Spring 2010

Evaluation of Recovery in Female Swimmers During a Competitive Season

D'arcy Wiart

EVALUATION OF RECOVERY IN FEMALE SWIMMERS DURING A COMPETITIVE SEASON

by

D'ARCY WIART

(Under the Direction of Thomas Buckley)

ABSTRACT

Objective: To monitor the stress and recovery of college swimmers throughout a competitive season. The *priori* hypothesis was that RESTQ-SPORT scores will change with changes in training load through the season **Patients or Other Participants:** 23 female swimmers (mean age = 19.48±1.16, mean height = 168.6 cm ± 5.5, mean weight = 65.91kg ± 7.78) that were members of a southeastern Division I intercollegiate swim team. **Interventions:** The training load was measured using session rate of perceived exertion (RPE). RPE uses a 0-10 Borg scale to define effort. Each individual's daily score was multiplied by practice duration to give a training load. The RESTQ-SPORT 76 was given monthly. The data was then placed into the RESTQ-SPORT computer program to calculate scores. **Main Outcome Measures:** RESTQ-SPORT 76 mean scores for recovery-stress state, global stress, and global recovery were recorded to two decimal places. A repeated measures ANOVA was run on each mean and significance was set at p=0.05. **Results:** There was a significant time effect for scores over the season (F_5=4.67; P<.001) for RESTQ total. A simple contrast using the initial RESTQ-Sport as a baseline (M=9.85 ± 10.34) showed the RESTQ total was significantly less at time point 2 (F_1=9.55, M=4.14 ± 10.06 P=.006) and time point 4 (F_1=5.88, M=11.65 P=.026). There was no significance for global recovery. Global stress showed a significant time effect for scores over the season (F_5=9.85, P<.001). There was no group effect or interaction. A simple contrast using the initial RESTQ-Sport as a baseline (M=19.60 ± 5.71) showed that time point 2 (F_1=21.23, M=24.00 ± 6.80 P<.001), time point 4 (F_1=20.96, M=26.08 ±

7.72 P<.001), and time point 5 (F_1=4.54, M=22.89 ± 7.68 P=.047) were significantly less than baseline. The highest training loads were seen at time points 2 and 4. **Conclusions:** The study shows that as training load increases through a season, the internal stress increases. This can lead to an increased risk of underrecovery. Swimmers need to be taught better strategies for recovery to gain the intended training effects and improve performance.

INDEX WORDS: Underrecovery, Training stress, Recovery, Seasonal effects, RESTQ-Sport

EVALUATION OF RECOVERY IN FEMALE SWIMMERS DURING A COMPETITIVE SEASON

by

D'ARCY WIART

B.S., Endicott College, 2008

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial

Fulfillment

of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA

2010

Evaluation of Recovery in Female Swimmers during a Competitive Season

by

D'arcy Wiart

Major Professor: Thomas Buckley

Committee: Stephen Rossi

Jim McMillian

Barry Joyner

Dissertation Approved:

May 2010

Acknowledgements

I would like to thank my thesis committee for all of their support during this process. Dr. Rossi and Dr. McMillan for the idea behind the research and help understanding the RESTQ-SPORT. Dr. Buckley for the hours put in editing writing and suggestions throughout the study. Dr. Joyner for his ability to help me understand the statistics that occasionally seemed over my head.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1- Introduction

The problem of underrecovery, also known as overtraining, has been known for over 70 years in exercise science.[1] Underrecovery can affect between 20-65% of endurance athletes at some point in their career.[2, 3] One of the main factors that has been shown to lead to underrecovery is excessive training loads, while not allowing adequate time for proper recovery.[1, 4-6] These sports-specific physiological stresses can be influenced by many factors such as training duration, periodization of training, fitness status, environment, and type of recovery practices attribute to underrecovery.[6] Lehmann suggested the two biggest circumstances leading to underrecovery are training monotony and an increase in training volume.[7] Other issues such as travel fatigue, altitude and extreme environmental conditions provide additional sources of stress that can contribute to underrecovery.[1] All aspects of an athlete's life are potentially involved in underrecovery. A change in any aspect can leave the individual at a higher susceptibility to underrecovery.[5, 8] However, it is difficult to differentiate specific sources of stress that lead to underrecovery because it is an individual process that is a fluid state, especially during training periods of high intensity.[5] Thus, it is important to develop a comprehensive monitoring protocol to detect underrecovery in athletes because a well established technique does not currently exsist.[9] A practical method of monitoring individuals that are becoming more susceptible to underrecovery during training would allow athletes to train at maximal training loads while decreasing the risk of underrecovery. This may allow athletes to perform at their greatest potential.

Underrecovery is a concern for athletes who participate in either anaerobic or aerobic sports. Indeed, 15% of elite athletes in Great Britain were found to display symptoms of underrecovery during a 12 month period regardless of the nature of their sport.[10] Swimmers are especially vulnerable to underrecovery due to their high training volume and frequency, often performing 12 training sessions or more in a week. Thus, it is not surprising that 20 – 65% of swimmers may suffer from underrecovery at some point in their career.[2, 3] Koutedakis suggested that 6.8% of 170 college swimmers were underrecovered each season over 4 years and an additional 32.1% were classified as in 'training distress', showing signs of being at a great risk for underrecovery.[11] A more recent investigation has supported Koutedakis' research suggesting that 5-10% of elite swimmers feel some sort of underrecovery type symptoms during the course of a competitive season.[12]

There are three stages to underrecovery: single training session, overreaching, and underrecovery.[13] Each stage is characterized by an increase in stress and the amount of time for recovery to return to a homeostatic state.[1] Stress is a destabilization or deviation from the average in a biological or psychological system.[14] This process is considered a normal training response for both the single training session and overreaching stages.[13] There are two types of stress: eustress and distress. Eustress is the stress that causes positive adaptations.[15] This is the type of stress that is the goal of training. When the body cannot tolerate anymore stress, distress can occur potentially leading to underrecovery. An athlete can recover in a few hours from a single training session and be able to perform the following day in practice. This process is common in sports with competitions in close proximity such as football, basketball, and soccer. The next stage, overreaching is a technique commonly utilized in athletes building to a single competition, where the body is put under increased stress and then allowed greater than normal recovery to increase performance.[16] It can take days to weeks to recover from overreaching depending on the individual.[1] This is an effective method to incorporate into training because there has been a positive dose-response relationship established between training and performance.[17] However, there is a potential risk associated with overreaching as this process increases the risk of underrecovery. A positive adaptation of overreaching occurs when the athlete is given sufficient time to recover and with this recovery a performance increase can be stimulated through adaptation.[13] However, if the recovery time is not sufficient and the stress continues to accumulate, the athlete may experience underrecovery.[13] Therefore, coaches trying to have an athlete reach a state of overreaching must carefully control training to allow for a sufficient amount of recovery.[14, 18]

There is no set of occurrences known that cause an athlete to develop underrecovery. This makes the monitoring of accumulation of stress a necessity throughout a training regiment. Recovery is the responsibility of both the coach and athlete.[14] If an athlete reaches a state of underrecovery, restoration of optimal performance can take months to years.[1, 5, 9] It is proposed that a state of underrecovery may lead to other factors that can decrease performance such as being more prone to physical illnesses and overuse injuries.[13] The current literature on this topic is unclear on whether these are effects of training or symptoms of underrecovery.[13]

In addition to the physical training load prescribed by the coach, other psychosocial issues including pressure to perform, inadequate nutrition, family issues, and problems with teammates may influence perceived stress.[16, 18, 19] Non-training stressors such as emotional stress, social stress, and conflicts occurring in the past 3-4 days have been shown to substantially affect recovery and performance.[14] Thus, appropriate monitoring of all aspects of an athlete's life that could provide stress, not just sport specific stressors, is required to fully evaluate for the potential development of underrecovery.[5] This information can than be utilized to appropriately adjust training loads to accommodate for these additional stressors in an athlete's life in an effort to reduce the risk of developing underrecovery.

An athlete's perception of effort is negatively influenced by underrecovery; therefore an underrecovered athlete will have a higher self-perception of effort than individuals who are not underrecovered.[1, 20] The session rate of perceived exertion (RPE) provides a objective reporting of athlete's self-perceived exertion of each training session.[21] This allows for an internal training load to be calculated rather than the currently used external load of distance swam, allowing for calculation of the intensity of practice to be based on the athlete's perception of practice.[22] An external training load assumes that each practice is the same intensity for all participants. The recommended weekly training load for swimmers has been proposed to be between 4000-5000 when calculated with session RPE.[9]

Underrecovery leads to changes in an athlete's mental state and physiological performance.[13] The effect on both of these components led to the development of the Recovery-Stress Questionnaire for Sports (RESTQ-SPORT).[14] This is an important tool for detecting symptoms of underrecovery. [5] The RESTQ-SPORT was developed from research based on the Profile of Mood States and Recovery-Stress Questionnaire that showed decreased mood scores with underrecovery.[1, 13] The sports-specific scales were developed because the Recovery-Stress Questionnaire scales were shown to be too general for use with athletes.[14] The 76 item RESTQ-SPORT questionnaire is a tool to measure an athlete's current perceived stress and recovery states.[8] The RESTQ-SPORT evaluates stress in an athlete's life and the recovery strategies to interpret how an individual will cope with stress.[14] After researchers developed and validated the scales, the scales were pilot tested to find a time frame as a reference period for the survey questions. The most specific time period that still gave a representation of the athletes mood state was chosen to be three days.[14] The 76 item RESTQ-SPORT generates three main scores (RESTQ total, global recovery, and global stress) from 19 subscales.[14] The use of these scores can be used to given a picture of an athlete's recovery-stress state. The development of the RESTQ-SPORT is a step forward in the development of a tool that can be used to prevent underrecovery in athletes.

These three main scores change in response to alterations in training load, as Gonzalez-Boto showed in swimmers with increased training loads lead to decreased RESTQ total and global recovery and increased global stress.[8] The RESTQ-SPORT has been studied in short periods of intense training.[5, 14, 23, 24] Gonzalez-Boto et al. found in a study of both female and male swimmers that the RESTQ-SPORT showed decreased RESTQ total and global recovery scores and increased global stress scores with increased training load.[8] Jurmaie et al. found the same response in male rowers during a six day training camp.[23] These results corresponded to increases in cortisol.[23] Kellman et al. found that the scales changed similarly in response to practice duration for eight rowers preparing for the Olympics.[18] However, there is little evidence on the effects of a full competitive season on an athlete's recovery-stress state with the RESTQ-SPORT.[24] One of the only studies looked at a sport, rugby that undergoes similar training loads throughout a season. Rugby players practice at similar training intensities and durations during a season with minor variations. Male rugby players showed no changes over a season for RESTQ total, global recovery, and global stress.[25] The effects of a taper have been shown to improve RESTQ total scores in sixteen male triathletes with an increase in performance.[24] A taper was defined as a training phase where the training load was progressively reduce to allow for physiological and psychological recovery from accumulated stress.[26]

Many of the physiological changes associated with proper training are also associated with underrecovery. Improvements in these physiological measures have been shown with a proper taper. Rowers were found to maintain a mean hematocrit of 47% throughout training for the junior world championship.[17] This is within the normal limit for adults of between 40-54%.[27] Hematocrit was found to be significantly lower after the endurance training phase.[28] A taper has been shown to allow the hematocrit to recover to a normal level after periods of intense training.[29, 30] Creatine kinase was found to be at its highest during the intense phases of training and lower after a taper.[17] Various studies have shown a decreased creatine kinase level following a taper in swimmers.[12, 29, 31] Uric acid was found to be at its highest after the initial training phase after which it decreased. Uric acid then returned to its original level after the taper.[17] Insulin decreased by 17% and C-peptide 7% from baseline during high intensity training. Both of these hormones increased significantly from baseline after tapering.[17] All of these changes are positive for the athlete showing recovery from the effects of training. A proper taper allowing for these recovery changes to take place can lead to increases in performance.

Athletes undergo different stressors that may leave them more susceptible to underrecovery. In order to better prepare athletes to reach optimum performance, advancements need to be made in the understanding of physiological and psychological stress and recovery. The sport of swimming is an ideal sport to use because it combines the theory of overreaching in training with tapering before a major competition, the combination of which is lacking current research on seasonal effects. Therefore, the purpose of this study is to examine psychological scores of stress and recovery across a competitive season in Division I collegiate women swimmers. It is hypothesized that the psychological scores of the participants will rise and fall with periods of intensified training and tapering.

Chapter 2- Methods

Participants

The participants in this study were 22 collegiate female swimmers (age = 19.55 ± 1.14 years old, height = 168.65 ± 5.63cm, weight = 65.61 ± 7.82kg) from a southeastern United States Division I NCAA University. All participants had been training as competitive swimmers for at least 5 years. The inclusion criterion for the study was being a swimmer on the intercollegiate swim team for the entire season. All participants provided written informed consent prior to participating as approved by the University's Institutional Review Board

Instrumentation

The *Recovery-Stress Questionnaire* (RESTQ-SPORT) attempts to estimate the recovery-stress states of participants.[14] The recovery-stress state measures the current self-perceived physical and mental stress of the participant, as well as their ability to recovery from this stress.[14] The questionnaire allows for a systematic and direct measure of the different stress and recovery states based on self-report by the subject. The period of reference, the time in between surveys, can be extended for four weeks and still is accurate.[14] This is important because the survey itself only asks questions related to the previous three days.[14] Cronbach alpha coefficients demonstrated acceptable internal consistency for all the factors of the instrument, as all scales have a value that is higher than 0.7.[14] The entire survey was found to have a Cronbach's alpha value of .89.[14] Previous investigations using a factor analysis found the survey was valid and did measure training stress and recovery with all four groups of scales, General Stress, General Recovery, Sports-specific Stress and Sports-specific Recovery having maximum likelihood factors above .6 for each of their subscales.[32] The RESTQ-SPORT consists of Likert scale questions with values ranging from 0 (never) to 6 (always). These numbers indicate the frequency with which the statements are true during the previous three days. There are a total of nineteen scales of measurement, twelve that come from the original RESTQ measuring general stress and recovery and seven scales that were added to the RESTQ-SPORT to measure sports-specific stress and recovery. Of these 19 scales, 9 assess stress and the remaining ten scales assess recovery (Appendix E).[14] An increase in recovery scales and decrease in stress scales are seen as positive changes for the recovery-stress state.

The second instrument used was Rating of Perceived Exertion (RPE) Scale (Appendix G) ranging from zero to ten.[21] RPE is both a common and valid method of measuring exercise intensity and is correlated to the heart rate zone method.[21, 22, 33] The RPE is believed to be better suited for swimmers because it does not require equipment in the water and/or alter performance.[22] RPE requires little training to administer and very little instruction.[21] The participant rates the training or conditioning 30 minutes post training using a Borg scale from 0 – 10 with the numbers corresponding to categories ranging from rest to maximal effort.[22]

Procedures

Two weeks prior to the start of the team's practice, height, using a wall chart, and weight, using a digital scale (Toledo Scale, model #8140), were measured and recorded for participants. The participants reported their rate of perceived exertion following practice or resistance training to the athletic trainer covering the session after being shown a perceived exertion scale. There were some data points missing at the beginning of the study, after week 3 the response rate for RPE was 100% when the participants became familiar with the routine. Participants reported to a classroom adjacent to the pool on September 19th, October 17th, November 20th, December 19th, January 18th, and February 17th to complete the 76-question recovery-stress questionnaire. The RESTQ-SPORT was given in a private and quiet controlled environment to ensure confidentiality of the participants' responses. After the participants submitted the questionnaire they immediately left the room.

Data Analysis

The participants were divided into three groups: 1) sprinters, 2) middle distance, and 3) long distance swimmers.

The dependant variables were the RESTQ total, global recovery, global stress, training volume, and training load. The training load for each practice was calculated as the length of practice in minutes multiplied by the RPE value for the each member of the team and average weekly training loads were calculated from these totals for each time period.[22] Training volume was the distance swam in yards for each practice and average weekly training volumes were calculated for each time period.

The RESTQ-SPORT scores were calculated by the four questions in each scale added together to produce a scale score. The score for each question was the number given on the Likert scale from 0-6. The score for two of the questions in the sleep scale were inverted. The four main scales were then calculated for General Stress, General Recovery, Global stress was calculated by adding General Stress and Sports-Specific Stress together. Global recovery was calculated by adding General Recovery and Sports-specific Recovery together. The 19 subscale scores are calculated using the RESTQ-SPORT computer program.[14]

Statistics

The data were analyzed using SPSS 17.0 for Windows (SPSS Inc. 2009). Four one-way ANOVAs were run on group demographics to ensure there were no significant differences between groups. A two-way univariate test with repeated measures compared the training load, training volume, RESTQ total, global recovery, and global stress for each of the three groups. The univariate test for repeated measures was followed by a repeated contrast for an effect between time points and a Scheffe post-hoc for group effect for training load and training volume. The univariate test for repeated measures was followed by a simple contrast for an effect between time points and a Scheffe post-hoc for group effect for RESTQ total, global recovery, and global stress. These comparisons were for both within and between groups. The α value for the test was set at P=0.01 after a Bonferroni correction.

Chapter 3- Results

There were no significant differences between groups for demographic measures (Table 1, Appendix D). The average weekly distance (Figure 1, Appendix D) and training load (Figure 2, Appendix D) were calculated for each group. The univariate test of variance with repeated measures showed a significant effect for training load over the season ($F_{2.81}$=84.86; P<0.001), however there was no group effect (p>0.05) or interaction (p>0.05). A repeated contrast using the time point before to compare training load showed time point 2 ($\bar{x}$ =5888.98, F_1=227.97, P<.001) was significantly greater than time point 1 ($\bar{x}$ =2603.52); time point 3 ($\bar{x}$ =4057.86, F_1=80.17, P<0.001) was significantly less than time point 2; time point 4 ($\bar{x}$ =5930.79, F_1=159.16, P<0.001) was significantly greater than time point 3; time point 5 ($\bar{x}$ =4573.74, F_1=61.80, p<0.001) was significantly less than time point 4; and time point 6 ($\bar{x}$ =3294.41, F1=249.05, p<0.001) was significantly less than time point 5.

The univariate test of variance with repeated measures showed a significant effect for training volume over the season ($F_{1.48}$=324.87; P<0.001). There were no group effects or interactions. A repeated contrast using the time point before to compare showed time point 2 ($\bar{x}$ =17324.24, F_1=9750.09, P<0.001) was significantly greater than time point 1 ($\bar{x}$ =52640.91); time point 3 ($\bar{x}$ =35220.91, F_1=152.39, P<0.001) was significantly less than time point 2; time point 4 ($\bar{x}$ =47441.67, F_1=267.54, P<0.001) was significantly greater than time point 3; time point 5 ($\bar{x}$ =38840.15, F_1=74.23, p<0.001) was significantly less than time point 4; and time point 6 ($\bar{x}$ =30789.09, F_1=311.75, $p<0.001$) was significantly less than time point 5.

The univariate test of variance with repeated measures showed a significant time effect for RESTQ total over the season (F_5=4.67; $P<0.001$) (Figure 3, Appendix D), however there was no group effect ($p>0.05$) or interaction ($p>0.05$). A simple contrast using the initial RESTQ-SPORT as a baseline ($\bar{x}$ =9.85) showed the RESTQ total was significantly lower at time point 2 ($\bar{x}$ =4.14, F_1=9.55, P=.006).

A univariate test of variance for repeated measures showed no significant effect for time, group, or interaction for global recovery ($p>0.05$) (Figure 4, Appendix D). A univariate test with repeated measures for global stress (Figure 5, Appendix D) showed a significant time effect for scores over the season (F_5=9.85, $P<0.001$), however there was no group effect or interaction ($p>0.05$). A simple contrast using the initial global stress score as a baseline ($\bar{x}$ =19.60) showed that time point 2 ($\bar{x}$ =24.00, F_1=21.23, $P<.001$) and time point 4 ($\bar{x}$ =26.08, F_1=20.96, $P<0.001$) were significantly higher than baseline.

Chapter 4- Discussion

This purpose of this investigation was to examine if psychological markers of stress and recovery would change across a competitive season in collegiate swimmers due to changes in training load. The results of this study found that both RESTQ total and global stress scores changed across a competitive season mirroring changes in training load, while global recovery did not change. The RESTQ total was reduced at all time points where a full taper was not present along with an increase in training loads. The changes in RESTQ total were consistent with changes in global stress at these time points. These findings are unique because they occur during a competitive season and not in a training camp.

There was a significant decrease in RESTQ total (recovery-stress state) for time point 2 in this study (Figure 3) compared to time point 1. This time point had the second highest mean weekly training load (Figure 2) and training volume (Figure 1) during the season. The finding of high training load and training volume is consistent with both RESTQ-SPORT and underrecovery studies that have found that psychological markers of underrecovery increased with increased training loads in swimmers and other sports.[6, 8, 12, 17, 18, 23, 24] Both rowers and triathletes had reported lower recovery-stress scores with increased training load.[17, 18, 23] Coutts found these changes were also accompanied by performance decreases potentially indicating an underrecovery state in triathletes.[24] Kellman and Gunther found that rowers preparing for the 1996 Olympics had lower recovery-stress states when practice duration was increased.[18] It was also found that the rowers had worse recovery-stress states in the few days leading up to their events at the Olympic games.[18] The proposed reasoning for this was that the athletes were under increased psychological stress because of the pressure to perform at the Olympics.[18] Swimmers were found to have decreased recovery-stress states when training volume was increased.[8] The swimmers were found to return to baseline when training volume was decreased back to baseline.[8] The results of this study agree with previous findings that the monitoring of RESTQ total can identify swimmers who may be more susceptible to underrecovery.[8, 18, 23]

These results differ, however, from a study of rugby players that found no significant changes in RESTQ total over the course of a season.[25] This is likely because the rugby players maintained similar training loads throughout the season, while the swimmers in this study changed training load and volume throughout the season. This likely results from swimming training that uses a method of that included overreaching during the season and tapering prior to a major competition. Further, this suggests that as training loads increased during a season, individuals potentially became more susceptible to symptoms of underrecovery.

There were significant increases in global stress during time points 2 and 4 of the season as compared to time point 1. These periods corresponded with the highest training load. Training duration at the same intensity has been linked to increased levels of stress in rowers when exercising at high intensity.[17, 18, 23] Exercising at low intensity for a longer duration as active rest has been proposed as a method of preventing underrecovery.[5] Time point 4 was a unique time in the athletes' season. This time point included times when the athletes had final exams and were training at an increased frequency. All of these factors make it difficult to pinpoint an exact cause of increased stress. Time point 4 included periods when the athletes were training twice a day at normal practice intensity for 14 practices a week, as well as, 3 dryland training (core exercises) 3 and weight training sessions per week. This is above the normal 9 training sessions a week that the athletes completed the rest of the season because they were not limited by rules that governed the amount of practice time when school is in session. These are times when training can be monotonous because the athlete is on a break from school and only concentrating on their sport.[1] Time point 4 included final exams along with the two weeks of increased training, which could have explained this time having the highest global stress scores. The individuals in this study during time point 4 had the highest level in the individual subscales of burnout, somatic complaints, disturbed breaks, and injury. Indeed, a disproportional number of the chronic overuse injuries occurred at this time. Although it is beyond the scope of this study to speculate whether this is due to the psychological or physiological stressors. The athletes also had the lowest score on the success scale during this time point. This time point did not include a meet, which could be why the success scores were so low. The athletes had no event to evaluate their performance after training. Time point 4 also included a member leaving the team. This could have had an effect on the team by increasing the stress on the members of the team that remained.

Time points 3, 4, 5, and 6 did not have significant changes from the baseline for RESTQ total. However, there were trends during time points 3 and 5 with decreases in RESTQ total scores. Time points 3 and 6 were the two time points during the season that included a taper. The largest taper was in Time point 6 before the conference meet with the number of practices and training volume decreased. This is where the largest increases, positive effects, in RESTQ total was seen through the season. Time point 6 was the only time point that had RESTQ total scores that were higher than the time point 1. The tapering may also explain why global stress scores did not change significantly during Time points 3 and 6. Tapering has been shown to provide positive results for psychological measures reducing the RESTQ total scores and global stress scores.[8, 24] Time point 5 included periods where the athletes did not train due to Christmas vacation. This could have provided mental relaxation, which has been proposed as a way of decreasing psychological signs of overtraining.[9, 13, 14] Previous research on Division I swimmers has found that a four day vacation decreased global stress scores.[14] Although time point 5 included two weeks of increased number of training sessions, it also included a ten-day Christmas break. This break from swimming could explain the lower global stress scores seen during this time period. It could be hypothesized that stress was increased from time point 1 because the only thing the athlete was doing at this time was practicing, there were few other activities to allow the athlete to get away from her sport. The increase in stress at certain time points was connected with increases in training and times when swimming was concentrated on solely. This could be because the athletes were participating in activities that allowed them to get away from their sport during periods of high training load. Kentta suggested that 'time-out' periods from training are recommended to keep the athlete from getting totally pre-occupied with their sport.[5] These 'time-out' periods are periods where the athlete can get away from training and relax. In the collegiate sports setting, these could be represented by vacations or team outings instead of practices.

These results were expected with the design of a swimming training program. The athletes were purposely overreached until a period of tapering. The results of this study suggest that, in principle, these strategies influenced the stress levels as planned. However, future studies should include a performance measurement using a randomized control group to identify the physiological effects of this training strategy.

Surprisingly, the global recovery scores did not change over the course of the season with changes in training load (Figure 2). This was different from past studies using sports such as rowing, swimmers, and triathletes.[8, 17, 18, 23, 24] Steinacker found that recovery followed a “reverse cubic path” that was the opposite of the “cubic path” training load.[17] In our study, the highest points for recovery were the beginning and end time points, with the lowest recovery score in the middle of the study, the opposite was true for the training load curve. Although these studies took place at six-week training camps, it does not explain the differences in global recovery. The differences in this study may be explained by the demographics of the participants, the athletes in this study were college students, not elite athletes at a training camp.[18, 23, 24] The present study’s recovery results more closely resembled the results seen in a study of adolescent rugby players in Australia, whose recovery scores did not change over a season.[25] The mean global recovery scores seen in the present study, between 27-30, were similar to the global recovery scores reported in rugby players, which ranged from 28.71-30.87.[25] Thus, the swimmers in this study did not change their recovery to adjust for changes in stress and training load during the course of a season. This could be because other aspects of their daily life, academics, did not allow for full recovery. Academics may have contributed to this lack of change in recovery. Collegiate swimmers have to concentrate on both training and academics, which may not allow for recovery strategies to be implemented.

There were no effects of different training groups on RESTQ total, global recovery, and global stress in this study (Figure 4, 5, 6). The distance group trained for aerobic endurance, while the sprint group trained anaerobically. The middle distance group used a combination of both. Interestingly, all three groups trained for the same duration each practice. The groups had similar intensities in RPE scores, although the designs of their practices were different. The long distance group had a significantly higher training volume (distance swam) than the sprinters, who swam short distances in intervals with longer recovery time. The fact that there were no group effects for the three RESTQ-SPORT scores supports the idea proposed by Wallace et al. that internal training load was a better indicator of practice intensity than training volume.[22, 33] Coutts found differences in RESTQ-SPORT scores in triathletes that were placed into randomized training groups with intensity differences.[24]

The design of this study was applied in nature and thus had multiple limitations. First, this study only investigated one collegiate swim team and, as each team is made up of individuals that respond psychologically and physiologically differently to the stressors of a competitive season, the results of this study should be viewed within this context. It is also acknowledged that an assumption is made in regards to honesty on the RESTQ-SPORT and session RPE. This assumption is not addressed in previous literature on the RESTQ-SPORT. Further, these results are limited to collegiate female swimmers and care must be taken when generalizing to other sports. The applied nature of this study prevents the control of recovery activity, as the coach did not have control of non-sport recovery during a season. The recovery activities away from the pool are often the responsibility of the athlete and their own personal preference and their influence on the swimmers' performance must be considered.

In summary, the changes in RESTQ-SPORT scores, representing psychological markers of susceptibility to underrecovery, over the course of a season corresponded to changes in training load in collegiate swimmers. The results of this study suggest that these changes should be monitored over the course of a season to ensure a proper training and recovery program is being implemented. The RESTQ-SPORT could possibly be used to ensure a proper taper before major competitions in swimmers. Future research should concentrate on changes in individual subscales over the course of a season, which could provide new insight into ways to improve the recovery-stress state over the course of a season. Also further research needs to be conducted to see whether there are gender differences in response to the RESTQ-SPORT over the course of a season. Individual case studies of athletes over the course of a season may also be beneficial. These could show individuals that make changes during the course of a season that are not seen when using the measurement of team means.

Practical Application

The results of this study can be used to provide insight into the psychological state of a swimmer during the course of a competitive season. It is one of the first studies that followed athletes through the course of a season preparing for a single major competition using an overreaching with a taper training model. The RESTQ-SPORT can be used to identify times throughout the season where more recovery may be needed. These times appear to be time points where the individuals do not have a break from intense training of at least three days. These could be times where the coach could implement a team activity or outing.

The results of the RESTQ-SPORT can also be used to monitor individuals that may be more susceptible to underrecovery as well. It could provide areas of concentration to allow for better recovery following practices. If this is the case then individual scales should be evaluated to show areas where improvement is needed. The RESTQ-SPORT could be used in combination with a taper to prepare athletes effectively for a competition.

Appendix A

Research Hypothesis

The null hypothesis for the research will be the following:

1. As training load is increased, RESTQ-SPORTS recovery-stress means for the groups will not change
2. As training load is increased, global recovery scores will not change over the season
3. As training load is increased, global stress scores will not change over the season
4. There will be no differences among groups for the three RESTQ-SPORT scores over the season

The following hypothesis are proposed for this study:

1. There will be change in RESTQ-SPORTS throughout the season for all three groups
2. As training load is increased, RESTQ-SPORTS recovery-stress means for the group will decrease
3. As training load is increased, global recovery scores will decrease through the season
4. As training load is increased, global stress scores will increase through the season
5. There will be no difference among groups for the three RESTQ-SPORT scores over the season

Limitations

The study will be limited by the small specific sample size of the participants. The study is limited by the inability of the researcher to set the training load of the participants. The coach will set the training since this is a field study.

Delimitations

This study will be delimited by the choosing of the participants. The participants will be collegiate female swimmers. The participants will come from a convenience sample of athletes at a DI institution in Georgia. The events and meets used for performance will be delimitations. Only one event will be used for each participant. The meets will be restricted to those that are standard colligate pools measuring 25 yds. The RESTQ-SPORT will be given once a time point.

Assumptions

There will be assumptions made with this study. These include that all participants will be honest on the RESTQ-SPORT and when giving RPE values. All participants are assumed to be giving full effort on the RESTQ-Sport and during practice. It is also assumed that the RESTQ-SPORT measures what it is intended to measure.

Definitions

The following terms will be used in this study:

Recovery- An inter- and intraindividual multilevel process in time for the re-establishment of performance abilities[14]

Swim Speed- An average speed calculated by dividing the distance of event by time. The measure will be given in yds/sec

Stress- A destabilization or deviation from the norm in a biological/psychological system[14]

Training Load- An internal measure of intensity calculated using duration of practice and RPE score

Appendix B

Overtraining Syndrome

Overtraining syndrome is a consequence of exercising more than the body is capable of performing.[1, 4, 5] Overtraining syndrome is known by many names in the exercise science field such as underrecovery, overwork, failing adaption, overstress, staleness, stagnation, chronic fatigue, and burnout.[5, 34] An intensified training period can result in a decrease or increase in performance.[13] Training is a process of overload that is used to disrupt homeostasis which results in acute fatigue followed by performance increases.[16] If the body is able to return to a homeostatic state with an appropriate period of rest then a 'supercompensation' effect can occur.[13, 16, 17] This is when an increase performance over the baseline is seen because the body overcompensates for training with changes to the physiological make-up of the body.[17] Overtraining syndrome is a state of training in which the normal training load is increased with increasing signs of strain and incomplete recovery characterized by prolonged fatigue with performance decrements.[17, 34] The differences between proper training and overtraining syndrome is a fluid state, especially during periods of heavy training.[5] Overtraining syndrome is a combination of both training and non-training stress.[5, 13] The problem of overtraining syndrome has been known for over 70 years, but still remains a topic of great debate.[1]

Overreaching and overtraining syndrome are though to develop when the balance between training, stress, and recovery are disproportional.[13] The two are distinguished from one and another by the time needed to restore performance.[13, 16] Overreaching is utilized in athletics during a typical training cycle.[16] Research has shown that there is a dose-response relationship to training and performance.[17] The amount of training must be carefully controlled by coaches because each athlete has an ideal amount of training that leads to maximum performance.[17] It is not possible to tell from intensity or duration of exercise when overtraining syndrome will occur when attempting to have the athlete obtain a state of overreaching. These other things that can lead to overtraining syndrome increase internal stress place on the body. The training volume and schedule need to be adjusted properly to not cause overtraining syndrome. A training volume and schedule that remains momentous can lead to overtraining syndrome, as well as one that changes suddenly.[7] Other things that have been shown to lead to overtraining syndrome are medical problems, inadequate nutrition, outside psychological stress, and unusual environmental stress.[5, 17, 18, 35]

If training was the only thing that led to overtraining syndrome, then decreasing training volume should decrease stress. This was found not to be the case. In rowers that were preparing for the Olympics, stress continued to rise with a decrease in training.[18] In a study of 12 swimmers that doubled their training distance, 4 were found to be able to tolerate higher training intensities proposed as signs of overtraining. These 4 swimmers were found to habitually eat less carbohydrates and had lower muscle glycogen stores.[19] Psychological stressors have also been linked to overtraining syndrome such as those dealing with work, teammates, coach, and family.[16] Environmental factors have also been suggested as overtraining syndrome triggers. These deal with changes in training environment such as altitude changes, heat exposure, and cold exposure.[16]

There are different stages in the overtraining syndrome classification. These can be divided based on how long it takes an athlete to recover and return to homeostasis, so classifications can only be made retrospectively.[13] The three stages of the overtraining syndrome continuum are single training session, overreaching, and overtraining syndrome.[1] An athlete can recover from a single exercise bout in a number of hours. It may take the athlete several days to recover from overreaching. A restoration of performance capacity may take up to several months for overtraining syndrome.[5, 13, 16] Overtraining syndrome can destroy an athlete's career. It is not possible to discern overreaching and overtraining syndrome from a single bout of exercise. It is necessary to monitor an individual over time to come to a conclusion of overtraining syndrome.[13] This is because each individual has a personal response to stress placed on the body.[5] The best method for curing overtraining syndrome still remains prevention.[1, 34]

Overtraining syndrome can occur in any type of athletics. Overtraining syndrome will affect between 20-65% of endurance athletes at some point in their career.[2, 3] It has been studied extensively in swimmers. Multiple researchers have found similar statistics in swimmers over a six-month training period.[13] Morgan et al. found over a six-month period that 5-10% of subjects were stale, while Hooper et al. found three out of 14 subjects were stale.[6, 12] Staleness was defined in both of these studies as an elevated state of fatigue over a long period of time. Although being stale does not lead to a state of overtraining syndrome, it can be an indication of individuals that are more susceptible to overtraining syndrome.[13]

A major limitation in many studies done on this topic is that they do not assess performance. There has been a movement by some researchers to describe overtraining syndrome as unexplained underperformance syndrome.[3] An inability to increase performance over time can be a strong indicator of a state of overtraining syndrome, when combined with other factors. These researchers believe that this term will avoid the confusion that has arisen because of the use of other terms to describe overtraining syndrome such as staleness, chronic fatigue, burnout, and sports fatigue syndrome.[3] These researchers feel that all of these terms imply causation, which is unknown.[3] A subject cannot be classified as overtrained solely based on performance. A failure to see better performance can be because of intensity and duration not being sufficient enough to produce an effect.[13] Many of the physiological markers of overtraining syndrome that have been suggested such as reduced submaximal heart rate and plasma lactate concentration are also indicators of training adaptation. Therefore these along with other indicators need to be used in combination with performance when looking at overtraining syndrome. [1, 13]

It is agreed in amongst researchers that overtraining syndrome is characterized by psychological disturbances. The Profile of Mood States (POMS) is a tool that can be used to diagnose overreaching.[13] Increases in POMS scores have been seen in individuals that were overreached.[13] This by itself does not indicate overtraining syndrome. Increase scores on the POMS were seen in swimmers that were not overtrained after 3 and 10 days of increased training.[13] Halson and Jeukendrup suggest that changes in mood states may be a useful indicator of overreaching, but some type of performance measure is also needed to diagnose overreaching.[13]

There has been a search for a biochemical marker that can indicate overtraining syndrome. The first thing that was studied was a lower submaximal and maximal blood lactate concentration. This has been the only biochemical marker that has shown consistent findings in studies.[13] These are normal reactions to increased training, so they need to be used in conjunction with a decrease in performance to diagnose overtraining syndrome. Other biochemical markers such as creatine kinase, urea and iron levels have all been inconclusive in studies. These markers have all had inconsistent findings and are unable to be distinguished from acute fatigue.[13]

There have been many anecdotal reports of increased incidences of illness and upper respiratory tract infections (URTI) with overtraining syndrome.[13] One study found that the secretion of secretory immunoglobulin A (s-IgA) was an important indicator of URTIs.[2] As training loads increased, the secretion of s-IgA decreased which lead to a greater incidence of UTRIs. The incidences of UTRIs were concentrated together which can be explained by teammates being in contact with infected teammates.[2] One study concentrating on overtrained swimmers found a higher rate of URTIs in athletes that responded positively to training than overtrained individuals.[13] This indicates that increased UTRIs are not an indicator of overtraining syndrome in athletes. An increased rate of UTRIs can be attributed to training.[2, 13]

There are many ways to manage fatigue associated with athletics. Fatigue is the "general sensations of tiredness and accompanying decrements in performance in physical performance".[9] Abnormal fatigue is indicative of overtraining syndrome or unexplained, underperformance syndrome. Two of the most obvious methods for managing fatigue are rest and sleep. It is recommended that athletes have one passive day of rest a week during periods of intense training.[9] This period of passive rest allows for athletes to not feel preoccupied with their sport. This distraction may alleviate boredom and lower the sports-specific stress felt by the athlete.[9] Sleep is important to fatigue management because prolonged sleep loss can have negative impacts on training. The primary need for sleep is neurally based. Cognitive functions are likely to be impaired, mainly the ability for the athlete to concentrate.[9] Researchers have suggested that athletes are able to overcome this area of sleep loss but it leads to decreased motivation to train.[9] Taking short naps can compensate for poor sleep patterns during training. A 30 minute nap with a 30 minute postnap recovery period has been shown to increase performance following a night of reduced sleep.[9] There are two other types of recovery that may be overlooked and these are nutrition and hydration. The key point to stress to athletes is that nutrition affects both health and performance.[9] Proper nutrition can help an athlete overcome a period of increased training without excessive fatigue, illness, or injury. It is important that athletes maintain their normal diet during periods of training.[9] The most important nutrient for athletes during training is carbohydrates. An inadequate carbohydrate intake has been shown to lead to an earlier onset of overtraining syndrome symptoms.[9] The other nutrient that is important in preventing overtraining syndrome is protein. This is because proteins can repair damage to tissue after periods of increased training.[9] An enhanced protein diet is necessary during the recovery phase of training. Improper hydration can lead to training deficits. These training deficits over time can lead to increase stress over time.[9] The increase in stress can make an athlete more susceptible to periods of overreaching.

Perceived Exertion Scale (RPE)

An athlete's perception of effort has been proven to be affected by underrecovery.[20] An athlete that is underrecovered will have a higher perception of effort than individuals who are not overtrained.[1, 20] The session RPE gives an athlete's perceived exertion of each practice session.[21] This allows for the periodization of an athlete to be based on the athlete perception rather than an external load established by a coach. The current accepted method for monitoring training load for swimming is to measure the external work done by the athlete (distance swam).[22] This does not allow for the monitoring of internal characteristics of training, the intensity of the practice.[22] These internal stimuli are what determine an individual's training adaptation.[24, 33] The session RPE scale was created to allow for more accurate monitoring of training load to improve athletes' preparation for competition.[22]

The advantage of session RPE comes in its simplicity.[21] It is a technique that requires minimal instruction to the athletes.[21] Individual athletes were found to be very consistent in their pattern of reporting of training using the RPE system.[21] 80% of athletes give a score that is a representation of the workout as a whole. The other 20% needed to think of each aspect of practice individually before giving a session RPE score.[21] The athletes subjectively rate the entire training session using the Borg scale.[22, 33] The practice is rated by answering the question "How hard was your workout?"[20, 21] This is where the concept of internal training load using RPE is derived from.

Foster et al. found that a RPE scale based on a Borg scale of 0 to 10 is highly correlated to summated heart rate zone.[21] Summated heart rate zone is the current accepted method for monitoring internal training load.[33] Foster stated that the session RPE method was a more practical field technique than summated heart rate in field studies because of the simplicity.[21] The use of session RPE eliminates the need to calculate a maximal heart rate to monitor training.[21] The session RPE was found to be significantly correlated to two heart rate methods (Banister's Training Impulse (TRIMP) [r=. 74], Edward's TRIMP [r= .75]), and the lactate threshold (r=. 77) in swimmers.[22, 33] The TRIMP methods are accepted as the best method for monitoring internal training load presently and is the product of training duration and average heart rate. All four of these methods were shown to have a worse correlation to distance swam (r= .65) than each other.[33] This means that RPE is giving a better idea of the intensity of practice on the body than distance swam. Session RPE is not interchangeable with the TRIMP method as significant differences were found between scores on the two scales.[21] This can be explained by the fact that the TRIMP method has 5 categories, while session RPE has 10 categories.[21]

RPE method has been found to be more useful over a wider range of exercises than the summated heart rate zone method. It eliminates two major limitations of the summated heart rate zone method.[21] Heart rate zone are unable to monitor such as high intensity exercise such as resistance training and plyometrics.[21, 22, 33] Session RPE may be more sensitive for high-intensity exercise than heart rate methods.[33] The correlations found in swimming between session RPE and heart rate methods were lower than the session RPE values found for other types of training (r=. 75-.90). This can be attributed to the interval training of swim practices, which have been shown to be difficult for heart rate methods to monitor.[21, 22, 33] Also, heart rate zones require that the athlete wears a device to monitor heart rate. These devices can either malfunction or the athlete can forget to wear them.[21] This is especially true in swimming because the likelihood of heart rate monitors failing is increased because the training takes place in an aquatic enviorment.[22, 33] This was seen in Wallace et al. where only 160 of 248 training sessions had usable heart rate monitor information because of device failure during training.[33] If this happens manual pulse palpations need to take place and these interrupt training.[33] All of these things support the use of session RPE to calculate a number to represent training load using duration and intensity for team practices over a method monitoring heart rate.[21] Researchers report that the session RPE is easy to use and reliable.[21] These are major advantage of session RPE over other methods, along with the fact that it is simple and relatively easy to interpret.[22]

The use of session RPE allows for monitoring an entire training plan and calculating a training load.[21] The session RPE scores can be kept and used to establish a weekly pattern of exercise.[21] The training load is calculated by multiplying the session RPE score by the duration of practice.[22, 24, 33] These training loads can be presented graphically to allow for coaches and researchers to have a visual representation of a periodization as experienced by the athlete.[21] This has been difficult to monitor in swimmers previously because of the different natures of swimming training.[22] Training consist of both interval and steady state training in the pool, as well as dryland training. The recommended weekly training load for athletes is 4000-5000 when calculated with session RPE.[9] A study using a RPE scale of 6-20 on soccer players found the training load to be 5697.5 ± 2150.7 and 12039.3 ± 3340.6 for the two weeks of the study.[36] Using the 0-10 scale used in swimming literature these numbers would be 1774.8 and 3799.8 for the weeks.

There are many advantages to implementing the use of session RPE for quantifying training load in swimmers. The use of different types of training has been discussed.[21, 33] Session RPE allows for summation of these different types of training to provide an overall training load.[22] Athletes often undertake training at an intensity that is different from the intended intensity of the coach. Wallace et al. found that athletes take recovery practices at higher intensities than prescribed and lower intensities during high-intensity practices.[22, 33] Session RPE allows for training to take place at the desired intensity. Finally, individuals adapt differently to training. Session RPE allows for an individual training load to be calculated for a swim practice.[22]

Changes over a Season

A state of overreaching is sometimes desirable for sports that build to a single championship rather than a season such as swimming, rowing, and track. A short period of overreaching with sufficient amount of time for regeneration can lead to performance increases.[17, 23] The initial response is a decrease in performance, but with a proper tapering performance increases are seen. Tapering is the training phase before competition when training load is decrease to allow adequate physical and psychological recovery.[26] Rowers were found to have a greater maximum power and faster 2000 meter 8 man coxed boat time right before the junior world championships after tapering.[17] The slowest 2000 meter time was seen during the second phase of training when the training intensity was at its highest.[17] This was supported by other researchers, which found the slowest 2000 meter ergometer times after the heaviest training period.[23]

There are cardiovascular effects that are indicative of a proper taper.[26] Two studies with three week tapers found that there was no changes in VO_2 max during a taper.[37, 38] These studies also found 4-8% increases in performance on 100 meter and 400 meter time trials. These findings are typical since a decrease in VO_2 max would be indicative of a poorly planned taper.[26] It is a consensus among researchers that the resting heart rate does not change during a taper.[12, 31, 39] Maximal heart rate is reduced after increased training.[40, 41] One study on swimmers found that there was lower maximal heart rates after a two week taper.[38] Submaximal heart rate was found not to be affected by a taper.[19, 38]

There are many physiological markers that change throughout a competitive season. Rowers were found to maintain a mean hematocrit of 47% throughout training for the junior world championship.[17] This is within the normal limit for adults of between 40-54%.[27] Swimmers were found to have similar hematocrit levels throughout a training cycle. The swimmers were found to have a significantly lower hematocrit after the endurance training phase.[28] A taper has been shown to allow the hematocrit to recover to a normal level after periods of intense training.[29, 30]

Creatine kinase was found to be at its highest during the intense phases of training and lower after a taper.[17] Creatine kinase is a blood enzyme that increases during intense exercise and is often used as an indicator of overtraining.[26] Various studies have shown a decreased creatine kinase level following a taper in swimmers.[12, 29, 31] These results suggest that training volume reflects training volume and not intensity that can lead to overtraining syndrome.[26]

Uric acid was found to be at its highest after the initial training phase after which it decreased. Uric acid then returned to its original level after the taper.[17] There were no changes in DHEAS, cortisol and testosterone during training when compared to the baseline. These hormones increased 10% after a taper.[17] Two other studies had conflicting results on testosterone as it decreased in one, while increasing in the other.[23, 31] Luteinizing hormone and follicle stimulating hormone (FSH) decrease 10 and 11% after the high intensity phases, with only FSH recovering after a taper.[17] Insulin decreased by 17% and C-peptide 7% from baseline during high intensity training. Both of these hormones increased significantly from baseline after tapering.[17] Human growth hormone increased during the high intensity training phase, but decreased 30% from baseline during tapering.[17]

Athletes have physiological changes through out the course of a year due to training and detraining. Swimmers at the collegiate level do not undergo intense training during the summer leading up to the preseason. It can be hypothesized that these athletes would undergo similar effects to other athletes that go through a similar training cycle. Caldwell and Peters looked at semiprofessional soccer players that went through this training cycle. Aerobic fitness in the form of VO_2 max and flexibility were found to decreased with detraining. These variables then increased from the preseason to midseason when they decreased again.[42] Athletes body fat was found to decrease consistently throughout a competitive season.[42] A taper was found to have no effect on percent body fat and body mass.[38]

Power and strength are important aspects in any sport. Athletes undergo sports specific weight training throughout the season. These programs are used in order to maintain power and strength throughout a season. Marques et al. researched the strength and power of women’s professional volleyball players over a 12-week season while using a resistance training and plyometric program. The program primarily consisted of bench press, parallel back squats, and plyometrics.[43] Athletes were found to not only maintain power and strength, but increase with a proper weight training program.[43] Strength and power were found to have an increase in a swimming season, also after a taper.[12, 19]

The program that these volleyball players underwent is very similar to the training program that swimmers undergo during their competitive season. It can be hypothesized from these results that if a swimmer undergoes a proper resistance training program it is possible for them to maintain, if not gain strength and power over the course of a competitive season. These same results have also been found with soccer players in regards to leg power.[42] These athletes were found to make consistent improvements through a competitive season. The major limitation with both of these studies was that there was no control group. This does not allow the researchers to conclude these effects would not be the same if no supplementary training programs were used. The researchers stated that this was not possible because it would be unethical to prohibit athletes from supplementary training during their seasons.[43] The authors also stated that it would have been too difficult to find a control group to match with similar training and performance variables at the baseline testing.[43]

It has been proposed that athletes are more susceptible to infection during the competitive season. A study followed swimmers through preparation for the World Championship Trials to verify or deny this hypothesis. These swimmers were undergoing 25-30 hours per week as well as 5 hours of dryland training.[44] The swimmers were found to have significant changes in natural killer cells, which could possibly increase risk of a viral infection. The study found there were no significant differences between the swimmers and a control for changes in lymphocytes, T cells, B cells, and natural killer cells. These changes have been supported by other research on the topic in swimmers, which showed no changes in leukocytes and lymphocytes in swimmers during a training cycle.[28] The swimmers were found to have no change in salivary IgA, IgG, and IgM.[44]

Although no significant change was seen the amount of these immunoglobulins were in the lowest 10th percentile of normal reference ranges.[44] The authors believe this to be a chronic effect of training, leaving athletes more susceptible to infection.[44]

Recovery-Stress Questionnaire for Athletes (RESTQ-SPORT)

Kellmann and Kellus developed the RESTQ-SPORT to offer an general measure of stress and recovery strategies being used.[14] The basic assumption of the RESTQ-SPORT is that as stress increases, then an increased time of recovery is needed.[4, 8] The RESTQ-SPORT is an instrument that measures the recovery-stress state of athletes according to Kellmann.[14] The recovery-stress state indicates the mental and physical stressors an athlete is under and their ability to deal with these stresses.[14, 18] Changes in the current levels of recovery and stress are valuable because they can often be seen before the symptoms of overtraining syndrome present.[17] This allows for the prediction of an overtraining syndrome state before undesirable outcomes become present allowing for quicker recovery.[18] The greatest advantage of this type of instrument is the quick availability of the information.[16]

The RESTQ-Sport consists of 19 Likert scales, 10 of which represent stress and 9 that look at recovery.[14, 18] The recovery-stress state is stable with fluctuations, unlike the actual condition of the athlete.[14] The RESTQ-SPORT was developed from research based on the Profile of Mood States. The RESTQ-SPORT asks, "What happened in the past three days/nights?"[14, 18] This information can be used to modify behavior in the future, so athletes can better adjust to stress.[14] The interpretation of the RESTQ-SPORT profile should refer to either a reference group of athletes or to intraindividual changes over time.[14]

Stress is a destabilization or deviation from the average in a biological or psychological system.[14] Stress is objective and is anything that is affecting someone from the outside.[14] Stress can accumulate, and without intervention, lead to overtraining syndrome.[14] Stress can have either a positive or negative effect depending on the person and the recovery process.[14] There are two types of stress eustress and distress.[15] Eustress is the stress that causes positive adaptations.[15] This is the type of stress that is the goal of training. When the body cannot tolerate anymore stress distress can occur. Distress effects the body negatively.[15] Distress is the type of stress that can lead to underrecovery occurring. The RESTQ-SPORT allows for taking into account the recovery strategies to interpret how an individual will cope with stress. Recovery is an inter- and intraindividual multilevel process in time for the re-establishment of performance abilities.[1] There are many strategies for proper recovery. These can range anywhere from proper nutrition and hydration to mental relaxation techniques.[5] Recovery is individual specific.

A study was done using two groups of triathletes. There was a group that underwent normal training and a group that underwent intensified training. The intensified training group underwent 290% more training than the normal training group. The study found that there was a significant effect of training load on the recovery stress score.[24] The intensified training group recovery scores significantly decreased and stress scores significantly increased during the overload period when compared with the normal training group.[24] This is consistent with another study that found an improvement in mood state after a taper.[31]The unique finding of this study was that the intensified training group saw a greater effect of tapering than the normal group. The intensified training group had a significantly greater increase in recovery scores and decrease in stress scores than the normal training group.[24] The study concluded that performance measures were still the only definitive measure to diagnose overtraining syndrome, but that the RESTQ-SPORT saw changes in overreaching athletes that biochemical and physiological markers could not pick up.[24]

These changes in RESTQ scores have been linked to changes in performance and hormone changes in another study.[17] Steinacker et al found that there were opposite cubic trends in global recovery and stress during a period of high intensity training followed by a taper. This is similar to the training strategy employed during a swimming season. The lowest recovery scores and highest stress scores were seen immediately before the taper.[17] The performance variable in this study, 2000 meter time for a 8 man coxed boat, followed the curve for global stress and closely related.[17] Jurimae et al also found that similar significant effects on global recovery and global stress. During heavy training stress scales increased and recovery scales decreased.[23]

Swimmers were shown to change moods throughout the season based on training.[14] Multiple studies have demonstrated that there is a dose-response relationship between moods and training.[14, 18, 23] One of the few studies to use the RESTQ-SPORT on swimmers followed nine swimmers through a six week training period.[8] This is unique since many studies on overreaching are done on swimming because of the high intensity and frequency causing a high total volume or training load.[8] Swimmers often progressively reduce training volume heading into an important meet.[8] This is known as tapering and is used in an effort to improve performance.

González-Boto et al found significant differences in two sports stress scales and two sports recovery scales when training volume was increased by 1,500 m and intensity increased. The emotional exhaustion and injury scale significantly increased.[8] The being in shape and self-efficacy scales significantly decreased as training load was increased.[8] The researchers also found that the recovery-stress state significantly decreased, as training volume was increased. This value progressively increased back to the initial value as the training volume was tapered.[8] The recovery-stress state is the total stress subtracted from the total recovery.[8, 14] González-Boto et al. is one of the first to show the positive effects of tapering in swimmers.[8] These results are consistent with those found in rowers by Kellmann et al found the same results in rowers comparing for the Olympics. The psychological measures of stress increased and recovery decreased as extensive endurance training increased.[18]

Hartwig et al. looked at male adolescent rugby players' RESTQ-Sport scales through the 2007 and 2008 seasons in Australia. The groups were broken up by age group and training volume. The researchers had each of the 106 participants fill out weekly training diaries to establish training volume in minutes. The training groups were broken up by average weekly training volume: low (< 357 min, n=32), moderate (358-542min, n= 40) and high (> 543 min, n= 32).[25] There were no significant differences in the RESTQ-Sport scales between the age groups.[25] There were significant differences found in the training volume groups, represented by the high-volume group being 36.1% lower for general stress, 24.9% lower for emotional stress, 25.1% lower for social stress, 21.6% lower for physical complaints, 26.5% lower for disturbed breaks, 28.9% lower for burnout/exhaustion, 18.7% higher for self-regulation than the low volume group.[25] There was also a significant difference with the high volume group being 24.9% lower for emotional stress than the moderate volume group.[25] The researchers explained these results were because the high volume group was able to deal with the stresses of training better because they were more used to the training volume. This is different from other RESTQ-Sport studies that found a strong dose-response relationship between training and the RESTQ-Sport.[8, 14] There were no seasonal difference found in global stress and recovery from the beginning of the season to the end.[25] The mean total recovery-stress scores can be calculated for each of the age groups from the numbers given for mean stress and mean recovery. These numbers were 8.41 for the schoolboy group, 12.37 for the representative squad, and 8.08 for the talent squad.

There were both weaknesses and strengths with this study. A major limitation in the reporting of the research was that the means for each scale were not presented. The numbers were represented graphically and as percent difference in the writing. This makes it difficult to interpret the results in relation to other studies. The data was also presented at each time point but one mean for each group at the end. Presenting the data at each time point would give a better representation of the scores over a season. The way that the training volume was tracked using a weekly training diary also presents a problem. The researchers are relying on the memory of adolescent males. This study would have been stronger, f the researchers track the training volume themselves. The greatest strength of the study is the large sample size. Most of the RESTQ-Sport research has between 10-12 subjects, so a sample size of 106 is very large. This also was unique for RESTQ-Sport research because it is one of the first studies that followed athletes through an entire competitive season. This is important because it shows the seasonal effect of the RESTQ-Sport, when used as a monitoring tool through a season.

Appendix C- Calendar

September 2009

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
31 PM, Weights	1 PM, Weights	2 PM	3 PM	4	5	6
7	8 PM, Weights	9 PM	10 PM	11 PM, Weights	12 AM	13
14 PM, Weights	15 PM, Weights	16 PM	17 PM	18 PM, Weights	19 AM	20
21 AM, PM, Weights	22 PM, Weights	23 AM, PM	24 PM	25 PM, Weights	26 AM **RESTQ-Sport**	27
28 AM, PM, Weights	29 PM, Weights	30 AM, PM				

October 2009

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
			1 PM	2 AM, PM, Weights	3 Dual Meet	4
5 AM, PM, Weights	6 PM, Weights	7 AM, PM	8	9 AM, PM, Weights	10 AM	11
12 AM, PM, Weights	13 PM, Weights	14 AM, PM	15 PM	16 AM, PM, Weights	17 AM **RESTQ-Sport**	18
19 AM, PM, Weights	20 PM, Weights	21 AM, PM	22 PM	23 AM, PM, Weights	24 Dual Meet	25
26 AM, PM, Weights	27 PM, Weights	28 AM, PM	29 PM	30 AM, PM, Weights	31 AM	

November 2009

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
						1
2 AM, PM, Weights	3 PM, Weights	4 AM, PM	5 PM	6 AM Dual Meet	7 AM	8
9 AM, PM, Weights	10 PM, Weights	11 AM, PM	12 PM	13 AM, PM, Weights	14 AM	15
16 AM, PM, Weights	17 PM, Weights	18 AM	19 Invitational	20 Invitational **RESTQ-Sport**	21 Invitational	22
23	24	25	26	27	28	29
30 AM, PM, Weights						

December 2009

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
	1 PM	2 AM, PM	3 PM	4 AM, PM, Weights	5 AM	6
7 AM or PM	8 AM or PM	9 AM or PM	10 AM or PM	11 PM	12 AM	13
14 AM, PM, Weights	15 AM, PM	16 AM, PM, Weights	17 PM	18 AM, PM, Weights	19 AM, PM **RESTQ-Sport**	20 AM
21	22	23	24	25	26	27
28	29	30	31			

January 2010

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
				1	2 PM	3 AM, PM
4 AM, PM, Weights	5 AM, PM	6 PM, Weights	7 AM, PM	8 AM, PM	9 AM	10
11 AM, PM, Weights	12 PM	13 AM, PM, Weights	14 PM	15 AM, Dual Meet	16 Dual Meet	17
18 AM, PM, Weights **RESTQ-Sport**	19 PM	20 AM, PM, Weights	21 PM	22 AM, PM, Weights	23 Dual Meet	24
25 AM, PM, Weights	26 PM	27 AM, PM, Weights	28 PM	29 AM, PM, Weights	30 AM	31

February 2010

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
1 AM, PM, Weights	2 PM	3 AM, PM, Weights	4 PM	5 AM, PM, Weights	6 AM	7
8 AM, PM, Weights	9 PM	10 AM, PM, Weights	11 PM	12 AM, PM, Weights	13 AM	14
15 AM, PM, Weights	16 PM	17 PM **RESTQ-Sport**	18 Conference Meet	19 Conference Meet	20 Conference Meet	21
22	23	24	25	26	27	28

Appendix D

	Sprint	Middle Distance	Long Distance
Height (cm)	169.86 ± 6.92	168.59 ± 5.46	169.86 ± 4.82
Weight (Kg)	67.70 ± 8.72	67.81 ± 7.93	61.69 ± 6.18
Age	19.38 ± 1.13	19.63 ± 1.30	19.43 ± 1.13
School Year	2.38 ± 1.13	2.25 ± 1.16	2.42 ± 1.40

Table 1. Means in demographics for each of the training groups. There were no significant differences between any of the groups.

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
RESTQ Total	9.85 ± 10.34	4.14 ± 10.06*	4.77 ± 10.00	2.28 ± 11.65	4.23 ± 10.59	11.65 ± 9.98
RESTQ Recovery	29.45 ± 6.46	28.14 ± 5.93	27.73 ± 5.38	28.36 ± 6.13	27.11 ± 5.70	28.95 ± 5.79
RESTQ Stress	19.60 ± 5.71	24.00 ± $6.80^{\#}$	22.96 ± 7.32	26.08 ± $7.72^{\#}$	22.89 ± 7.68	17.31 ± 6.66

*Table 2***.** Team mean scores for RESTQ total, global recovery, and global stress each month of the season. *Significantly different than Month 1 RESTQ total (p =.006). $^{\#}$Significantly different than Month 1 RESTQ Stress (p<.001)

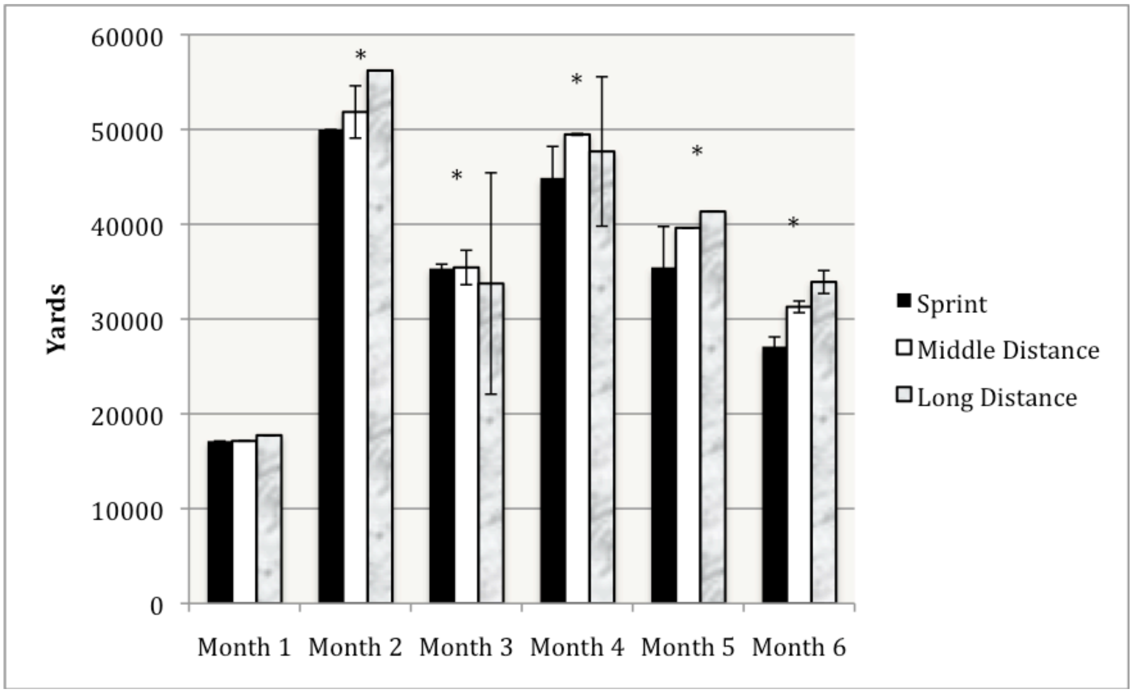

Figure 1. Average weekly distance in yards for each group in each month of the season. * Month is significantly different than previous month (p<.001)

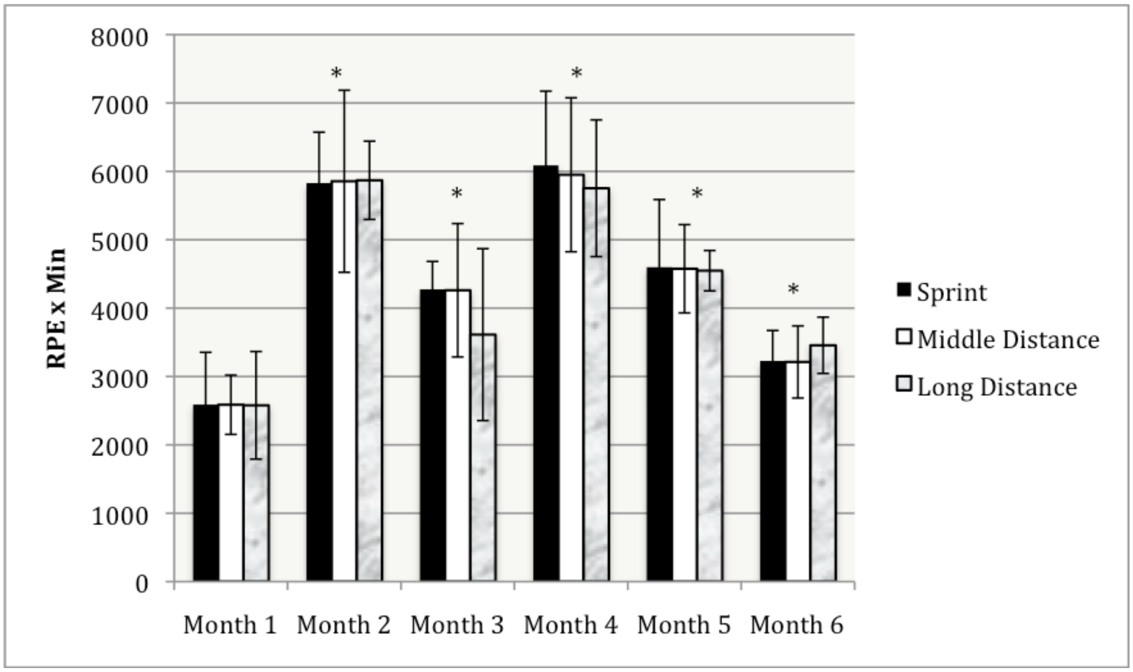

Figure 2. Average weekly training load for each group in each month of the season. * Month is significantly different than previous month ($p<.001$)

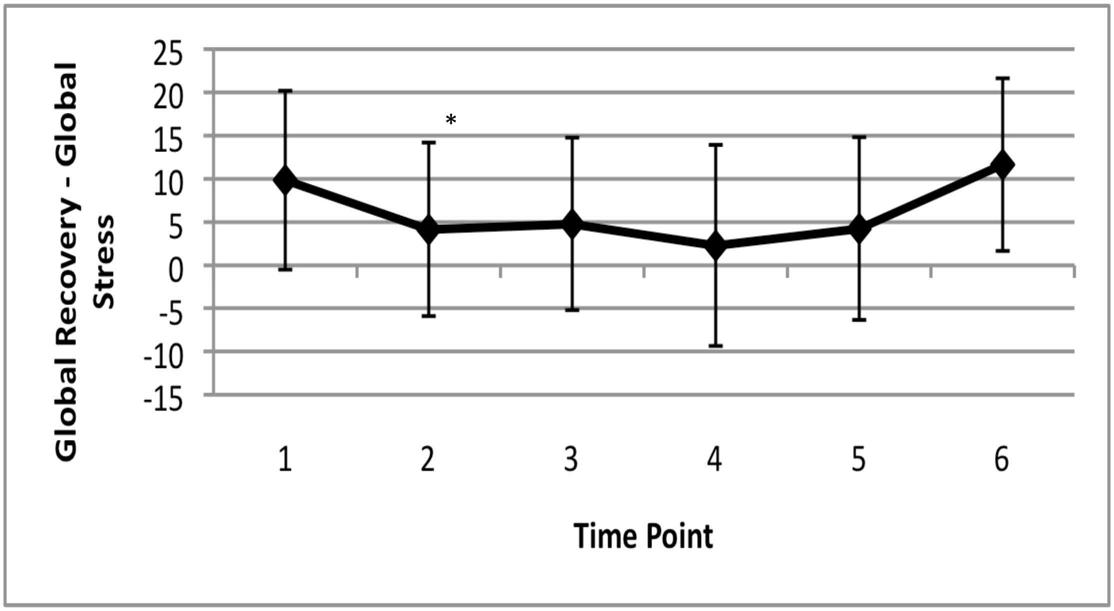

Figure 3. Team means for RESTQ total in each month that the RESTQ-Sport was given during the season. *Significantly different than Month 1 (p =.006).

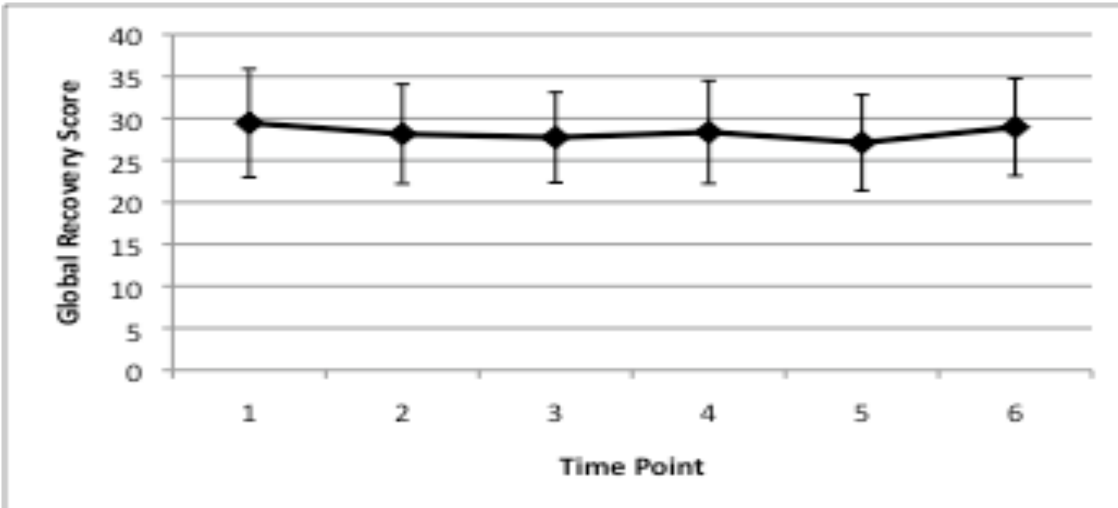

Figure 4. Team means for global recovery for each month during the season. There were no significant differences.

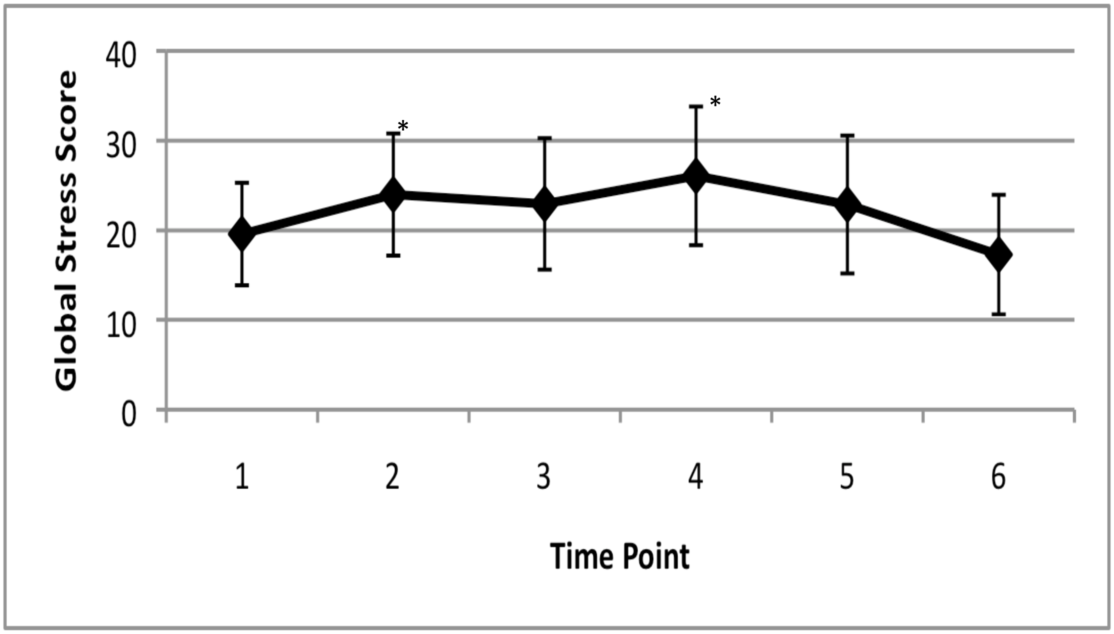

*Figure 5***.** Team means for global stress for each month during the season. *Significantly different than Month 1 (p<.001).

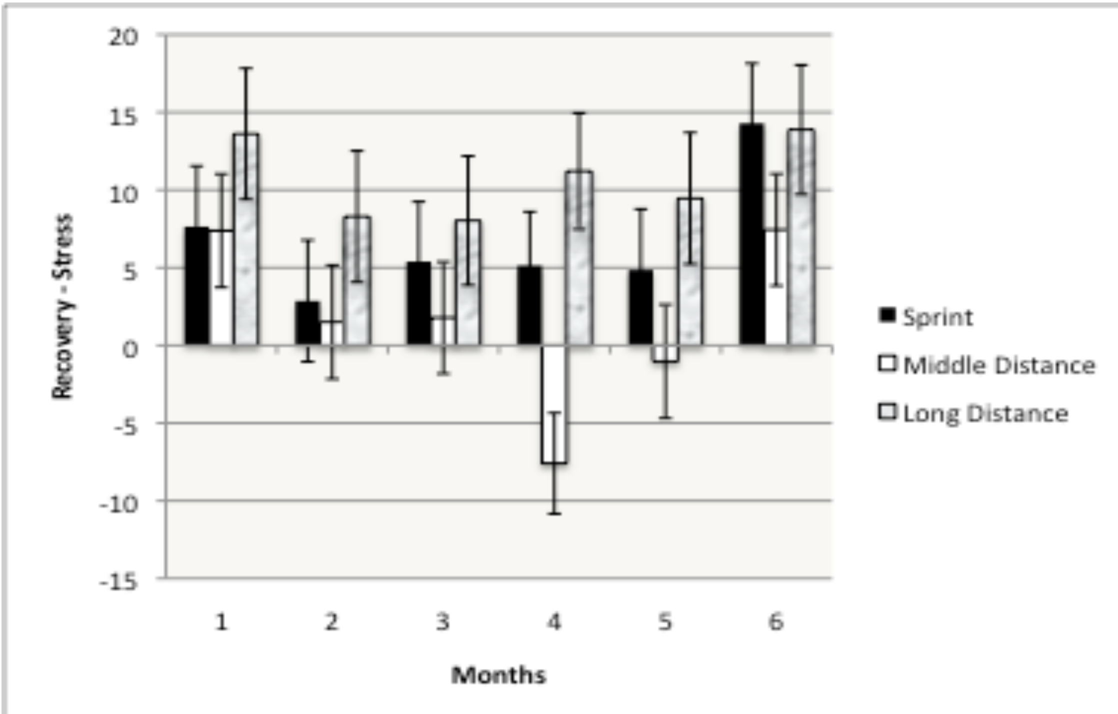

Figure 6. RESTQ total means for the training groups in each month. There was no significance.

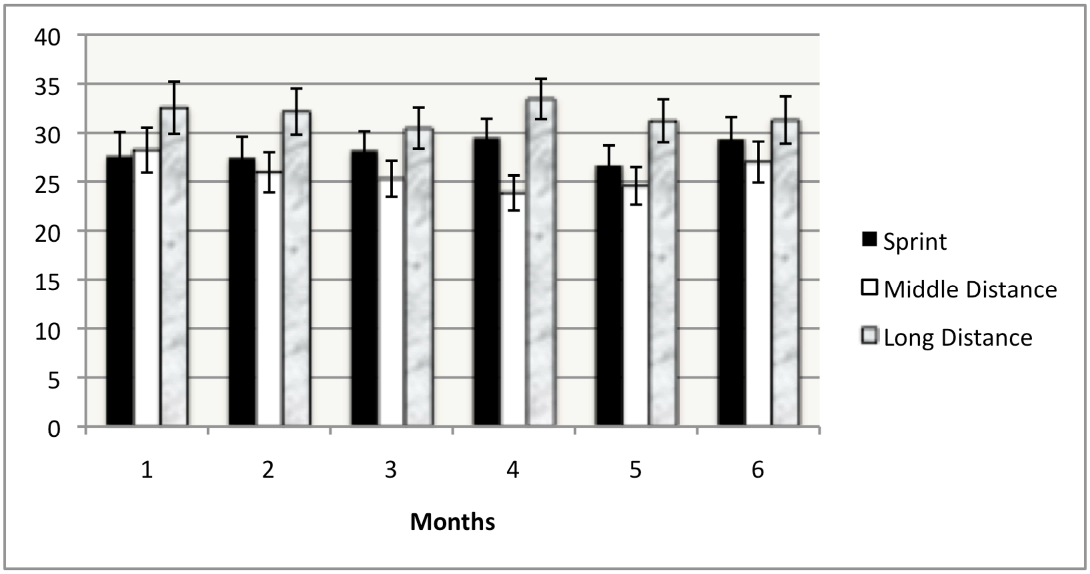

Figure 7. RESTQ global recovery score means for the training groups in each month. There was no significance.

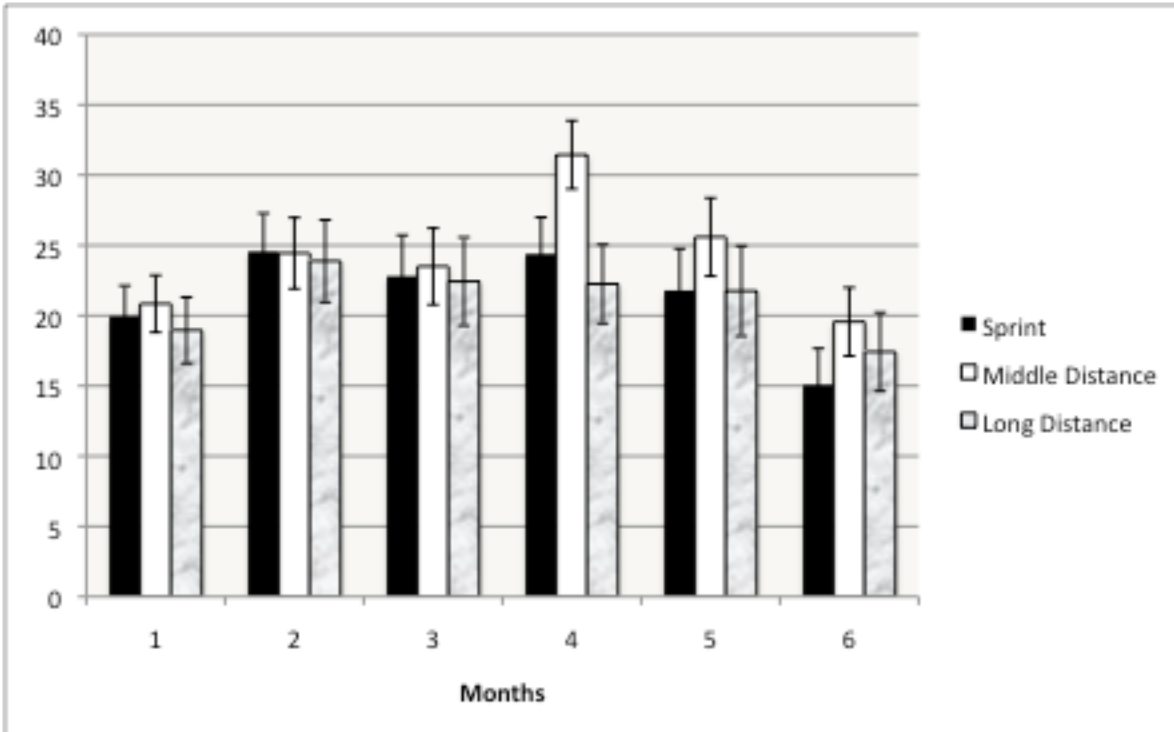

Figure 8. RESTQ global stress score means for the groups in each month. There was no significance.

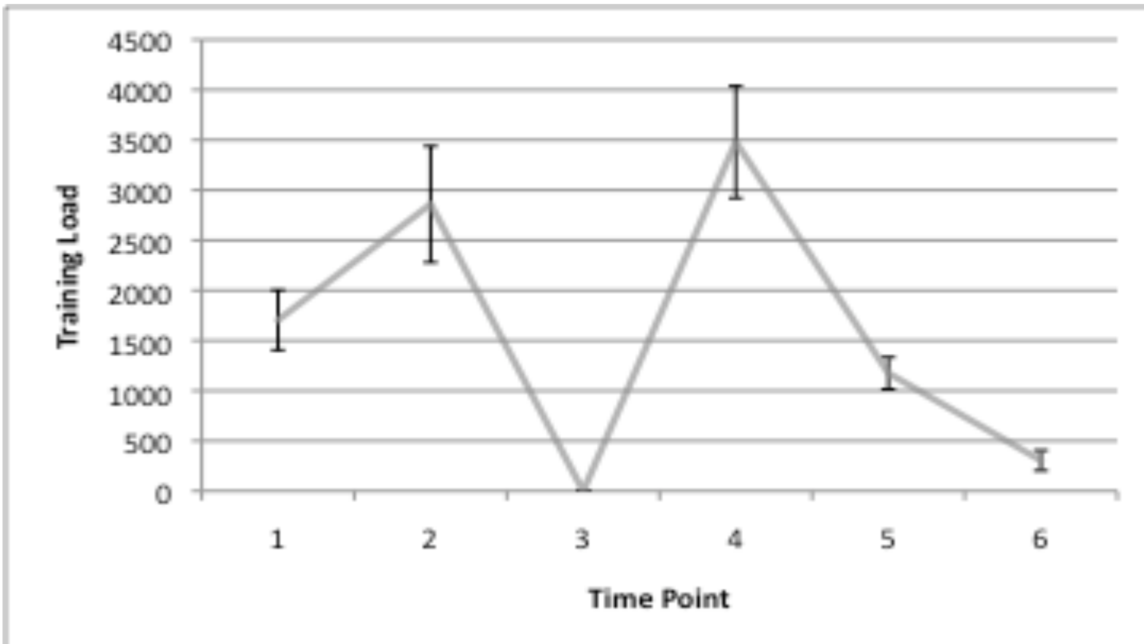

Figure 9. Means for training load in the tree days leading to each trial of the RESTQ.

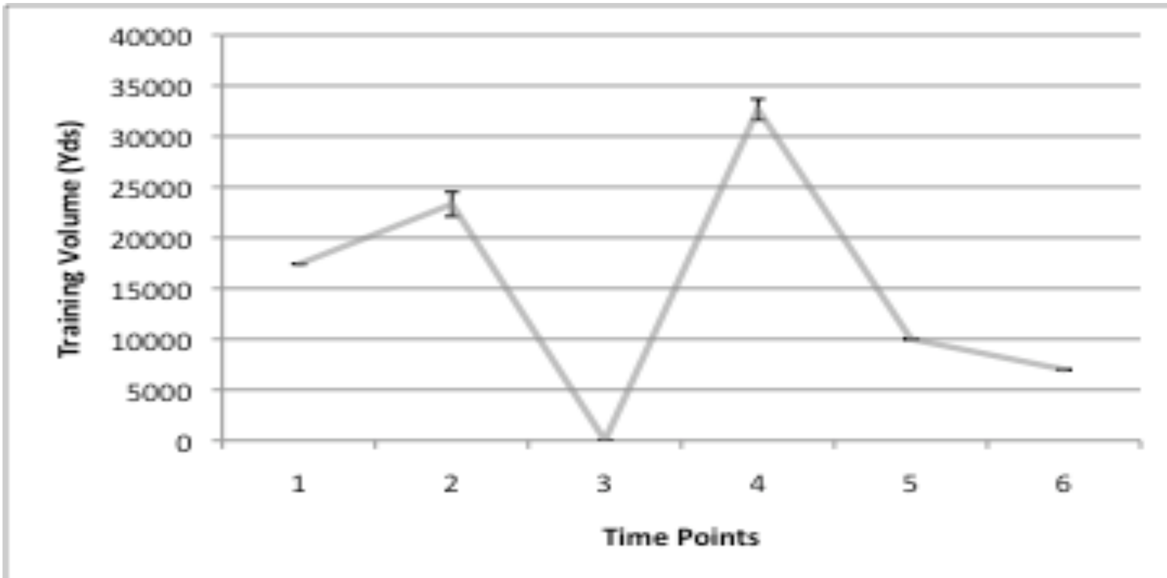

*Figure 10***.** Means for training volume in the tree days leading to each trial of the RESTQ.

Appendix E

Scale Name	**RESTQ Part**	**Question #'s from the 76**	**What does it measure**	**Is higher better or worse?**
General Stress	Stress	22, 24, 30, 45	Mental stress and depression	Worse
Emotional Stress	Stress	5, 8, 28, 37	Irritation, aggression, and anxiety	Worse
Social Stress	Stress	21, 26, 39, 48	Frequent arguments and fights	Worse
Conflicts/Pressure	Stress	12, 18, 32, 44	Dealings with unsettled and unpleasant things	Worse
Fatigue	Stress	2, 16, 25, 35	Overfatigue	Worse
Lack of Energy	Stress	4, 11, 31, 40	Lack of energy and inability to concentrate	Worse
Somatic Complaints	Stress	7, 15, 20, 42	Physical whole body complaints	Worse
Success	Recovery	3, 17, 41, 49	Success	Better
Social Relaxation	Recovery	6, 14, 23, 33	Relaxation and amusement	Better
Somatic Relaxation	Recovery	9, 13, 29, 38	Physical recovery and well-being	Better
General Well-Being	Recovery	10, 34, 43, 47	Good moods and contentment	Better
Sleep Quality	Recovery	19, 27, 36, 46	Recovery sleep	Better
Disturbed Breaks	Sports-specific Stress	51, 58, 66, 72	Interrupted recovery	Worse
Burnout/Emotional Exhaustion	Sports-specific Stress	54, 63, 68, 76	Burnout and wanting to quit sport	Worse
Fitness/Injury	Sports-specific Stress	50, 57, 64, 73	Acute injury	Worse
Fitness/Being in Shape	Sports-specific Recovery	53, 61, 69, 75	Personal view of physical fitness	Better
Burnout/Personal Accomplishment	Sports-specific Recovery	55, 60, 70, 77	Enjoyment of sport and integration within team	Better
Self-Efficacy	Sports-specific Recovery	52, 59, 65, 71	Individual feels optimally prepared	Better
Self-Regulation	Sports-specific Recovery	56, 62, 67, 74	Use of mental skills	Better

Appendix F

Scale Scores

Scale	General Stress	Emotional Stress	Social Stress	Conflicts	Fatigue	Lack of Energy	Somatic Complaints	Success	Social Relaxation	Somatic Relaxation	General Well-Being	Sleep Quality	Disturbed Breaks	Emotional Exhaustion	Injury	Being in Shape	Personal Accomplishment	Self-Efficacy	Self-Regulation
Sprint																			
T1	0.96	1.54	1.61	2.04	2.64	1.46	1.93	3.00	4.29	2.82	3.64	3.07	1.82	2.29	3.68	2.86	2.96	2.57	2.39
T2	1.46	2.04	2.14	3.04	2.57	2.07	2.61	3.11	4.00	2.36	3.43	3.25	1.86	2.64	4.14	2.75	3.07	2.64	2.82
T3	1.65	1.98	1.70	2.62	2.93	2.25	2.75	3.39	3.87	2.69	3.14	3.11	1.89	2.04	3.00	2.93	2.86	2.93	3.29
T4	1.68	2.07	2.18	2.64	2.93	1.82	2.93	2.82	4.21	2.79	3.86	3.21	2.18	2.00	3.96	3.11	3.21	3.32	3.00
T5	1.36	1.68	1.36	2.46	2.68	2.25	2.07	2.43	3.82	2.61	3.61	3.36	1.86	2.57	3.50	2.79	2.79	2.54	2.71
T6	0.96	1.64	1.43	2.07	1.50	1.79	1.50	2.71	4.11	2.96	3.86	3.39	0.93	1.39	1.86	3.46	2.82	3.04	3.00
Middle Distance																			
T1	1.38	1.69	1.47	2.69	2.38	2.22	2.16	3.19	4.06	2.59	3.72	3.50	2.09	1.63	3.16	2.53	3.09	2.88	2.66
T2	1.47	1.88	1.78	2.44	2.88	2.34	2.78	2.91	3.94	2.56	3.59	3.22	2.34	2.56	3.97	2.06	2.56	2.47	2.63
T3	1.78	2.09	2.19	2.75	2.69	2.16	2.50	2.78	3.94	2.66	2.88	3.25	2.06	2.81	2.47	2.47	2.41	2.25	2.66
T4	2.59	2.38	2.69	2.69	4.19	2.59	3.56	2.22	3.69	2.19	2.84	2.50	2.72	3.53	4.50	2.34	2.34	2.56	3.16
T5	2.09	2.16	2.13	3.03	3.13	2.31	2.19	2.63	3.69	2.41	2.84	2.69	2.53	3.03	3.00	2.53	2.56	2.38	2.84
T6	1.81	2.19	2.13	2.53	1.81	2.19	1.88	2.72	3.78	2.69	3.22	3.25	1.44	1.75	1.84	2.97	2.53	2.78	3.06
Distance																			
T1	1.21	1.82	1.57	2.36	2.11	1.89	1.57	3.57	4.07	3.50	4.16	3.82	1.39	1.25	2.64	3.46	3.21	3.54	
T2	1.61	2.14	2.14	2.79	2.82	2.11	2.43	3.43	3.36	3.11	3.68	3.57	1.64	1.75	3.50	3.46	3.39	3.50	3.86
T3	1.50	1.79	2.00	2.67	2.79	2.18	2.25	3.29	3.71	3.08	3.71	3.25	1.83	2.13	3.29	3.29	3.08	3.42	3.63
T4	1.21	1.61	1.36	2.39	2.68	1.75	2.39	3.25	4.04	3.39	4.04	3.79	2.00	2.32	3.93	3.39	3.36	3.50	3.61
T5	1.54	1.79	1.61	2.64	3.07	2.04	1.82	3.04	3.96	3.36	3.89	3.75	1.64	2.11	2.64	3.00	3.36	2.79	3.36
T6	1.50	1.86	1.82	2.29	1.71	1.64	1.75	3.43	3.96	3.18	3.89	3.36	1.50	1.36	1.54	3.36	3.11	3.21	3.29

Appendix G

RPE Scale

0- Rest

1- Very Light

2-

3- Light

4- Fairly Light

5- Somewhat Hard

6-

7- Hard

8- Very Hard

9- Extremely Hard

10- Maximal Effort

Appendix H

R E S T Q - 76 Sport

SingleCode: ______________________ GroupCode: ______________________

Name (Last): ______________________ **(First):** ______________________

Date: __________ Time: __________ Age: __________ Gender: __________

Sport/Event(s): ____

This questionnaire consists of a series of statements. These statements possibly describe your mental, emotional, or physical well-being or your activities during the past few days and nights.

Please select the answer that most accurately reflects your thoughts and activities. Indicate how often each statement was right in your case in the past days.

The statements related to performance should refer to performance during competition as well as during practice.

For each statement there are seven possible answers.

Please make your selection by marking the number corresponding to the appropriate answer.

Example:

In the past (3) days/nights

... I read a newspaper

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

In this example, the number 5 is marked. This means that you read a newspaper very often in the past three days.

Please do not leave any statements blank.

If you are unsure which answer to choose, select the one that most closely applies to you.

Please turn the page and respond to the statements in order without interruption.

In the past (3) days/nights

1) ... *I watched TV*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

2) ... *I did not get enough sleep*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

3) ... *I finished important tasks*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

4) ... *I was unable to concentrate well*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

5) ... *everything bothered me*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

6) ... *I laughed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

7) ... *I felt physically bad*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

8) ... *I was in a bad mood*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

9) ... *I felt physically relaxed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

10) ... *I was in good spirits*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

11) ... *I had difficulties in concentrating*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

12) ... *I worried about unresolved problems*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

C.2 From *Recovery-Stress Questionnaire for Athletes: User Manual* by Michael Kellmann and K. Wolfgang Kallus, 2001, Champaign, IL: Human Kinetics.

In the past (3) days/nights

13) ... *I felt at ease*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

14) ... *I had a good time with friends*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

15) ... *I had a headache*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

16) ... *I was tired from work*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

17) ... *I was successful in what I did*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

18) ... *I couldn't switch my mind off*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

19) ... *I fell asleep satisfied and relaxed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

20) ... *I felt uncomfortable*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

21) ... *I was annoyed by others*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

22) ... *I felt down*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

23) ... *I visited some close friends*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

24) ... *I felt depressed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

In the past (3) days/nights

25) ... *I was dead tired after work*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

26) ... *other people got on my nerves*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

27) ... *I had a satisfying sleep*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

28) ... *I felt anxious or inhibited*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

29) ... *I felt physically fit*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

30) ... *I was fed up with everything*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

31) ... *I was lethargic*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

32) ... *I felt I had to perform well in front of others*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

33) ... *I had fun*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

34) ... *I was in a good mood*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

35) ... *I was overtired*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

36) ... *I slept restlessly*

0 never	1 seldom	2 sometimes	3 often	4 more often	5 very often	6 always

In the past (3) days/nights

37) ... *I was annoyed*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

38) ... *I felt as if I could get everything done*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

39) ... *I was upset*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

40) ... *I put off making decisions*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

41) ... *I made important decisions*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

42) ... *I felt physically exhausted*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

43) ... *I felt happy*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

44) ... *I felt under pressure*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

45) ... *everything was too much for me*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

46) ... *my sleep was interrupted easily*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	alwayss

47) ... *I felt content*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

48) ... *I was angry with someone*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

In the past (3) days/nights

49) ... *I had some good ideas*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

50) ... *parts of my body were aching*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

51) ... *I could not get rest during the breaks*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

52) ... *I was convinced I could achieve my set goals during performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

53) ... *I recovered well physically*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

54) ... *I felt burned out by my sport*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

55) ... *I accomplished many worthwhile things in my sport*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

56) ... *I prepared myself mentally for performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

57) ... *my muscles felt stiff or tense during performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

58) ... *I had the impression there were too few breaks*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

59) ... *I was convinced that I could achieve my performance at any time*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

60) ... *I dealt very effectively with my teammates' problems*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

C.6 From *Recovery-Stress Questionnaire for Athletes: User Manual* by Michael Kellmann and K. Wolfgang Kallus, 2001, Champaign, IL: Human Kinetics.

In the past (3) days/nights

61) ... *I was in a good condition physically*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

62) ... *I pushed myself during performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

63) ... *I felt emotionally drained from performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

64) ... *I had muscle pain after performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

65) ... *I was convinced that I performed well*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

66) ... *too much was demanded of me during the breaks*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

67) ... *I psyched myself up before performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

68) ... *I felt that I wanted to quit my sport*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

69) ... *I felt very energetic*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

70) ... *I easily understood how my teammates felt about things*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

71) ... *I was convinced that I had trained well*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

72) ... *the breaks were not at the right times*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

In the past (3) days/nights

73) ... *I felt vulnerable to injuries*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

74) ... *I set definite goals for myself during performance*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

75) ... *my body felt strong*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

76) ... *I felt frustrated by my sport*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

77) ... *I dealt with emotional problems in my sport very calmly*

0	1	2	3	4	5	6
never	seldom	sometimes	often	more often	very often	always

Thank you very much!

References

1. Uusitalo AL. Overtraining: making a difficult diagnosis and implementing targeted treatment. *Phys Sportsmed.* May 2001;29(5):35-50.

2. Ganzanno F. The overtraining syndrome detection and prevention. 2006; http://www.athletemonitoring.com/articles/overtrainingprevention_en.pdf. . Accessed October 12th, 2009.

3. Budgett R, Newsholme E, Lehmann M, et al. Redefining the overtraining syndrome as the unexplained underperformance syndrome. *Br J Sports Med.* Feb 2000;34(1):67-68.

4. González-Boto R, Salguero A, Tuero C, Márquez S, M K. Spanish adaptation and analysis by structural equation modeling of an instrument for monitoring overtraining: the recovery-stress questionnaire (RESTQ-SPORT). *Social Behavior and Personality.* 2008;36(5):635-649.

5. Kentta G, Hassmen P. Overtraining and recovery. A conceptual model. *Sports Med.* Jul 1998;26(1):1-16.

6. Morgan WP, Brown DR, Raglin JS, O'Connor PJ, Ellickson KA. Psychological monitoring of overtraining and staleness. *Br J Sports Med.* Sep 1987;21(3):107-114.

7. Lehmann M, Foster C, Keul J. Overtraining in endurance athletes: a brief review. *Med Sci Sports Exerc.* Jul 1993;25(7):854-862.

8. Gonzalez-Boto R, Salguero A, Tuero C, Gonzalez-Gallego J, Marquez S. Monitoring the effects of training load changes on stress and recovery in swimmers. *J Physiol Biochem.* Mar 2008;64(1):19-26.

9. Robson-Ansley PJ, Gleeson M, Ansley L. Fatigue management in the preparation of Olympic athletes. *J Sports Sci.* Feb 16 2009:1-12.

10. Koutedakis Y, Sharp NC. Seasonal variations of injury and overtraining in elite athletes. *Clin J Sport Med.* Jan 1998;8(1):18-21.

11. Raglin JS, Morgan WP. Development of a scale for use in monitoring training-induced distress in athletes. *Int J Sports Med.* 1994;15(2):84-88.

12. Hooper S, Mackinnon L, Howard A. Physiological and psychometric variables for monitoring recovery during tapering for major competitions. *Med Sci Sports Exerc.* 1999;31:1205-1210.

13. Halson SL, Jeukendrup AE. Does overtraining exist? An analysis of overreaching and overtraining research. *Sports Med.* 2004;34(14):967-981.

14. Kellmann M, Kallus K. *Recovery- Stress Questionairre for participants: users manual*. Champaign, IL: Human Kinetics; 2001.

15. Kimball A, Freysinger V. Leisure, stress, and coping: the sport participation of collegiate student-athletes. *Leisure Sciences.* 2003;25:115-141.

16. Meeusen R, Duclos M, Gleeson M, Rietjens G, Steinacker JM, Urhausen A. Prevention, diagnosis, and treatment of the Overtraining Syndrome. *Eur J Sport Sci.* 2006;6(1):1-14.

17. Steinacker JM, Lormes W, Kellmann M, et al. Training of junior rowers before world championships. Effects on performance, mood state and selected hormonal and metabolic responses. *J Sports Med Phys Fitness.* Dec 2000;40(4):327-335.

18. Kellmann M, Gunther KD. Changes in stress and recovery in elite rowers during preparation for the Olympic Games. *Med Sci Sports Exerc.* Mar 2000;32(3):676-683.

19. Costill DL, Flynn MG, Kirwan JP, et al. Effects of repeated days of intensified training on muscle glycogen and swimming performance. *Med Sci Sports Exerc.* Jun 1988;20(3):249-254.

20. Garcin M, Fleury A, Billat V. The ratio HLa : RPE as a tool to appreciate overreaching in young high-level middle-distance runners. *Int J Sports Med.* Jan 2002;23(1):16-21.

21. Foster C, Florhaug JA, Franklin J, et al. A new approach to monitoring exercise training. *J Strength Cond Res.* Feb 2001;15(1):109-115.

22. Wallace L, Coutts A, Bell J, Simpson N, Slattery K. Using Session-RPE to Monitor Training Load in Swimmers. *Strength and Conditioning Journal.* 2008;30(6):72-76.

23. Jurimae J, Maestu J, Purge P, Jurimae T. Changes in stress and recovery after heavy training in rowers. *J Sci Med Sport.* 2004(7):334-339.

24. Coutts AJ, Wallace LK, Slattery KM. Monitoring changes in performance, physiology, biochemistry, and psychology during overreaching and recovery in triathletes. *Int J Sports Med.* Feb 2007;28(2):125-134.

25. Hartwig TB, Naughton G, Searl J. Load, stress, and recovery in adolescent rugby union players during a competitive season. *J Sports Sci.* Aug 2009;27(10):1087-1094.

26. Mujika I, Padilla S, Pyne D, Busso T. Physiological changes associated with the pre-event taper in athletes. *Sports Med.* 2004;34(13):891-927.

27. Copstead L, Banasik J. *Pathophysiology*. 3rd ed. Philadelphia, PA: Elsevier Saunders; 2005.

28. Santhiago V, da Silva AS, Papoti M, Gobatto CA. Responses of hematological parameters and aerobic performance of elite men and women swimmers during a 14-week training program. *J Strength Cond Res.* Jul 2009;23(4):1097-1105.

29. Burke E, Falsetti H, Feld R. Blood testing to determine overtraining in swimmers. *Swimming Tech.* 1982;18:29-32.

30. Rushall BS, Busch JD. Hematological responses to training in elite swimmers. *Can J Appl Sport Sci.* Sep 1980;5(3):164-169.

31. Flynn MG, Pizza F, Boone Jr. J. Indices of Training Stress During Competitive Running and Swimming Seasons. *Int J Sports Med.* 1994;15:21-26.

32. Davis IV H, Orzeck T, Keelan P. Psychometric item evaluations of the Recovery-Stress Questionnaire for athletes. *Psychology of Sport and Exercise.* 2007;8(6):917-938.

33. Wallace LK, Slattery KM, Coutts AJ. The ecological validity and application of the session-RPE method for quantifying training loads in swimming. *J Strength Cond Res.* Jan 2009;23(1):33-38.

34. Eichner ER. Overtraining: consequences and prevention. *J Sports Sci.* Summer 1995;13 Spec No:S41-48.

35. Fahlman MM, Engels HJ. Mucosal IgA and URTI in American college football players: a year longitudinal study. *Med Sci Sports Exerc.* Mar 2005;37(3):374-380.

36. Brink MS, Nederhof E, Visscher C, Schmikli SL, Lemmink KA. Monitoring Load, Recovery, and Performance in Young Elite Soccer Players. *J Strength Cond Res.* Mar 2010;24(3):597-603.

37. Van Handel P, Katz A, Troup J. Oxygen consumption and blood lactic acid response to training and taper. *Swimming Science*. Champaign, IL: Human Kinetics; 1988:269-275.

38. D'Acquisto L, Bone M, Takahashi S. Changes in aerobic power and swimming economy as a result of reduced training volume. *Biomechanics and medicine in swimming*. London: E & FN Spon; 1992:201-205.

39. Haykowsky MJ, Smith DJ, Malley L, Norris SR, Smith ER. Effects of short-term altitude training and tapering on left ventricular morphology in elite swimmers. *Can J Cardiol.* May 1998;14(5):678-681.

40. Jeukendrup AE, Hesselink MK, Snyder AC, Kuipers H, Keizer HA. Physiological changes in male competitive cyclists after two weeks of intensified training. *Int J Sports Med.* Oct 1992;13(7):534-541.

41. Urhausen A, Gabriel HH, Weiler B, Kindermann W. Ergometric and psychological findings during overtraining: a long-term follow-up study in endurance athletes. *Int J Sports Med.* Feb 1998;19(2):114-120.

42. Caldwell BP, Peters DM. Seasonal variation in physiological fitness of a semiprofessional soccer team. *J Strength Cond Res.* Aug 2009;23(5):1370-1377.

43. Marques MC, Tillaar R, Vescovi JD, Gonzalez-Badillo JJ. Changes in strength and power performance in elite senior female professional volleyball players during the in-season: a case study. *J Strength Cond Res.* Jul 2008;22(4):1147-1155.

44. Gleeson M, McDonald WA, Cripps AW, Pyne DB, Clancy RL, Fricker PA. The effect on immunity of long-term intensive training in elite swimmers. *Clin Exp Immunol.* Oct 1995;102(1):210-216.