ABSTRACT

GOTTSCHALL, L. L.  Training patterns and illness during a men's collegiate basketball season. MS in Adult Fitness/Cardiac Rehabilitation, December 1999, 34pp. (C. Foster)

This study was designed to follow training patterns and the incidence of injury and illness in members of the 1998-99 University of Wisconsin-La Crosse men's basketball team during a competitive playing season. Additionally, a Rating of Perceived Exertion (RPE) and a heart rate (HR) based method of monitoring training intensity were compared. Adult male athletes (18-23 yr) participated in the study (N = 14). The relationships among illnesses/injuries, training load (weekly average), training monotony (daily mean/standard deviation), and training strain (load*monotony) were determined. The HR scores were summated into 5 training zones and converted into points. They were then compared to the points generated from the session RPE method. It was observed that a high percentage of illness/injury occurred during the first 2 weeks of the basketball season, possibly due to high values of both training load and strain at this time. The HR method for monitoring training load paralleled the RPE method of recording exercise training intensities. These results suggest that the use of the RPE and HR method are both valid and useful tools to monitor exercise training intensity, not only in individual sports, but also in team sports (e.g., basketball).
TRAINING PATTERNS AND ILLNESS DURING A MEN'S
COLLEGIATE BASKETBALL SEASON

A MANUSCRIPT STYLE THESIS PRESENTED
TO
THE GRADUATE FACULTY
UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE
MASTER OF SCIENCE DEGREE

BY
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DECEMBER 1999
Candidate:  Lori Lynn Gottschall

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science-Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature  Date

Thesis Committee Member Signature  Date

Thesis Committee Member Signature  Date

This thesis is approved by the College of Health, Physical Education, and Recreation.

Associate Dean, College of Health, Physical Education, and Recreation  Date

Director of University Graduate Studies  Date
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I would also like to thank my roommate, Suzanne. She has helped me through many hard times and picked me up when I needed it most. I truly do not know what I would have done if I had not met her. She has made my time here in La Crosse an experience to remember forever.

Most importantly, I would like to thank my Mom. She has always had faith in me and pushed me to do things I thought impossible. She has been there for me whenever I needed her and I know she will be there to guide me in the future. Thank you for always believing in me. I love you Mom!
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INTRODUCTION

Athletes usually improve their performance with training. However, when training is too severe or too prolonged, decompensation may occur. This decompensation may lead to deterioration of performance or to an increased incidence of illness or injury. When the stress of a training program becomes too great, an imbalance between exercise and recovery may occur. Athletes who overexert themselves over an extended period of time risk negative outcomes including overtraining syndrome which may affect their performance levels. Prolonged fatigue and underperformance are the most obvious symptoms of overtraining syndrome which may lead to an increased incidence of illness [8]. Performance disorders, including overtraining syndrome, are still imperfectly understood. They are most commonly observed in endurance athletes but may also occur with significant frequency in team sport athletes [7]. Strategies for monitoring the training load of athletes may allow us to understand training patterns leading to performance disorders thereby minimizing the risk of developing overtraining syndrome [3].

The recent development of the “session Rating of Perceived Exertion (RPE) method” of monitoring training offers an approach to evaluating the likelihood of overtraining in endurance athletes [3]. The session RPE method has been shown to correlate with both heart rate and blood lactate-based methods of evaluating training [5]. However, no data are available regarding the
effectiveness of this method in team sport athletes who may have very intermittent work patterns. Since overtraining syndrome may also affect these athletes [4], validating strategies for evaluating training may be beneficial for those involved in the training of team sport athletes (e.g., basketball players).

Accordingly, this study was designed to follow responses to training including injuries and illnesses in team sport athletes in order to determine whether clear relationships exist. Additionally, the researchers sought to evaluate the relationship between the session RPE method and the heart rate based method of monitoring exercise training intensities.

METHODS AND PROCEDURES

Subjects

The subjects for this study were 14 volunteers from the 1998-99 University of Wisconsin-La Crosse Division III men's basketball team. Characteristics of the subjects are shown in Table 1 which were obtained from the conjoining thesis of Suzanne Parker [9]. They were evaluated and followed over a period of 5 months (1998-99 basketball season) as part of a larger study tracking performance and physiologic changes over a basketball season. Data collection began on October 21, 1998 and ended on February 21, 1999. Each subject provided informed consent prior to participation (see Appendix A). The study had been previously approved by the UW-L Institutional Review Board. A questionnaire (see Appendix B) was given to each participant upon completion of each practice session to monitor daily training load, injuries, and illnesses.
Table 1. Preseason Descriptive Characteristics of Subjects (N = 14)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
<th>Range</th>
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<tbody>
<tr>
<td>Age (yr)</td>
<td>20.2 ± 1.5</td>
<td>19 - 23</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>191.4 ± 4.9</td>
<td>183 - 198.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>89.3 ± 7.8</td>
<td>80.7 - 102</td>
</tr>
<tr>
<td>Measured VO₂ peak (ml/kg/min)</td>
<td>51.9 ± 4.2</td>
<td>44.6 - 58.6</td>
</tr>
<tr>
<td>HR max (bpm)</td>
<td>182.4 ± 8.6</td>
<td>164 - 190</td>
</tr>
<tr>
<td>Percent Fat (%)</td>
<td>12.8 ± 2.8</td>
<td>9.1 - 17.6</td>
</tr>
</tbody>
</table>

**Testing Methodology**

Heart rate monitors were used to measure heart rate throughout selected training sessions and intersquad games [2]. In addition to keeping track of their perceived training intensity, illnesses, and injury, levels of muscular soreness and fatigue were also noted in the daily training log. Borg's 10 point category ratio scale [1] was used to score how training sessions were perceived along with the levels of muscular soreness and fatigue (see Appendix C).

The data obtained were categorized into variables of training load, training monotony, and training strain. Training load was calculated as the product of the session RPE (a global index of intensity) and the duration of training, summated over a week. Training monotony was calculated as the daily mean training load divided by the standard deviation of the training load over a week. Training strain
(the factor previously demonstrated to be associated with negative adaptations to training in cyclists and speed skaters) was calculated as the product of weekly training load multiplied by training monotony [3,6]. A comparison of longitudinal associations between illness/injuries and training parameters were made to test the hypothesis that training strain is highly related to negative adaptations to training.

Additionally, a summated heart rate score was used to compare training load calculated using the heart rate method and the session RPE method [3]. This was accomplished by summatting the duration of heart rate in five training zones (50-60, 60-70, 70-80, 80-90, and 90-100% of maximum heart rate) then multiplying the duration in each zone by a "point value" for that zone (1, 2, 3, 4 and 5, respectively) as suggested by Edwards [2]. The points derived were summated and compared to the "points" generated from the session RPE method. Each subject was evaluated during practices of differing intensities as well as during simulated competition.

**Statistical Analyses**

The statistical analysis involved the descriptive characterization of changes in training load, monotony, and strain, and the temporal matching of illness/injury to training characteristics. Since this was effectively an exploratory study, no hypothesis testing statistical procedures were used. Additionally, correlations between the session RPE and summated heart rate methods were calculated at various training loads.
RESULTS

During the first 2 weeks of practice, training load, monotony, and strain were significantly elevated. After this period a relatively constant value was maintained over the remainder of the season (see Figures 1-3).

Figure 1. Average weekly load over the season

Figure 2. Average weekly monotony over the season
Figure 3. Average weekly strain over the season

The incidence of illness/injury was greatest during the first two weeks when both the team average weekly load and strain were elevated. Figure 4 demonstrates that approximately 50% of the athletes experienced some type of illness.

Figure 4. Percentage of ill athletes over the season
(e.g., cold or flu) during the first 2 weeks of practice. This may signify overtraining; however, it could also represent a virus spreading throughout campus which is affecting many students, not just athletes. As shown in Figure 5, injuries were also high (40-50%) during the first 2 weeks; however, the

![Graph showing percentage of athletes experiencing injuries over the season.](image)

Figure 5. Percentage of athletes experiencing injuries over the season incidence of injuries varied throughout the season ranging from 10-40% of the team experiencing some type of injury. An average of approximately 25% was demonstrated following the first 2 weeks of practice. This variability could be due to old injuries prior to the beginning of the season and may not necessarily reflect the overtraining syndrome. When the training load exceeded an average of above 2500 units per week, the percentage of healthy athletes dropped drastically (see Figure 6). Additionally, if the average weekly strain exceeded
Figure 6. Relationship of healthy athletes vs. weekly load

3000 units per week, the percentage of healthy athletes continually dropped. A training threshold is demonstrated by a downward slope when approximately 2000 units per week is achieved (see Figure 7).

Although the absolute values are different, the heart rate method for monitoring training load generally correlates with the RPE method for assessing exercise training intensities (see Figure 8). Therefore, it is safe to assume that the use of the RPE method is a valid and useful tool to determine exercise training intensities, not only in individual sports, but also in team sports (e.g., basketball).
Figure 7. Relationship of healthy athletes vs. weekly strain

Figure 8. Relationship of HR and RPE methods of monitoring exercise training
DISCUSSION

Many people, including athletes, become sick for a variety of reasons including viral and bacterial infections. Therefore, the occurrence of illness may not necessarily be related to the presence of overtraining syndrome. However, in this study almost 50% of the athletes experienced some type of illness (e.g., cold or flu) during the first 2 weeks of practice. This increase in the incidence of illness paralleled the elevated levels of both weekly load and strain. This may be related to immunosuppression during periods of heavy training that in turn makes an athlete more susceptible to illness [3].

Many studies show that athletes acquire a belief that in order to improve performance they have to work harder. The results of the present study indicate that when both the weekly load and strain levels increased beyond certain points, the percentage of healthy athletes decreased drastically. If the weekly load were to be kept below 2500 units per week a greater percentage of the athletes would remain healthy. Also, it appears that if the weekly strain were to be kept below 3000 units per week, fewer athletes would become ill.

Coaches need to be aware of how hard they are training their athletes and make adjustments as needed. Many athletes are quite familiar with the term “hell week” which usually occurs in the first 2 weeks of practice. This is when coaches push athletes the hardest and try to get them into the best physical condition for the upcoming season. However, coaches need to take into account that pushing
athletes into a training zone to which they are not accustomed can provoke unnecessary illness and injury.

In this study, the heart rate method for monitoring training load paralleled the RPE method for assessing exercise training intensity. The evaluation of exercise training outcomes requires a quantitative index of intensity, frequency, and duration. However, intensity has been the most difficult to determine. As an alternative to HR, the RPE method is commonly used to monitoring exercise intensity. Foster concluded that the session RPE method may be a useful global index of exercise training intensity in cyclists and speed skaters [3]. The current study suggests that the RPE method is a useful tool to monitor exercise training in basketball players.

SUMMARY

The current study monitored HR and RPE responses to training as well as the incidence of injury and illness over the course of a 17-week basketball season. It was observed that a high percentage of illness/injury occurred during the first 2 weeks of the basketball season, possibly due to high values of both training load and strain at this time. The HR method for monitoring training load paralleled the RPE method of recording exercise training intensities. These results suggest that the RPE and HR methods are valid and useful tools to monitor exercise training intensity, not only in individual sports, but also in team sports (e.g., basketball).
Much of the current literature contains information concerning endurance or elite athletes. Few studies have been completed that have monitored team sport athletes as in the current study. This would suggest the need for more research in this related area in the future.
REFERENCES


8. N C C Sharp British Medical Centre, Northwick Park Hospital, Harrow, UK Y Koutedakis School of Health Sciences Wolverhampton Polytechnic. Sport and the overtraining syndrome: Immunological aspects. UK British Medical Bulletin 1992; 48(3): 518-33

APPENDIX A

INFORMED CONSENT FORM
INFORMED CONSENT FORM

The University of Wisconsin - La Crosse
La Crosse, Wisconsin

PHYSIOLOGICAL, PERFORMANCE, AND TRAINING
RESPONSES DURING A MEN'S BASKETBALL SEASON
(Suzanne E. Parker and Lori L. Gottschall)

I, ___________________________, give my informed consent to participate in this study to determine the physiological, performance, and training adaptations that occur over a basketball season. I have been informed that throughout this study my identity and the results of my performance will be kept confidential. I consent to publication of the study results so long as the information is anonymous and that no identification of the individual subjects will be made.

This study will measure my VO$_2$$_{max}$ via a treadmill test, my jumping ability, my basketball specific fitness, my body composition, and my heart rate response during practice and an intersquad game and how I respond to training.

My maximal aerobic power (VO$_2$$_{max}$) will be determined on a treadmill test which will consist of walking/running to voluntary fatigue on a motor-driven treadmill. Beginning from very easy effort the speed and grade of the treadmill belt will be increased until I become fatigued.

During the exercise testing, I will breathe room air through a scuba type mouthpiece with my nose clamped so that my exhaled air can be collected and analyzed. Although this test will require maximal effort, I have been informed that I can stop the test anytime I wish. I will have several skinfold thickness and girths measured to determine body composition. I will perform a standard vertical jump test and a basketball specific functional fitness test. I will also answer questions regarding my response to daily training sessions and injuries and illness I might experience. The anticipated risk involved in this study is fatigue from laboratory testing. Although severe complications (e.g., cardiac arrest) are theoretically possible, their occurrence in young athletes is very infrequent (<1/10,000 tests).
I have been informed that my heart rate will be monitored with a heart rate monitor which will be strapped to my chest at about heart level. Heart rate response may be measured at various times including laboratory evaluations, practice and an intersquad game. Other than the possible discomfort of the strap, there should be no interference with my ability to play basketball.

All testing sessions will be scheduled at my convenience and will be supervised/conducted by Suzanne Parker and Lori Gottschall, graduate students enrolled in the Adult Fitness/Cardiac Rehabilitation graduate program under the direction of Carl Foster, Ph.D.

To my knowledge, I do not possess any disabilities or physical limitations, especially heart conditions, which would preclude me from participation in this study. I have been informed that muscle fatigue, strains, and sprains may occur. Also, I have been informed there is a chance of serious complications during exercise testing (e.g., heart attack) but the risk of this is low (<1/10,000 tests).

I have read the above statements and understand them. Any questions I might have had have been answered. I have been informed of the potential risks and their implications. I voluntarily consent to participate in this study. I have been informed that I may withdraw at any time without any type of penalty.

Further, I have been informed that neither participation in this study nor the results of these tests will influence my chance of being selected to the 1998-99 UW-La Crosse men’s basketball team.

Any concerns or questions that may arise throughout the study may be referred to the primary researchers, Suzanne Parker or Lori Gottschall at (608) 785-3954 or the thesis advisor, Carl Foster, Ph.D. at (608) 785-8687.

NAME: ____________________________ DATE: ________________
WITNESS: _________________________ DATE: ________________
WITNESS: _________________________ DATE: ________________

Contact Garth Tymeson, UW-L IRB Chair, if you have questions about the protection of human subjects (608) 785-8155.
APPENDIX B

DAILY TRAINING QUESTIONNAIRE
DAILY TRAINING QUESTIONNAIRE

Training Patterns and Illness During a Men’s Collegiate Basketball Season

NAME _____________________________________________

DATE _____________________________________________

1. According to Borg’s RPE scale, how would you rate the intensity of today’s practice?

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<tbody>
<tr>
<td>0</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Rest</td>
<td>Easy</td>
<td>Moderate</td>
<td>Sort of Hard</td>
<td>Hard</td>
<td>Very Hard</td>
<td>Maximal</td>
<td></td>
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2. Are you currently experiencing some sort of illness?

   Yes____   No____

   If so, what? ________________________________________________

3. Are you suffering from any injuries?

   Yes____   No____

   If so, what? ________________________________________________
APPENDIX C

BORG’S RATING OF PERCEIVED EXERTION CHART
Borg's Rating of Perceived Exertion (Borg, 1982)

0    Rest
1    Very Easy
2    Easy
3    Moderate
4    Somewhat Hard
5    Hard

7    Very Hard
8
9

10   Max
APPENDIX D

REVIEW OF LITERATURE
If you are an endurance athlete, then probably at some point in your athletic career you have been overtrained. What athletes do not realize is that training too hard to improve performance can be counterproductive. When training is too severe or too prolonged, decompensation may occur. This decompensation may lead to deterioration of performance or to an increased incidence of illness or injury.

Technically, overtraining is an imbalance between exercise and recovery in which the stress of a person's training program exceeds the body's limits [1]. Intensive interval training of 1 to 6 minutes hard exercise with little to no rest is most likely to cause the overtraining syndrome [2]. The overtraining syndrome has also been referred to as "staleness," "overreaching," "burnout," and "chronic fatigue" [2,3,17]. However, there are distinct differences among the terms. Two forms of the overtraining syndrome are apparent. However, the terms are generally not used due to lack of evidence for a separate parasympathetic type [3]. Common in sprint type sports is the sympathetic form. This is a response to prolonged stress and normally elevates the resting heart rate [3,24]. However, the resting heart rate is decreased in the parasympathetic form. This form is common in endurance sports [20,24] and characterized by hypoglycemia during
exercise [3]. Although there are differences between the two forms, decreased overall performance and increased fatigue are common to both.

Overtraining is usually associated with both elite and endurance athletes but the condition can affect exercisers in any sport [1,9,13]. Similar symptoms can occur in recreational athletes who exhibit different levels of skill and performance. According to Hendrickson and Verde [13] and Fry, Morton, and Keast [10], nonelite athletes may be more susceptible to these types of problems because their exercise routines have to be intertwined with many other activities and stresses throughout their daily activities. Keep in mind, however, that overtraining for one athlete may be insufficient for another [1].

In diagnosing overtraining, there is really no test that can pinpoint the cause, but there are plenty of warning signs that should be monitored [1]. Fry et al. [10] suggest that the monitoring of only one or two variables would not prevent overtraining. However, overtraining symptoms may be due to the athletes’ type of sport, genetic and phenotypic differences, psychological profile, level of performance, and personality [10]. Prolonged fatigue and underperformance are the most obvious symptoms of overtraining syndrome, which may inevitably lead to an increased incidence of illness [1,2,21,23]. Athletes will often ignore fatigue, heavy muscles, and depression until performance is chronically affected and more serious symptoms occur [2,10]. Coaches and trainers also need to realize that not all athletes will have the same symptoms, but there is still little consensus about how to diagnose this disorder [6,10,18]. The warning signs of
overtraining have been broken down into three basic areas: psychological, physiological, and performance symptoms.

The psychological symptoms associated with overtraining are more difficult to detect than the physiological ones [17]. According to the literature, psychological overtraining is characterized by sleep disturbances/insomnia [6,13], chronic fatigue, and apathy [1,17]. In addition, loss of self-confidence, irritability, depression [6,13], anxiety, and confusion are also exhibited [17]. In a study of 52 patients who presented with overtraining or fatigue, 19% of them were diagnosed with depression [13]. An overtrained athlete may also lose their drive and love for the game, become angry and possibly hostile. One of the more obvious symptoms is the mood of the athlete or their approach toward the sport in which they participate [17,21].

Many physiological symptoms of overtraining are reviewed in the literature. These include an elevated resting heart rate, weight loss, increased injuries [1,17], and changes in normal blood pressure [2,6,17]. Johnson and Thiese stated that both an increase and decrease [3] in resting blood pressure occurred in overtrained athletes [17]. Overtraining can also lead to decreased immunity [12,17,18]. This can be brought on by a decrease in the white blood cell count. Therefore, heavy training or overtraining can reduce the efficiency of the immune system [2,10,18,23]. Immunosuppression can also be caused by elevated cortisol levels and reduced plasma glutamine levels [3]. An increased incidence of colds, allergic reactions, and other infections has also been associated with overtraining [17].
The causes of overtraining syndrome are associated with physical training and competition that in turn can present some performance symptoms. They include a decreased performance level, delayed recovery from training, and intolerance to training [1]. Physical training and competition can also provoke the overtraining syndrome through the length of the competitive season, training monotony [2,21], lack of positive reinforcement, high levels of competitive stress, and stringent rules [17]. There are ways for detecting overtraining to which the coach and staff may not have immediate access. Therefore, in addition to a systematic and objective approach to the monitoring of training performance, the coach's empathy and interpersonal relationship with the athlete is an important tool in the prevention of overtraining [5]. The athletic trainer is also a key component when it comes to monitoring athletes for the overtraining syndrome. Through the athletic trainer, the coach can monitor the athletes and direct their training toward eliminating and preventing overtraining.

Recognizing the overtraining syndrome may be important to its prevention but this is only the first step. To prevent or reverse overtraining and to decrease the chance of injury and illness, the training quality, quantity, and frequency need to be individually assessed [23]. Other factors including diet and psychological status also need to be taken into consideration [23]. One of the easiest treatments for overtraining and currently the only known way to cure the symptoms of overtraining is rest [18]. If the overtraining has occurred over a long period of time then more rest is required [3,24]. This may mean that a reduction
in training may be necessary to allow adequate recovery from injuries or illnesses [17]. Usually three to five days is sufficient rest when overtraining has occurred for only a short period of time [19,24]; however, a gradual approach to recovery tends to work best [1]. Five weeks of rest has been shown to improve both performance quality and attitude but evidence has shown that low levels of exercise during this period will speed the recovery process [1,17]. Athlete compliance is also another important factor to take into consideration. Informing the athlete that improvement will not occur overnight is very crucial [13]. It is important that the factors causing the overtraining be identified and corrected; otherwise the overtraining syndrome is more than likely to reoccur. Many coaches suggest alternate-day hard and light practices to prevent overtraining [2,19].

Avoiding overtraining can be easily accomplished; however, the athlete needs to take control over his life and all the stressors in it. Training levels must be carefully monitored, stressors minimized, and adequate rest must be attained. In the long run, it is better to be undertrained than overtrained [3,19,24].

Many studies have been completed that look at the overtraining syndrome and its characteristics. The following studies have been done concerning various aspects of the overtraining syndrome and athletes.

Foster [7] monitored training in athletes by relating injuries and illnesses to different types of training. The athletes recorded their training levels using the RPE method. It was found that increased training load, monotony, and strain
above individual training thresholds were associated with increased levels of illness [7]. Foster concluded that monitoring different training characteristics may allow athletes to continue with training but also know when overtraining is occurring.

Callister et al. [4] performed a study on judo athletes to determine if any effects occurred in sudden increases in training volume on performance. The use of overtraining syndrome symptoms to monitor performance changes was also tested. Fifteen subjects were evaluated over a period of 10 weeks with interval and resistance training volumes increased throughout. The performance characteristics measured did not change significantly with increased training volume [4]. Callister et al. concluded that overtraining may or may not affect performance. The authors stated that performance, however, might be affected before symptoms of the overtraining syndrome appear [4].

A study by Steinacker et al. [27] demonstrated how the overtraining of rowers before world championships can be avoided. Competitive rowing involves approximately 70% of the body's muscle mass in a period of less than 10 minutes at a very high power output [27]. Training load was increased along with prolonged training (3 hours/day) at least 2-3 weeks prior to competition [27]. This was prime time for the overtraining syndrome to take effect. Fortunately, a combination of crosstraining, alternate hard and easy training days, and rest were incorporated into the exercise regimen to reduce the risk of overtraining.

A recent longitudinal study by Gabriel et al. [11] investigated whether the
overtraining syndrome had any effect on the immune system. Laboratory methods (immunophenotyping and flow cytometry) along with a self-learning classification system helped in determining the overtraining syndrome. Results indicated that there were no significant differences between immune cells in the overtrained versus trained athletes [11]. Gabriel et al. [11] concluded that overtraining did not alter immunophenotypes and that a decrease in immunity was not detected.

Parry-Billings et al. [25] recently conducted a study on glutamine concentration in the overtraining syndrome and the possible effects on the immune system. Glutamine is an essential amino acid for rapidly dividing cells such as lymphocytes [2] and a key fuel for the cells of the immune system [25]. All subjects were diagnosed as experiencing poor athletic performance, fatigue, depression, irritability, and insomnia. Subjects participated in a wide variety of sports, including middle and long distance running, swimming, rowing, cycling, race-walking, squash, and sprint running [25]. Blood samples were taken from both control subjects and overtrained athletes. Glutamine levels were decreased in overtrained athletes after long-term exercise; however, glutamine levels increased after short-term exercise [2,25]. Parry-Billings et al. concluded that the decrease in glutamine in overtraining might be related to the immunosuppression that occurs in the overtraining syndrome [25].

Rowbottom et al. [26] performed a study similar to Parry-Billings et al. dealing with different haematological, biochemical, and immunological tests. The
data showed that there was no change in any of the blood parameters usually associated with exercise stress in subjects experiencing overtraining. However, the glutamine levels were significantly higher from the normal range [26]. Rowbottom et al. stated that they are unsure at this time whether any correlation exists between glutamine levels and symptoms of overtraining [26].

A 1995 study by Mackinnon and Hooper [22] proposed to determine the effects of intensified training on glutamine levels and if these levels contribute to respiratory infections in swimmers. Decreased performance and fatigue in 8 of the 24 subjects demonstrated overtraining. It was found that only 1 overtrained athlete developed a respiratory infection during the study [22]. Glutamine levels were lower in overtrained compared to trained swimmers, but there was no difference in glutamine levels between athletes who got sick and those who did not. This study suggested that glutamine levels may not always decrease when the training level or intensity is increased [22].

Glutamine concentrations in athletes from different sports were reported in a study by Hiscock and Mackinnon [14]. They compared resting glutamine levels in athletes from different sports (distance runners, swimmers, cyclists, powerlifters, and nonathletes) to determine if a relationship existed between glutamine levels and dietary protein consumption. Glutamine levels differed among athletes from different sports [14] with cyclists having the highest and powerlifters and swimmers having the lowest. No relationship existed between dietary protein consumption and glutamine levels. This demonstrated that levels
of glutamine may vary in athletes from different sports but this also may be due to the demands of each sport [14].

Measurement of substrates, enzyme activities, and other parameters are often used to diagnose or prevent overtraining syndrome [28]. The role of hormones in the overtraining syndrome is still not fully understood [2]. A study by Hooper et al. [15] measured the hormonal responses of elite swimmers to overtraining over a 6-month season. Stress hormones, such as adrenaline and cortisol, have been shown to increase in overtrained athletes [2]. In the study by Hooper et al., no significant differences were seen in norepinephrine and cortisol concentrations in response to overtraining [15]. Three of the 14 swimmers experienced overtraining along with norepinephrine levels being higher than others. Although this evidence is not confirmed, norepinephrine may be an indicator of overtraining syndrome in the future [15].

The recent development of the "session Rating of Perceived Exertion (RPE) method" of monitoring training offers an approach to evaluating the likelihood of overtraining in endurance athletes [7]. A study by Foster, Fitzgerald, and Spatz [8] demonstrated that the session RPE method correlates with both heart rate and blood lactate based methods of evaluating training.

A study done by Foster [7] compared the effectiveness of the session RPE and HR methods. The subjects included primarily speed skaters who were monitored throughout the season. The results indicated that the HR method of monitoring training load paralleled the RPE method of recording exercise training
intensities [7]. These results suggest that the use of the RPE and HR method are both valid and useful tools to determine exercise training.

Another study by Jackson et al. [16] illustrated the relationship of the HR and RPE methods before and during a 1.5 mile run in college-age male subjects. Results show a linear relationship between both HR and RPE responses as a function of cumulative time and distance; however, very little significance was found between the two during the run [16].

**SUMMARY**

The review of literature addresses many different aspects of the overtraining syndrome and athletes. Prevention is the key to overtraining, but is not always possible in athletes who strive for the best. Overtraining can be largely avoided, just by training smart and paying attention to your body. Remember, smart training is the path to faster times and good health.
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