% of the experienced participants.

The mean scores for RPE and pain during the race are shown in Figure 3.3.

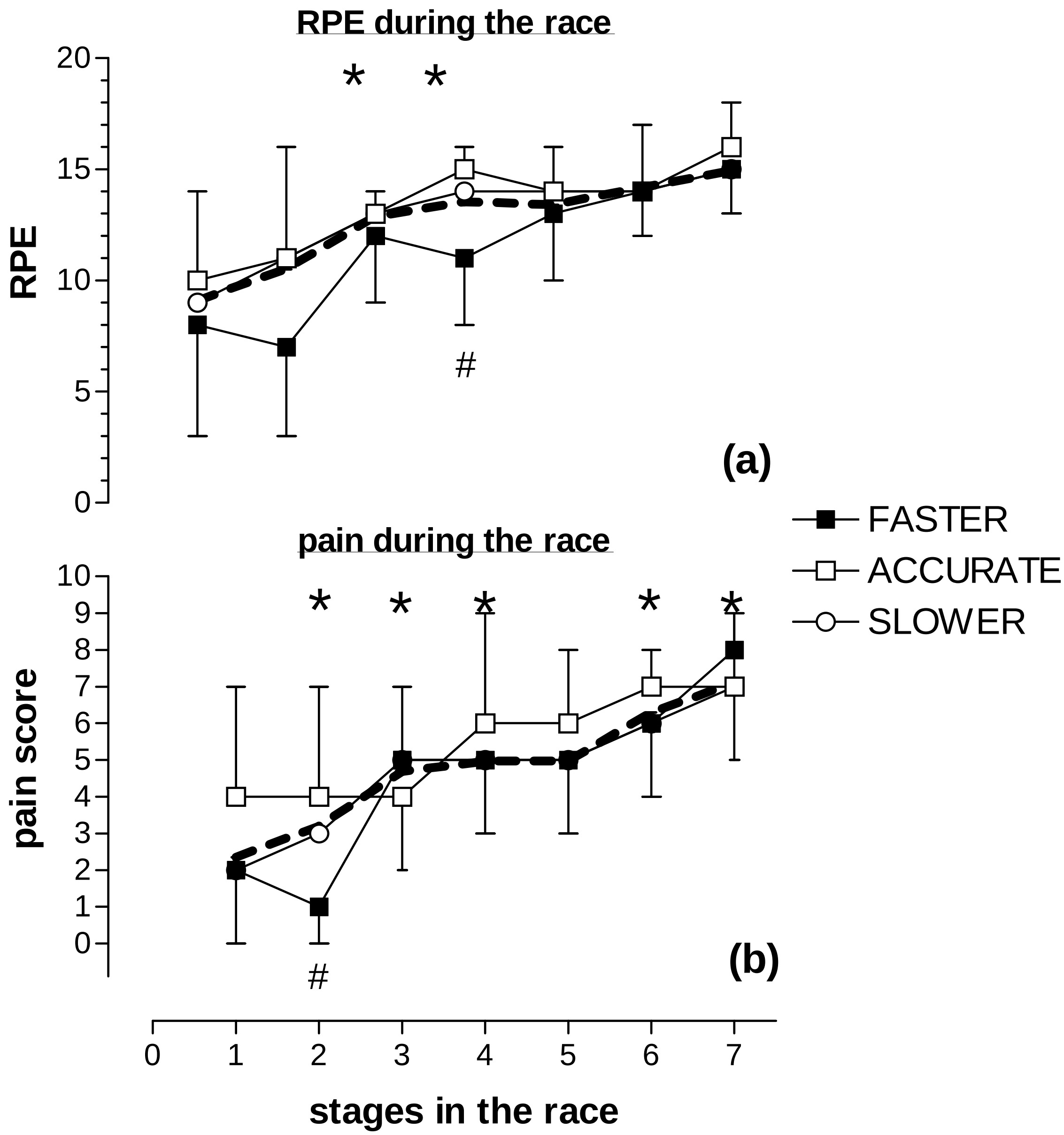

Figure 3.3. RPE (a) and Pain (b) for the entire group during the Ironman (solid dotted lines) and also for the individual groups of FASTER< ACCURATE and SLOWER. Data are expressed as mean ± SD.
** P , 0.05 different to the preceding value (group analysis)*
 # RPE: P < 0;05 FASTER less than ACCURATE, and FASTER less than SLOWER
 # PAIN: P < 0.05 FASTER less than SLOWER, and FASTER less than ACCURATE

(Station 1, 2, 3, 4, 5, 6, and 7 represent approximately 6, 27, 44, 61, 67, 80 and 91% of the total time. See legend in Table 2.3 for an explanation of the calculation).

These data (RPE and PAIN during are also shown in Tables 3.9 and 3.10 respectively. The FASTER group had a tendency to have a lower RPE ($P < 0.06$) at station 2 (55 km into the cycle leg). At station 4 (175 km in the cycle leg and about 61% of the total time) the RPE of the FASTER group was significantly lower than the ACCURATE and SLOWER groups.

Table 3.9 RPE scores for the FASTER, SLOWER and ACCURATE groups during the Ironman Triathlon

The % in brackets next to the station represents the approximate duration (see Table 3.3)

RPE	**FASTER** (n = 16)	**SLOWER** (n = 85)	**ACCURATE** (n = 16)	P
Station 1 (6%)	8 ± 5	9 ± 4	10 ± 4	0.88
Station 2 (27%)	7 ± 4	11 ± 4	11 ± 5	0.06
Station 3 (44%)	12 ± 3	13 ± 3	13 ± 1	0.81
Station 4 (61%)	11 ± 3[#]	14 ± 3	15 ± 1	0.02
Station 5 (67%)	13 ± 3	14 ± 3	14 ± 2	0.64
Station 6 (80%)	14 ± 2	14 ± 3	14 ± 3	0.66
Station 7 (91%)	15 ± 2	15 ± 3	16 ± 2	0.84

# $P < 0.05$ FASTER less than ACCURATE, and FASTER less than SLOWER

The Pain scores for during the Ironman for the three groups are shown in Table 2.10. The FASTER group had less pain than the other groups ($P < 0.05$) at Station 2 which coincided with the 55 km into the cycle leg (about 27% of the time for the entire race).

Table 3.10. Pain scores for the FASTER, SLOWER and ACCURATE groups during the Ironman Triathlon

PAIN	**FASTER** (n = 16)	**SLOWER** (n = 85)	**ACCURATE** (n = 16)	P
Station 1 (6%)	2 ± 2	2 ± 2	4 ± 3	0.17
Station 2 (27%)	1 ± 1#	3 ± 2	4 ± 3	0.008
Station 3 (44%)	5 ± 2	5 ± 2	4 ± 2	0.90
Station 4 (61%)	5 ± 2	5 ± 2	6 ± 3	0.70
Station 5 (67%)	5 ± 2	5 ± 2	6 ± 2	0.17
Station 6 (80%)	6 ± 2	6 ± 2	7 ± 1	0.87
Station 7 (91%)	8 ± 1	7 ± 2	7 ± 2	0.27

# $P < 0.05$ FASTER less than SLOWER, and FASTER less than ACCURATE

Figure 3.4 shows the pain scores on a daily basis for each day after the race and then on a weekly basis for 7 weeks. For the first 7 days the pain scores were significantly lower each day after the race (compared to the preceding days score). At 28 days the pain score was significantly higher than the score at 21 days ($P < 0.05$). There were no differences between groups. Some of the triathletes started training and competing in other races in as short as 2 weeks after the Ironman. Some triathletes indicated that they started racing after approximately 2 weeks after the Ironman Triathlon.

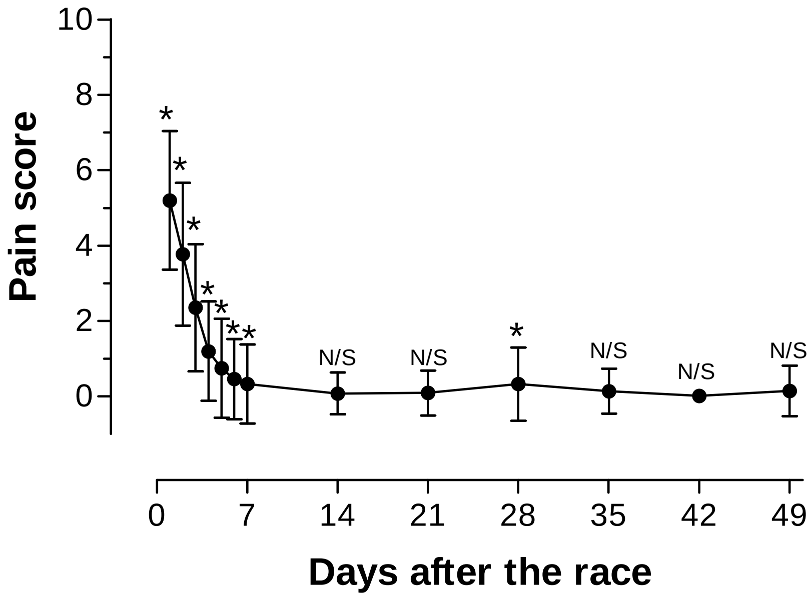

*Figure 3.4. Pain score for 7 consecutive days after the race and then weekly scores thereafter for 7 weeks. The * indicates a significant difference to the preceding score*

DISCUSSION

The first main finding was that, as expected, the triathletes got progressively more tired and pain scores increased as the race progressed. There were subtle differences between the 3 groups (Figure 3.2) but these were not particularly remarkable. It has been shown previously that the rate at which the RPE increased could serve as a marker of the time left to exhaustion during exercise at a constant workload (Noakes, 2004). According to this theory, at the onset of exercise, the subconscious brain calculates on the basis of some carbohydrate signal the anticipated duration of the exercise that can be safely sustained without causing whole body energy depletion. The brain centre responsible for the generation of the RPE, anticipates the maximal RPE that the individual will tolerate, and then increases the RPE in relation to the total exercise time that has been completed, or the percentage of time that remains (Noakes , 2004). A study by St Clair Gibson, (2001) supports this finding. Using a closed loop design (100 km time trial, interspersed with 1 km and 4 km sprints), these authors found that neuromuscular activity in the peripheral skeletal muscles (as assessed by integrated electromyogram) decreased in parallel with the reduced power output during the 1 km and 4 km sprints (St Clair Gibson et al., 2001). This study provided evidence that a central neural governing command might exist to reduce the active muscle recruited during prolonged endurance exercise, in accordance with the task at hand (i.e. a closed loop system) together with afferent feedback from metabolic processes. The low coefficient of variation found in other closed loop design studies (Hopkins et al., 2001) further supports the importance placed on ‘‘knowing the expected outcome’’ by a central programmer (i.e. the brain). A study by Baden et al. (2005), showed that physiological demands of a running task did not change at the same stage as which changes in RPE was observed. This supports Borg’s statement that RPE is not only an indicator of physical strain, but that cognitive and psychological processes are involved as well and also emphasises the concept of "knowing the expected outcome" before the event starts. Peeling et al. (2005) showed that subjects who completed the 1500 m swim leg of the triathlon in a slower time than their maximal ability, perceived their physical status as more comfortable (as measured by RPE), during the swim-cycle combination. In this case it might be that the brain was anticipating the maximal intensity of exercise (the maximal intensity that the athlete was able to maintain in a previous maximal time trial attempt) and when the intensity was much lower, the athlete perceived the effort in the swim-cycle combination as much easier. These findings can also explain the increased RPE towards the end of the Ironman, as it was also a “closed loop system”, (the athletes knew exactly the distance that they had to swim, cycle and run). In a study by Morgan and Borg (1976) in which RPE was measured during progressive maximal exercise to exhaustion for measurement of $VO_{2\ max}$, it was reported that the rating of perceived exertion was found to increase in a linear fashion as work intensity increased. The linear function permits extrapolation to a theoretical end point, which in turn makes possible the prediction of maximal work capacity. Thus, it was shown in 1976 already that the RPE is a good predictor of the point at which an individual will discontinue work. The finding by Hortsman et al. (1979), which shows that the RPE increases as a linear function of the duration of exercise that remains, even when the exercise intensity is unchanged, suggests that humans have the capacity to accurately predict the duration of exercise they will be able to sustain at any exercise intensity. This linear relationship between duration of exercise and RPE correlates with the findings in our present study. At station 2 (the first cycling station), the RPE of the FASTER group was marginally lower than the RPE of the SLOWER group ($P < 0.06$) and at station 4 (the 3rd and last cycling station), the RPE was also lower than in the ACCURATE group. Also, the pain of the FASTER group was lower than the ACCURATE and SLOWER groups at station 2 ($P < 0.06$) . However, at 5 out of the 7 stations, there were no significant differences between the groups. The statistical analysis suggests that Ironman triathletes who predicted their performance better, had a lower perception of effort and experienced less pain during the race, compared to athletes who did not predict their Ironman times accurately, However, it is debatable whether these subtle changes are really meaningful, considering the precision of measurement of both RPE and muscle pain.

The second main finding of this study was that triathletes who actually trained less (measured by duration), performed better in the Ironman. The FASTER group (i.e. those subjects that had a race time which was faster than predicted) trained less days per week than the SLOWER group (i.e. subjects who had a race time which was slower than expected) and the ACCURATE group (i.e. those subjects that had finishing time which was close to their predicted finishing time). Furthermore, the group FASTER trained less hours and distance for running compared to the ACCURATE group. It should be clarified however that in the study, the athletes' training programs were examined in the questionnaires (i.e. self-reported data), whereas the split and total times were recorded from the Ironman website after the race.

This finding is supported by Gulbin and Gaffney (1999), who found that less training was required for non-elite competitors to finish an Ironman than had been previously reported. They studied lower level or non-elite triathletes who competed in the 1995 Lanzarote Ironman and asked them to complete a retrospective questionnaire related to their athletic background, triathlon experience and performances, and training preparation. The questionnaires for the Lanzarote Ironman study and the current study were designed differently and therefore the training histories of the triathletes in the different races cannot be compared directly. However, the data of Gulbin and Gaffney (1999) should be interpreted with caution. It stands to reason that there is an optimal training volume and intensity for maximal performance for each individual.

This optimal training protocol is very individualistic and each individual will have a different protocol to which he/she responds to optimally (Bouchard and Rankinen, 2001). This is supported by a study of triathletes which showed that training distances varied for swimming, cycling and running (O'Toole, 1989). For example, peak weekly swim distances ranged from 1.7 to 34.0 km, with an average weekly distance of 12.2 km. Peak weekly cycling distances ranged from 26 to 740 km with an average of 386 km. Run distances ranged from 7 to 179 km per week with an average of 77 km per week. The training distances of the subjects in the current study were all within the above ranges reported in this study (O'Toole, 1989). Long term performance enhancement requires training loads of sufficient intensity and duration to progressively overload and stress the physiological structures and processes that determine performance (Midgley et al., 2006). Unfortunately, the questionnaire for this study did not inquire about multi-block training, but a study by Hue et al. (2002) showed that multi-block training improves the neuromuscular adaptation from cycling to running, as well as the technical adaptation to the next phase. It might be possible that the athletes who did do multi-block training adapted better to the next discipline and therefore perceived the pain and RPE as lower. This however, is only an assumption and needs to be investigated with further research.

The effects of manipulating training intensity and duration to elicit adaptation to enhance particular physiological determinants of performance have been considered for over 30 years (Pollock, 1973). VO_{2max} has been considered as an important physiological determinant of middle and long distance running performance (Brandon, 1995), and this can play a role in the triathletes running performance, and consequently in the overall performance, in the Ironman triathlon. There appears to be little information in the scientific literature relating to the most effective training intensity for the enhancement of VO_{2max} (Midgley et al., 2006). Several authors have suggested that intensity is the most important training variable that can be manipulated for eliciting the training induced enhancement of VO_{2max} (Fox et al., 1973), although the total work performed has also been considered important (Pollock, 1973). Support for the premise that training at or near VO_{2max} is the optimal intensity for its enhancement comes from a review of 59 training studies in which it was concluded that the degree of the enhancement in VO_{2max} was positively related to training intensity in the range of 50% - 100% VO_{2max}. This relationship existed almost irrespective of training frequency and duration, program length and initial VO_{2max} (Wenger and Bell, 1986). This finding could also explain the results in our current study, that the triathletes who trained less hours and days, maybe trained at a higher intensity, maximising their training, compared to the triathletes who trained more days and hours, but maybe at a lower intensity. This however is only speculation as the questionnaire in the current study was not designed to measure training intensity, only training volume and the above statement therefore cannot be proven from our results.

Chapman et al. (2008), found that there was a difference in muscle recruitment between trained and less trained cyclists and to a lesser extend in trained and less trained runners. The triathletes in the study were elite athletes who had had experience at Australian national or international-level competition or had qualified for Triathlon World Championship representation in the year of testing. This is in contrast with the current study, where triathletes did not necessarily compete at national or international level, but only had to have entered and completed the 2006 South-African Ironman competition to be eligible for the study. In the study of Chapman et al. (2008) the single sports of cycling and running were compared to multi discipline training. The differences in muscle recruitment between trained and less-trained runners were of less magnitude than the differences between trained cyclists and less-trained cyclists. The study also showed less skilled muscle recruitment (i.e., the ability of the neuromuscular system to adapt to training), by multidisciplinary athletes, compared with single sport athletes (i.e. cyclists or runners). These findings provide evidence that muscle activity becomes more skilled in single-discipline athletes as a result of continued training, and also that control of locomotion can be influenced by training (Chapman et al., 2008). From these results, it would be expected that more training would result in more skilled muscle recruitment and activity, and presumably better performance. The triathletes in the Chapman study however, were all competing on national or international level, compared to our study where all athletes who volunteered, entered and completed the 2006 South-African Ironman, were included in the study.

As mentioned earlier, the training was defined as duration, and the intensity of the training was not measured. Another interpretation of the data is that the SLOWER group trained too much, thus overtraining, and influencing their race results negatively (Meeusen et al., 2006). Although over training can influence results negatively, over training was not researched in the current study and therefore it is largely speculative and not proven at all. From the above discussion it is clear that an optimal training program has not been established as yet and further research needs to be done to investigate different training programs.

The third finding was that there were no significant differences between the three groups with regards to muscle pain after the race and during the recovery period (up to 7 weeks). This suggests that the pain in the muscles of subjects in all 3 groups subsided within 7 days after the Ironman. The rate of decrease of pain occurred independently of training duration before the race, or pacing during the race. Although a simplistic interpretation is that muscle pain reflects the state of recovery, these data should be interpreted with caution from a recovery perspective. It is well known that pain is a poor marker of muscle repair (Nosaka et al., 2002). It is also believed that neither muscle soreness nor the plasma serum level of muscle enzymes accurately reflects the extent of muscle damage (Warren et al., 1999). According to Warhol et al. (1987) muscle regeneration was not complete after 12 weeks after a marathon. After the Ironman the pain had subsided by day four. Assuming that the degree of muscle damage was at least as severe after the Ironman, compared to the marathon (Warhol et. al., 1987), then it must be concluded that muscle regeneration cannot be tracked accurately by symptoms of pain. Other studies have reported changes in markers of muscle damage after long distance triathlon races (Farber et al., 1991; Margaritis et al., 1999). Prolonged, strenuous endurance exercise induces muscle damage and impairs muscle function. Skeletal muscle is able to repair itself and adapt, but there may, however, be a limit to its regenerative capacity and adaptability, resulting in an accumulation of chronic skeletal muscle pathology (Grobler et al., 2004). Measures of muscle function such as strength and power may provide the most effective method for assessing the degree of muscle damage (Warren et al., 1999). In addition to the decrease in muscular strength, Suzuki et al. (2006) also found that squat and countermovement jump height decreased after the race, and the decrease in squat jump height was greater than that of the countermovement jump. Impaired jump performance may be due to factors such as reduced force and electromyographic activity, stretch-reflex sensitivity, muscle and joint stiffness (Byrne et al., 2004).

Some triathletes started training and competing in other races after 2 weeks of the Ironman. These triathletes probably used their pain as an indicator to start training and racing again, and as seen from the above mentioned facts, pain is not an accurate indicator of muscle regeneration and recovery (Warren et al., 1999), and that muscles take up to 12 weeks to regenerate (Warhol et al., 1987). This premature return to training and competition may contribute to chronic skeletal muscle damage and impaired training and racing performance in endurance athletes with a history of high volume endurance training and racing (Grobler et al., 2004). An increase in skeletal muscle pathology and training intolerance in endurance athletes were also established (Grobler et al., 2004). The fact that some of the triathletes started training and competing after only a 2 weeks after completing the Ironman, can also explain the occasional upwards spikes in pain scores in the 7 weeks after the race (Figure 3.3).

With regards to the rate of tapering, no differences between the groups were found, and therefore it is not a confounding factor. No further discussion in this regard is necessary.

In conclusion, our study shows that the triathletes who trained less days and hours performed better and perceived their effort as less during the race, compared to the triathletes who trained more days and hours. One interpretation is that the "less trained" group trained at higher intensities than the "higher trained" group or maybe made use of multi-block training, however this cannot be confirmed from the data in this study. The RPE increased as a linear function of the progress in the race, which is accordance with the "central governor" theory of regulation and could be explained by the triathletes anticipating the end of the race. The changes in training and pacing strategies during the race did not affect muscle pain or recovery after the race. Most of the participants resumed training within 2 weeks of the Ironman.

CHAPTER 4

SUMMARY AND CONCLUSIONS

Introduction

Triathlon comprises of swimming, cycling and running. The three activities combined have different physiological demands compared to the single sports. It is possible that these different physiological characteristics of the triathlon may make some athletes more suited to compete in triathlons, compared to single discipline sports (O'Toole and Douglas, 1995). It has also been suggested that these physiological characteristics required to meet the demands of the triathlon can be acquired with training (Millet et al., 2000).

Predicting performance

No studies could be found investigating the athletes' ability to predict their Ironman performance. Only laboratory studies were found, and these were only done on sprint and Olympic distance triathlon. Findings from the current study regarding prediction of performance will be incorporated with the rest of the findings in the discussion below.

Training

There is a lack of existing data quantifying athletic performance and training load as well as intra-individual differences in the effect of exercise training on physical fitness (Bouchard and Rankinen, 2001). Furthermore, Gratze et al. (2005) hypothesised that for each individual, there could be a narrow range of an appropriate level of training, for any given training state.

From the study, we concluded that for the 2006 Ironman South-Africa, the group FASTER (>1%), trained less days per week than the SLOWER (<1%) and ACCURATE (within 1%) groups. Also, the group FASTER trained less hours and distance for running compared to the group ACCURATE. It seems that athletes who trained less, actually performed better than athletes who trained more. This is supported by the findings of Gulbin and Gaffney (1999), who found that less training is required for non-elite competitors to finish an Ironman than has been previously reported. However, these data should not be interpreted as meaning that athletes should under train. A more prudent interpretation is that there is an optimal training volume and intensity for maximal performance for each individual. Training above or below this volume will not be associated with best performances.

RPE and pain

Borg stated that the RPE is the "*single best indicator of physical strain*" and that the perceived exertion rating "*integrates various information, including the many signals elicited from the peripheral working muscles and joints, from the central cardiovascular and respiratory functions, and from the central nervous system*" (Borg, 1982). RPE is not merely an indicator of physical strain, but also incorporates cognitive and psychological processes, and may be influenced by the subject's knowledge or expectations of task duration (Borg, 1982). Previous memory of fatigue will allow one to estimate one's reserves and tolerance levels, and allow decision-making to occur about whether to continue, reduce activity or halt the physical activity (St Clair Gibson et al., 2003). Studies have also shown that expectations of task duration and anticipation of an end point influence subjective ratings of perceived exertion (Rejeske and Ribisl, 1980).

The current study shows that RPE and pain during the Ironman triathlon increased gradually as the race progressed and as the athletes got progressively tired during the race. At one station, the FASTER group's RPE was lower than the SLOWER group and at another station the RPE was also lower in the ACCURATE group. Also, the pain in the FASTER group was lower than the pain of the ACCURATE and SLOWER groups at yet another station. This might indicate that athletes who were better prepared for the race and performed even better than they predicted, experienced less pain during the race and their perception of effort was also lower.

Recovery

Endurance training and racing causes acute and chronic changes and therefore the athlete needs a period of recovery from this damage and changes. It has been suggested that adaptations associated with endurance training should enhance recovery from high intensity intermittent exercise (Thoden, 1991), but again, there is a wide range in recovery after an endurance event (Chambers et al., 1998).

When examining the recovery (level of pain) after the race, the current study shows no significant differences between the three groups. Therefore, it may be concluded that all 3 groups recovered similarly after the Ironman, certainly if the absence of pain was used as a marker for recovery. Most athletes started training about a week after the Ironman and some started competing in races soon after that. Whilst this may suggest they had recovered sufficiently, another interpretation is that they had insufficient rest after the race which may eventually contribute to symptoms of maladaptation. This is based on the fact that there are signs of regeneration up to 12 weeks after a marathon (Warhol, 1987).

For future studies, it is suggested that a smaller, more elite group of triathletes will be used. Elite athletes keep more accurate records of their training programmes, which might improve the accuracy of the data and results. The researches might also want to make use of muscle biopsies and blood tests to investigate recovery more accurately, rather than using subjective pain scales.

Further research needs to be done with factors associated with the athlete's ability to predict split and overall Ironman times accurately, as this is a field of very little previous research.

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APPENDICES

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2006 IRONMAN – MEDICAL AND TRAINING QUESTIONNAIRES

These questionnaires have been constructed by the Medical Research team, in conjunction with the Medical Director of the Ironman 2006. The information obtained from these questionnaires is essential for the planning of medical care during events such as the Ironman 2006. We acknowledge that the questionnaires are long, but we are asking about 20 minutes of your valuable time to complete them. The completion of the questionnaires is voluntary, all the information will be kept confidential and will only be used for research and medical care planning purposes. We suggest that you consider completing this before the event, or at the time of registration.

Prof Martin Schwellnus (Chairman, Research Team)

Dr Peter Schwartz (Medical Director, Ironman 2006)

Instructions

You can either complete the questionnaires electronically using Microsoft word or print the questionnaires and complete them manually. Please answer each question by filling in the details in the allocated space or checking one or more of the option boxes.

If you complete the questionnaire electronically using Microsoft word, please e-mail the completed forms to ironman@sports.uct.ac.za and bring the signed consent form to the research table at race registration.

If you complete the questionnaire manually, please bring the completed forms together with the signed consent form to the research table at race registration.

Please complete sections A, B, C, D and E

Section A	Personal Details	Page 2
Section B	Racing, Training and Equipment Use History	Pages 3-5

Section A: Personal details

2006 Ironman Race Number				
Surname				
First Name				
		Postal/ Zip Code		
E-mail address		Phone (day time)	code	number
Date of birth	yyyy-mm-dd	Cell		
Height	cm	Gender	Male ☐	Female ☐
Weight	kg	Age		
	Black/African ☐	White ☐	Indian ☐	
	Mixed Ancestry (Coloured) ☐	Asian ☐	Other ☐	
	Father:		Unknown ☐	
	Mother:		Unknown ☐	
Country of Birth				
Dominant Hand	Left ☐ Right ☐ Both ☐	Dominant Leg	Left ☐ Right ☐ Both ☐	
Occupation				
What **percentage** of your **working** day is spent in the following activities?	Sitting: _____ % Standing: _____ %			

	Walking (Lower body activity) _____ % Manual Labour (upper and body activity) _____ %

Section B. Racing and training history

Type of triathlon	**Sprint**	**Standard (1.6, 40, 10)**	**½ Ironman**	**Ironman**
Which triathlons have you **<u>ever</u>** participated in?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Year of first event				
How many events have you **<u>ever</u>** participated in?				
How many Olympic (or above) triathlon races have you completed over the **past 2 years**?				
Personal best time **<u>ever</u>**	_____ hrs:min	_____ hrs:min	_____ hrs:min	_____ hrs:min
What was your time for your last triathlon race during the **past 12 months**?	_____ hrs:min	_____ hrs:min	_____ hrs:min	_____ hrs:min
Type of running event	**5 km**	**10 km**	**21.1 km**	**42.2 km**
Which races have you **<u>ever</u>** participated in?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Year of first event				
How many events have you **<u>ever</u>** participated in?				
Personal best time **<u>ever</u>**	_____ hrs:min	_____ hrs:min	_____ hrs:min	_____ hrs:min
What is your best time, in a running race, in the **last 15 weeks**?	_____ hrs:min	_____ hrs:min	_____ hrs:min	_____ hrs:min
Type of event	**Two Oceans Marathon**	**Comrades Marathon**		
Which races have you **<u>ever</u>** participated in?	Yes ☐ No ☐	Yes ☐ No ☐		
Year of first event				
How many events have you **<u>ever</u>** participated in?				
Personal best time	_____ hrs:min	_____ hrs:min		
What is your best average cycling speed (km/h) in a race over 80 km in the **last 15 weeks**?		Average speed: _____ km/h; Distance: _____ km		

What is your best swimming performance in the **last 15 weeks**?	Time: _____ min Distance: _____ m
What is your predicted time for the entire 2006 Ironman event and each of the three splits?	Entire event: _____ min Swim: _____ min Cycle: _____ min Run: _____ min

Please answer the following questions, with your answers reflecting your average in the **most recent 15 weeks i.e. beginning December 2005 to 18th March, 2006.**	
How many days a week did you train during the **last 15 weeks**?	days/week
What distances did you train in an average week during the **last 15 weeks**?	Swim: _____ km/week Cycle: _____ km/week Run: _____ km/week
How many hours a week did you train in an average week during the **last 15 weeks**?	Swim: _____ hrs/week Cycle: _____ hrs/week Run: _____ hrs/week
What **distances** did you train in the week before the race?	Swim: _____ km Cycle: _____ km Run: _____ km
How many **hours** did you train in the **week before** the race?	Swim: _____ hours Cycle: _____ hours Run: _____ hours

Flexibility training history

Do you perform flexibility training (stretching exercises)?	Yes ☐ No ☐
If YES, please complete the rest of the flexibility training history section below:-	
If NO, continue completing the questionnaire from the top of page 5 (Equipment use history).	
On average, how many days a week do you perform a stretching session?	days/week
On average, how times a day do you perform a stretching session?	times/day
Please tick which muscle groups do you include in your stretching session?	☐ Hamstrings ☐ Quadriceps ☐ Calf (gastrocnemius)

	☐ Calf (soleus) ☐ Groin (inner thigh) ☐ Upper body limbs ☐ Other: ____________________
Please tick when you stretch? (before, during and/or after exercising. You can tick more than one box)	☐ Before Exercise ☐ During Exercise ☐ After Exercise
When you stretch an individual muscle group, on average, **how long do you hold the stretch** for?	seconds
When you stretch an individual muscle group, on average, **how many times do you stretch the muscle for**?	☐ Once ☐ Twice ☐ 3 times ☐ 4 times ☐ 5 times ☐ 6 or more times

Equipment use history	
Please indicate which type of **bicycle** you use?	☐ Kuota ☐ Kestrel ☐ Trek ☐ Aegis ☐ Litespeed ☐ Softride ☐ Felt ☐ Quintana Roo ☐ Javelin ☐ Cervelo ☐ Argon 18 ☐ Scott

	☐ Elite ☐ Specialized ☐ Guru ☐ Giant ☐ Other: ______________________
Please indicate which type of **handle bars** you use?	☐ Bontrager ☐ HED ☐ Zipp ☐ Profile Design ☐ Vision Tech ☐ Oval Concepts ☐ Deda ☐ Easton ☐ Syntace ☐ Pedalsoft ☐ Kestrel ☐ Other: ______________________
Please indicate which type of **saddle** (Brand - model) you use?	☐ Selle San Marco- Azoto TriathGel ☐ Profile Design- Tri Stryke (with a groove) ☐ Selle San Marco- Rever Profil ☐ Fizik- Arione Tri ☐ Terry ☐ Koobi ☐ Other: ______________________
Please indicate which brand of **helmet** you use?	☐ Trek ☐ Bell ☐ Giro ☐ MET ☐ Other: ______________________
Please indicate which type of **cycling shorts** you use?	☐ Thin lycra (no padding) ☐ Padded cycling shorts ☐ Triathlon shorts with some padding ☐ Swimming costume ☐ Other: ______________________
Do you normally wear **underwear** together with cycling shorts?	☐ Yes ☐ No

Please indicate which type of **cycling shoes** you use?	☐ Olympic ☐ Nike ☐ Diadora ☐ Shimano ☐ Carnac ☐ Sidi ☐ Other: ______________________
Please indicate which type of **kit** you use?	☐ Anatomic ☐ Nike ☐ Velo ☐ Howzit ☐ Adidas ☐ Orca ☐ De Soto ☐ Louis Garneau ☐ Quintana Roo ☐ Zoot ☐ Other: ______________________
Please indicate which **brand of running shoe** you use?	☐ Adidas ☐ Asics ☐ Brooks ☐ New Balance ☐ Nike ☐ Mizuno ☐ Puma ☐ Reebok ☐ Saucony ☐ Other: ______________________
Please indicate which **type of running shoe** you use?	☐ Soft neutral shoe ☐ Mild anti-pronation shoe ☐ Motion control shoe ☐ Light racing shoe ☐ Unknown or not sure ☐ Other: ______________________

Section C. History of medication and supplement use

	Name of medication		Years taken
	☐ ☐	☐ Every session	☐ Most sessions
		☐ Some sessions	☐ Very occasionally
Are you currently taking dietary supplements/vitamins?			Yes ☐ No ☐
	Name of supplement		Years taken

	☐ Multi-vitamins ______ ☐ Anti-oxidants ______ ☐ Immune boosters ______ ☐ Protein powders/supplements, Protein bars. BCAAs ______ ☐ Creatine ______ ☐ Caffeine ______ ☐ Fat cutters ______ ☐ Carbohydrate drinks/powders/gels ______ ☐ Other: ______________________________ ______		
	☐ ☐	☐ 3 months	☐ 6 months
		☐ 12 months	☐ 24 or more months
	☐ ☐	☐ 3 months	☐ 6 months
		☐ 12 months	☐ 24 or more months
	☐ ☐	☐ Once	☐ Twice
		☐ 3 times	☐ >3 times
	☐ ☐	☐ 3 months	☐ 6 months
		☐ 12 months	☐ 24 or more months

List of some fluoroquinoline antibiotics:

ADCO-CIPRIN	CIPROBAY	SANDOZ CIPROFLOXACIN
AVELON	CIPROGEN	TAFLOC
BACTIDRON	CPL ALLIANCE CIPROFLOXACIN	TARIVID
CIFLOC	DYNAFLOC	TAVANIC
CIFRAN	FACTIVE	TEQUIN
CIPLA-CIPROFLOXACIN	FLOXIN	UNIQUIN
CIPLOXX	MAXAQUIN	UTIN-400
CIPRO-HEXAL	NOROXIN	ZANOCIN

	ORPIC	

Lifestyle and habits history

Please indicate your smoking status	Current smoker ☐	Ex smoker ☐	Never smoked ☐
	Number of years of smoking:	If stopped, how many years ago:	
	What is (was) the average number of cigarettes per day:		
On average, how much alcohol do you drink per week (tots, glasses) of spirits, wine or beer?		_______ glasses beer/cider per week _______ glasses wine per week _______ tots of spirits per week	

Fluid Intake

How do you best describe your fluid intake during an Ironman triathlon race?	(a) I drink to thirst ☐ (b) I drink as much as tolerable ☐ (c) I drink according to a predetermined fluid intake schedule ☐ (d) I drink to prevent any weight loss during exercise ☐ (e) I combine (a) with (c) ☐ (f) I combine (b) with (c) ☐ (g) Other: ______________________________ ☐
What percentage of your fluid intake will consist of these beverages?	Water: ☐ 0-25% ☐ 26-50% ☐ 51-75% ☐ 76-100% Sports drink: ☐ 0-25% ☐ 26-50% ☐ 51-

	75% ☐ 76-100% Coke: ☐ 0-25% ☐ 26-51% ☐ 51-75% ☐ 76-100% Other: ☐ 0-25% ☐ 26-50% ☐ 51-75% ☐ 76-100% Specify other: ______________________________
What will be your estimated **total** fluid intake be **(if at all)** during the **swim**?	ml
What will be your estimated **total** fluid intake be during the **cycle**?	ml
What will be your estimated **total** fluid intake be during the **run**?	ml
Rank the following sources of information on their importance in formulating your drinking strategy. (1 being most influential and the lowest number being least influential)	_____ Fellow triathletes _____ Coach / trainer _____ Magazines / books _____ Website (please specify: ______________________________) _____ Drinking guidelines from sports associations _____ Adverts _____ Self-experimentation _____ Other: ______________________________

Section D. Family medical history

Have any of your blood (biological) relatives ever had the following?

Please tick yes or no. If yes, please tick the relationship of that person to you (You may tick more than one of the relationship blocks).

Description		**If Yes, please indicate the relationship**
Exercise associated muscle cramps	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother

		☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother
Night muscle cramps	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother
Chronic Achilles tendon injury	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother
Achilles tendon rupture	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother
Any ligament injury	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother
Asthma	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother
Allergies (in general)	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother
Heart Disease	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother

		☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother
Diabetes	Yes ☐ No ☐	☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Child ☐ Grandfather ☐ Grandmother

Section E. Personal general medical history

In this section, you are asked to read through 14 questions about your personal general medical history. If you answer "yes" to any of questions 1 to 12, please complete the additional questions at the end of the section (section F on page 11).

1. In the **6 weeks before this race** (from 1st February) did you suffer from any **symptoms of flu** (fever, sore throat, blocked or runny nose, cough, wheeze, muscle aches and pains)?	Yes ☐ No ☐
2. Have you **ever** in triathlon career suffered from **muscle cramping** during or immediately (within 6 hours) after exercise (in training or competition)?	Yes ☐ No ☐
3. Have you **ever** in your triathlon career suffered from **a tendon or ligament injury** (pain, swelling, stiffness) in any tendon (including Achilles tendon, knee tendons, and shoulder tendons) or ligaments (partial or complete tear)?	Yes ☐ No ☐
4. Have you **ever** in your triathlon career **used medicines to treat injuries** in the week **before or during a race** – including anti-inflammatory drugs, cortisone (pills, or injection), or pain killers?	Yes ☐ No ☐
5. Have you **ever** in your triathlon career suffered **gastrointestinal** symptoms **during exercise** including heartburn, nausea, vomiting, abdominal pain, urge to defecate (pass a stool), diarrhoea, or blood in the stools?	Yes ☐ No ☐
6. Have you **ever** in your triathlon career suffered from symptoms of the **nervous system** including exercise induced headaches, nerve tingling or loss of sensation?	Yes ☐ No ☐
7. Have you **ever** in your triathlon or cycling career (in particular with **cycling**) suffered from **injury to the genital area** including genital numbness after cycling, genital pain after cycling, genital swelling or altered sexual	Yes ☐ No ☐

function after cycling?	
8. Have you **<u>ever</u>** in your triathlon career suffered from **<u>symptoms of allergies</u>** including nose allergies (hay fever), allergic sinusitis, allergic asthma, skin allergies, a past history of allergies to medication, plant material or animal material?	Yes ☐ No ☐
9. Do you **<u>currently suffer from asthma</u>** including exercise induced asthma, or symptoms of asthma such as shortness of breath, wheezing, or chronic coughing?	Yes ☐ No ☐
10. Have you ever **collapsed** (fell down **not because of an accident,** needing medical attention) during, at the finish or after a race or training session?	Yes ☐ No ☐
11. Do you **<u>currently</u>** suffer from any **<u>symptoms of injury</u>** in the muscles, tendons, bones, ligaments or joints?	Yes ☐ No ☐
12. Do you **<u>currently</u>**, or did you **<u>in the last year</u>**, suffer from any symptoms of **<u>exercise related skin disease</u>**?	Sunburn: Yes ☐ No ☐ Skin cancer: Yes ☐ No ☐ Other skin damage resulting sun exposure: Yes ☐ No ☐
13. Please tick in which anatomical area you ever had **<u>surgery</u>** performed.	☐ Head ☐ Finger ☐ Neck ☐ Lower back ☐ Face ☐ Hip ☐ Front chest ☐ Thigh ☐ Back chest ☐ Knee ☐ Shoulder ☐ Lower leg ☐ Upper arm ☐ Achilles ☐ Elbow ☐ Ankle ☐ Forearm ☐ Foot ☐ Wrist ☐ Abdomen ☐ Other (Specify: ______________________)
14. **Female athletes only:** Please complete the following questions (14a. to 14g.) related to your menstrual cycle and other gynaecological history	
14a. At what age did you start your periods (menstruating)?	(years)
14b. <u>In the last 12 months</u>, how many menstrual cycles did you have?	

14c. Have you ever had irregular menstrual periods in the past? (excluding pregnancy)?	Yes ☐ No ☐
14d. Have you had a hysterectomy/ovarectomy?	Yes ☐ No ☐
14e. How many times have you been pregnant?	(times)
14f. What form of contraception are you currently using?	☐ None ☐ Oral contraceptive pill ☐ Injection ☐ Intra-uterine device ☐ Sterilization (tubes tied) ☐ Other: ____________
14g. If yes to question 14f. above, for oral contraceptive pill, for what reason was the pill prescribed?	☐ Not applicable ☐ Dermatological ☐ Contraception ☐ Regulate period ☐ Other: ____________

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

If you have answered **YES** to any of the first 11 questions of the Personal General Medical History questionnaire (section E) please complete the relevant additional questions that follow in section F.

If you have completed the questionnaire manually, please bring the completed forms together with the signed consent form to the research table at race registration.

If you have completed the questionnaire electronically using Microsoft word, please e-mail the completed forms to ironman@sports.uct.ac.za and bring the signed consent form to the research table at race registration.

Section F. Additional detailed medical history

(Please complete all the sections to which you answered "Yes" in the Personal general medical history)

1. Flu symptoms in the last 6 weeks

If you answered **YES** to **question 1** in section E, please complete the following two questions related to flu symptoms in the last 6 weeks.

(1a) Please tick which of these flu symptoms you suffered from **in the last 6 weeks**.	☐ Fever ☐ Cough ☐ Joint pains ☐ Blocked nose ☐ Wheezing ☐ Runny nose ☐ Muscle aches ☐ Any other flu symptoms (Specify: ______________________________)
(1b) Please tick which of these flu symptoms you suffered from **in the last 7 days**.	☐ Fever ☐ Cough ☐ Joint pains ☐ Blocked nose ☐ Wheezing ☐ Runny nose ☐ Muscle aches ☐ Any other flu symptoms (Specify: ______________________________)

2. Muscle cramping

If you answered **YES** to **question 2** in section E, please complete the following questions (2a. to 2m.) related to your cramping.

(2a) For how many years have you suffered from cramping?	(years)
(2b) Did you suffer from cramping during or after exercise in the **last 12 months**?	Yes ☐ No ☐
(2c) With what **type of exercise** is your cramping associated (You can tick more than one form of exercise)?	☐ Swimming ☐ Cycling ☐ Running
(2d) In the **last 10 races or training sessions**, how many times have you experienced cramping?	Races: _____/10 Training sessions: _____/10
(2e) What treatment/s have you had that **successfully relieved** an acute cramp? (can tick more than one)	☐ Stretching ☐ Resting ☐ Drinking fluid ☐ Ice application ☐ Massage ☐ Magnesium ☐ Salt (tablets or solution) ☐ Other (Specify: ______________________________)
(2f) At **what point in the race or training run** do you	☐ First quarter ☐ Second quarter

usually first experience cramping?	☐ Third quarter ☐ Fourth quarter ☐ After the race ☐ No pattern
(2g) In which **muscles** do you usually cramp (please list the muscle by the one which cramps most frequently (as 1) and the others after that (2-4)?	☐ Calves ☐ Hamstrings ☐ Quadriceps (thigh) ☐ Foot muscles ☐ Other (Specify: ______________________________)
(2h) Have you **ever** suffered from cramping in your **whole body** (arms and legs)?	Yes ☐ No ☐
(2i) Have you **ever** been **admitted to hospital** following cramping?	Yes ☐ No ☐
(2j) Have you **ever** been **confused or in a coma** during or after a cramping episode?	Yes ☐ No ☐
(2k) Have you ever had **"dark urine"** in the 3 days following a cramping episode?	Yes ☐ No ☐
(2l) If you cramp, **how long** does the cramp usually last for (min)?	(minutes)
(2m) If you cramp, how **severe** is the cramp usually? (please tick).	☐ Mild: < 5 minutes and you are able to continue exercising ☐ Moderate: 5-15 minutes and you are able to continue exercising ☐ Severe: >15 minutes or if you have to STOP exercising

3. Past Tendon and Ligament Injury History

If you answered **YES** to **question 3** in section E, please complete the following questions (3a. to 3d.) related to your past history of tendon/ligament injury/ies.

		Tendon	**Longstanding Pain (Tendionapthy)**	**Acute Tear/ Rupture**
	Foot and ankle:	☐ **Achilles tendon**	☐	☐
		☐ **Tibialis posterior**	☐	☐
		☐ **Plantar fascia**	☐	☐
	Knee:	☐ Patellar tendon	☐	☐
	Elbow and wrist:	☐ **Wrist extensor tendon**	☐	☐

	Shoulder:	☐ **Rotator cuff**	☐	☐
	Other: ______________________________		☐	☐
	Ligament		**Sprain**	**Complete Tear**
	☐ **Shoulder ligaments**		☐	☐
	☐ **Elbow ligaments**		☐	☐
	☐ **Wrist ligaments**		☐	☐
	☐ **Finger ligaments**		☐	☐
	☐ **Knee (ACL)**		☐	☐
	☐ **Knee (MCL)**		☐	☐
	☐ Knee (PCL)		☐	☐
	☐ Knee (LCL)		☐	☐
	☐ Ankle lateral ligaments		☐	☐
	☐ Ankle medial ligaments		☐	☐
	☐ Spinal ligaments		☐	☐
	☐ **Other:** ______________________________			
(3c) Please tick if you have you ever suffered from any of the following **joint capsule** injuries?	☐ Acute shoulder dislocation ☐ Chronic shoulder instability ☐ Other: ______________________________			
(3d) Do you suffer from any other **connective tissue or rheumatological diseases** or disorders? (If yes, please specify which one)	Yes ☐ No ☐ (refer to the list on the next page) (If yes, specify: ______________________________)			

List of some Connective Tissue and/or Rheumatic Diseases and Disorders		
Ankylosing Spondylitis	Lipid Storage Diseases	Pseudogout
Aspartylglycosaminuria (AGU)	Marfan Syndrome	Reactive Arthritis

Behcet's Syndrome	Menkes Kinky Hair Syndrome	Reiter's Syndrome
Crohn's Disease	Mucopolysaccharidoses	Relapsing Polychrondritis
Discoid Lupus Erythematosus	Myopathies and Dystrophies	Scleroderma
Ehlers-Danlos syndrome (EDS)	Ochronosis (Homocystinuria)	Sjogren's Syndrome
Eosinophilic Fascitis	Osteogenesis imperfecta (OI)	Systemic Lupus Erythematosus (SLE)
Giant Cell (Temporal) Arthritis	Polyarteritis Nodosa	Systemic Sclerosis
Gout	Polymyalgia Rheumatica	Wegener's Granulomatosis
Hypersentive Vasulatis	Polymyositis & Dermatomyositis	

4. Use of medicines to treat an injury before or during participation

If you answered **YES** to **question 4** in section E, please complete the following two questions related to medicine use for injuries before or during races.

(4a) Which of the following medicines have you used in the past to treat an injury **<u>in the week just before</u>** a race?	☐ Paracetamol (e.g. Panado, Tylenol) ☐ Non-steroidal anti-inflammatories (e.g. Voltaren, Cataflam) ☐ Cortisone (pills) ☐ Cortisone injection ☐ Codeine ☐ Anti-inflammatory gels/creams/patches ☐ Any other pain killers (Specify: ______________________________)
(4b) Which of the following medicines have you used in the past to treat an injury **<u>during a race</u>**?	☐ Paracetamol (e.g. Panado, Tylenol) ☐ Non-steroidal anti-inflammatories (e.g. Voltaren, Cataflam) ☐ Cortisone (pills) ☐ Cortisone injection ☐ Codeine ☐ Anti-inflammatory gels/creams/patches ☐ Any other pain killers (Specify: ______________________________)

5. Gastrointestinal symptoms during exercise

If you answered **YES** to **question 5** in section E, please indicate which gastrointestinal symptoms you have ever suffered from **during exercise** and, how frequently (in the last 12 months and in the last 10 races), and in which type of exercise.

Symptom	Number of times in the last 12 months **(during exercise)**	Number of times in last 10 races **(during races)**	**Tick type of exercise**
Nausea			☐ Swimming, ☐ Cycling, ☐ Running
Vomiting			☐ Swimming, ☐ Cycling, ☐ Running
Heartburn			☐ Swimming, ☐ Cycling, ☐ Running
Abdominal pain			☐ Swimming, ☐ Cycling, ☐ Running
Urge to pass a stool (defecate)			☐ Swimming, ☐ Cycling, ☐ Running
Diarrhoea			☐ Swimming, ☐ Cycling, ☐ Running
Passing blood in the stool			☐ Swimming, ☐ Cycling, ☐ Running

6. Diseases of the nervous system

If you answered **YES** to **question 6** in section E, please indicate which nervous disease symptoms you have ever suffered from **during exercise** and, how frequently (in the last 12 months and in the last 10 races), and in which type of exercise.

Symptom	Number of times in the last 12 months **(during exercise)**	Number of times in last 10 races **(during races)**	**Tick type of exercise**
Headaches			☐ Swimming, ☐ Cycling, ☐ Running
Nerve tingling in the hands			☐ Swimming, ☐ Cycling, ☐ Running
Loss of sensation in the hands			☐ Swimming, ☐ Cycling, ☐ Running

7. Genital tract injury during cycling

If you answered **YES** to **question 7** in section E, please indicate which symptoms of genital tract injury have you suffered from **during or after cycling**, how frequently (in the last 10 sessions), how long symptoms last, and what factors prevent or relieve symptoms?

Symptom	**Number of times in the last 10 cycling sessions**	**Please indicate when the symptoms occur**	**Please indicate if any of the following reduce or prevent the symptoms (can tick more than one)**
Genital numbness		☐ Only during cycling ☐ During and up to 1 hour after cycling ☐ During and 1-24	☐ Changing the saddle type ☐ Changing the saddle position ☐ Using padded cycling shorts

		hours after cycling ☐ During and > 24 hours after cycling	☐ Wearing no underwear ☐ Wearing additional underwear ☐ Other (Specify: ____________________)
Genital pain		☐ Only during cycling ☐ During and up to 1 hour after cycling ☐ During and 1-24 hours after cycling ☐ During and > 24 hours after cycling	☐ Changing the saddle type ☐ Changing the saddle position ☐ Using padded cycling shorts ☐ Wearing no underwear ☐ Wearing additional underwear ☐ Other (Specify: ____________________)
Genital bruising		☐ Only during cycling ☐ During and up to 1 hour after cycling ☐ During and 1-24 hours after cycling ☐ During and > 24 hours after cycling	☐ Changing the saddle type ☐ Changing the saddle position ☐ Using padded cycling shorts ☐ Wearing no underwear ☐ Wearing additional underwear ☐ Other (Specify: ____________________)
Altered sexual function following a cycling session		☐ Up to 1 hour after cycling ☐ 1-24 hours after cycling ☐ > 24 hours after cycling	☐ Changing the saddle type ☐ Changing the saddle position ☐ Using padded cycling shorts ☐ Wearing no underwear ☐ Wearing additional underwear ☐ Other (Specify: ____________________)

8. Allergy history

If you answered **YES** to **question 8** in section E, please complete the following questions (8a. to 8e.) related to your current and past history of allergies.

(8a) Please indicate how long (years) have you been suffering from allergies? years

(8b) Please tick which <u>type of allergy</u> do you currently suffer from

Nose (hay fever)	Yes ☐ No	Sinusitis	Yes ☐	Asthma (allergic)	Yes ☐

	☐		No ☐		No ☐
Skin allergies	Yes ☐ No ☐	Eye allergies	Yes ☐ No ☐	Allergy to plant material	Yes ☐ No ☐
Allergy to foods	Yes ☐ No ☐	Allergy to animals	Yes ☐ No ☐	Other	
(8c) Please tick which type of allergy do you currently take medication for					
Nose (hay fever)	Yes ☐ No ☐	Sinusitis	Yes ☐ No ☐	Asthma (allergic)	Yes ☐ No ☐
Skin allergies	Yes ☐ No ☐	Eye allergies	Yes ☐ No ☐	Allergy to plant material	Yes ☐ No ☐
Allergy to foods	Yes ☐ No ☐	Allergy to animals	Yes ☐ No ☐	Other	
(8d) Please tick which type of medication do you currently take					
Cortisone nose spray	Yes ☐ No ☐	Cortisone nose inhaler	Yes ☐ No ☐	Anti-histamine tablets	Yes ☐ No ☐
Cortisone cream	Yes ☐ No ☐	Anti-histamine cream	Yes ☐ No ☐	Other inhaler / tablets or cream	Yes ☐ No ☐
(8e) Please tick which symptoms of allergy do you currently suffer from					
Sneezing	Yes ☐ No ☐	Itchy runny nose	Yes ☐ No ☐	Headache	Yes ☐ No ☐
Itchy palate	Yes ☐ No ☐	Streaming eyes	Yes ☐ No ☐	Fatigue	Yes ☐ No ☐
Itchy eyes	Yes ☐ No ☐	Blocked nose	Yes ☐ No ☐	Poor sleep	Yes ☐ No ☐
Post nasal drip	Yes ☐ No ☐	Coughing	Yes ☐ No ☐	Wheezing	Yes ☐ No ☐
In which months of the year do you currently have symptoms of allergies? (You tick more than one)	☐ Jan ☐ Feb ☐ March ☐ April ☐ May ☐ June ☐ July ☐ Aug ☐ Sept ☐ Oct ☐ Nov ☐ Dec				
(8f) Please tick which type of allergy did you suffer from in the past (NOT currently)					
Nose (hay fever)	Yes ☐ No ☐	Sinusitis	Yes ☐ No ☐	Asthma (allergic)	Yes ☐ No ☐
Skin allergies	Yes ☐ No ☐	Eye allergies	Yes ☐ No ☐	Allergy to plant material	Yes ☐ No ☐
Allergy to foods	Yes ☐ No ☐	Allergy to animals	Yes ☐ No ☐	Other	

9. Asthma history

If you answered **YES** to **question 9** in section E, please complete the following questions (9a. to 9k.) related to your current history of asthma

(9a) Do you currently suffer from asthma?	Yes ☐ No ☐
(9b) How many years have you suffered from asthma?	(years)
(9c) How was your asthma diagnosed?	☐ A doctor taking a history and performing an examination

	☐ Lung function test (blow test) but no exercise ☐ Lung function test (blow test) before and after exercise ☐ Metacholine challenge test ☐ Eucapnic hyperventilation test (rebreathing test) ☐ Other test (Specify: ________________________)
(9d) Which **type of asthma** do you currently suffer from?	☐ Asthma that occurs at any time but not during exercise ☐ Asthma that occurs at any time including during exercise ☐ Asthma that only occurs during exercise
(9e) Please indicate **how frequently do you currently experience the symptoms** of asthma (shortness of breath, wheezing, coughing or coughing after exercise)?	**Daytime symptoms (per week)** ☐ < 2 / week ☐ 2-4 / week ☐ >4 / week ☐ All the time **Night time symptoms (per month)** ☐ < 1 / month ☐ 2-3 / month ☐ $\geq$4 / month ☐ All the time **Exercise related symptoms (per 10 exercise sessions)** ☐ <1 per 10 sessions ☐ 2-3 per 10 sessions ☐ $\geq$4 per 10 sessions
(9f) Please indicate if you had symptoms of asthma that were severe enough to necessitate **hospital admission in the last 12 months**	☐ No hospital admission for asthma in the last 12 months ☐ 1-2 hospital admissions for asthma in the last 12 months ☐ 3-4 hospital admissions for asthma in the last 12 months ☐ >4 hospital admissions for asthma in the last 12 months
(9g) Which **symptoms of asthma** do you currently suffer from?	☐ Wheezing ☐ Dry cough ☐ Shortness of breath ☐ Tight chest ☐ Chest pain ☐ Other (Specify: ________________________)
(9h) What **medication do you currently use** for your asthma? (you may tick more than one option)	☐ Cortisone inhaler (e.g. Beclate, Becloforte, Becodisks, Becotide, Budeflam, Flixotide, Inflammide, Pulmicort, Qvar, etc) ☐ Salbutamol (bronchodilator) inhaler (e.g. Ventolin,

	Venteze, Vomax, Airomir, Asthavent etc.) ☐ Salmeterol (bronchodilator) inhaler (Serevent) ☐ Fenoterol (bronchodilator) inhaler (Berotec) ☐ Terbutaline (bronchodilator) inhaler (Bricanyl) ☐ Formoterol (bronchodilator) inhaler (e.g. Foradil, Foratec, Oxis) ☐ Ipratropium (bronchodilator) inhaler (Atrovent) ☐ Tiotropium (bronchodilator) inhaler (Spiriva) ☐ Combined cortisone and bronchodilator inhaler (e.g. Atrovent, Berodual, Combivent, Duolin, Duovent, Seretide, Symbicord) ☐ Cortisone tablets ☐ Bronchodilator tablets ☐ Leukotriene receptor antagonist tablets (e.g. Acccolate, Singulair) ☐ Other inhaler ☐ Other medication (Specify: ________________________)
(9i) **When do you use your medication** for your asthma?	☐ Daily (irrespective of exercise) ☐ Only before exercise ☐ Other (Specify: ________________________)
(9j) **How long before an exercise session** do you use your medication for asthma?	min
(9k) Have you obtained **TUE (therapeutic use exemption forms)** for your asthma medication?	Yes ☐ No ☐

10. History of previous collapse

If you answered **YES** to **question 10** in section E, please complete the following questions (10a. to 10d.) related to your current history of asthma

(10a) Have you collapsed during training or racing?	☐ Training ☐ Racing ☐ Training and racing
(10b) How many times have you collapsed in training session or races during the last **five years**?	_____ training session _____ races

(10c) When you collapse, does it mostly occur before of after the finish line / completion of the training session?	☐ Before the finish ☐ After the finish
(10d) What is the cause of you collapse?	☐ Dehydration ☐ Heat illness ☐ Hyponatremia ☐ Low blood pressure ☐ Low blood sugar ☐ Other condition (Specify: ________________________)

11. History of any current injury that you suffer from

If you answered **YES** to **question 11** in section E, please complete the following questions (11a. to 11g.) related to each of your current injury/ies (Space is provided for two injuries)

Injury 1

(11a) What was the approximate date when you first became aware of the injury?	Month Year
(11b) Please indicate which side of your body is injured (if applicable)	☐ Right ☐ Left
(11c) Please indicate which anatomical area is currently injured	☐ Head ☐ Elbow ☐ Hamstring ☐ Neck ☐ Forearm ☐ Quadriceps ☐ Face ☐ Wrist ☐ Knee ☐ Front chest ☐ Finger ☐ Shin ☐ Back chest ☐ Lower back ☐ Achilles ☐ Shoulder ☐ Hip ☐ Ankle ☐ Upper arm ☐ Thigh ☐ Foot Other (Specify: ________________________)
(11d) Please indicate the type of structure that was injured	☐ Muscle ☐ Ligament ☐ Tendon ☐ Joint ☐ Bone Other (Specify: ________________________)
(11e) Please indicate in which sport (discipline) the injury occurred	☐ Running ☐ Cycling ☐ Swimming Other (Specify: ________________________)

(11f) Please indicate the severity of the injury (tick one box please)	☐ I only experience symptoms after exercise - Grade 1 ☐ I experience symptoms during exercise, but it does not interfere with exercise - Grade 2 ☐ I experience symptoms during exercise that may interfere with my training/ competition - Grade 3 ☐ I am so painful that I may not be able to train or compete - Grade 4
(11g) Please indicate how your injury was treated to date (you can tick more than one)?	☐ Rest ☐ Tablets ☐ Stretches ☐ Cortisone injection ☐ Physiotherapy ☐ Other injection ☐ Surgery ☐ Orthotics ☐ Strengthening exercises ☐ Equipment change Other (Specify: ________________________)

Injury 2	
(11a) What was the approximate date when you first became aware of the injury?	Month Year
(11b) Please indicate which side of your body is injured (if applicable)	☐ Right ☐ Left
(11c) Please indicate which anatomical area is currently injured	☐ Head ☐ Elbow ☐ Hamstring ☐ Neck ☐ Forearm ☐ Quadriceps ☐ Face ☐ Wrist ☐ Knee ☐ Front chest ☐ Finger ☐ Shin ☐ Back chest ☐ Lower back ☐ Achilles ☐ Shoulder ☐ Hip ☐ Ankle ☐ Upper arm ☐ Thigh ☐ Foot Other (Specify: ________________________)
(11d) Please indicate the type of structure that was injured	☐ Muscle ☐ Ligament ☐ Tendon ☐ Joint ☐ Bone Other (Specify: ________________________)
(11e) Please indicate in which sport (discipline)	☐ Running ☐ Cycling

the injury occurred	☐ Swimming Other (Specify: ________________________)
(11f) Please indicate the severity of the injury (tick one box please)	☐ I only experience symptoms after exercise - Grade 1 ☐ I experience symptoms during exercise, but it does not interfere with exercise - Grade 2 ☐ I experience symptoms during exercise that may interfere with my training/ competition - Grade 3 ☐ I am so painful that I may not be able to train or compete - Grade 4
(11g) Please indicate how your injury was treated to date (you can tick more than one)?	☐ Rest ☐ Tablets ☐ Stretches ☐ Cortisone injection ☐ Physiotherapy ☐ Other injection ☐ Surgery ☐ Orthotics ☐ Strengthening exercises ☐ Equipment change Other (Specify: ________________________)