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Using the maximal vertical jump test to evaluate training and fatigue in collegiate soccer players| A series of case studies

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USING THE MAXIMAL VERTICAL JUMP TEST TO EVALUATE TRAINING AND FATIGUE IN COLLEGIATE SOCCER PLAYERS, A SERIES OF CASE STUDIES

By

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USING THE MAXIMAL VERTICAL JUMP TEST TO EVALUATE TRAINING AND FATIGUE IN COLLEGIATE SOCCER PLAYERS, A SERIES OF CASE STUDIES

Chairperson: Steven E. Gaskill

An effective and simple mode for coaches to monitor training and fatigue in his or her athletes in the team sport setting has yet to be developed. It is imperative for coaches to avoid overtraining their athletes, and to help them achieve peak physical performance at the time of competition. PURPOSE: The purpose of this study was to use the maximal vertical jump test (VJ) to identify patterns related to overreaching and overtraining in female collegiate soccer players. METHODS: Twenty-three members of The University of Montana women's soccer team (age 19.4±1.3 years) served as subjects for this study. Subjects were monitored for 12 weeks during the NCAA collegiate soccer season consisting of regular training sessions and 17 games. Data collection occurred on a daily basis during pre-season training and weekly during the regular season. VJ, resting (RHR) and submaximal exercise heart rates (EHR), hours of sleep, and mood state questionnaire data were collected 17 times during the season. RESULTS: Mean data shows a positive correlation between VJ and hours of sleep (r = 0.45), positive affect (r = 0.41) and positive mood state (r = 0.41). A negative correlation was found between VJ and negative mood state (r = -0.48). There was no significant correlation between VJ and RHR or EHR. Individually, a strong, positive correlation was shown for six players between VJ and hours of sleep, five players for VJ and positive affect, and six players for VJ and positive mood state. A strong, negative correlation was found between VJ and negative mood state for five players. CONCLUSION: Findings of this examination suggest that in a team sport setting there is individual variability in response to internal and external stressors during the course of the season. Athletes require individualized training programs in addition to frequent monitoring by coaches to avoid overtraining.

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Thank you to my committee members, Dr. Steven Gaskill, Dr. Arthur Miller, and Dr. James Laskin for all of your support and guidance throughout the process of this research, as well as the entire hectic two years at The University of Montana.

Thank you, Steve, for serving as a true inspiration and mentor to me in the past two years. Thank you for believing in me when I chose to abandon old laboratory projects and replace them with new, practical, field research. Thank you for helping me on those cold, October mornings at 6:30am with data collection, and most importantly thank you for being there to help me whenever I needed it.

Thank you to coach Neil Sedgwick and The University of Montana women's soccer team for their enthusiastic participation in this study. I hope that the findings of this study may serve as a basis for alterations in subsequent seasons' practice and scrimmage schedules to minimize the training stress and maximize performance.

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Chapter One

Introduction

Introduction:

Competitive soccer is an activity that requires the athlete to possess high levels of aerobic endurance, speed, agility, power, as well as skill. Past research that focused on the physical demands of soccer has led investigators to define soccer as an intermittent, high-intensity exercise (Dupont, Akakpo, and Berthoin, 2004; Krustrup, Mohr, Ellingsgaard, and Bangsbo, 2005; Siegler, Gaskill, and Ruby, 2003). This type of intermittent exercise performed in soccer involves a change in speed and/or direction every four to six seconds (Mohr, Krustrup, and Bangsbo, 2005). As a consequence of the physical demands of soccer, conditioning programs require that aerobic capacity, strength, power, speed, and speed endurance be developed as fundamental components of physical conditioning (Kraemer, French, Paxton, Hakkinen, Volek, Sebastianelli, Putukian, Newton, Rubin, Gomez, Vescovi, Ratamess, Fleck, Lynch and Knuttgen, 2004). It is imperative for athletes to train knowledgably in order to peak at the time of competition and avoid the detrimental effects of overtraining.

Overtraining can be defined as an imbalance of time spent in training and competition compared to recovery time. An acute bout of overtraining is defined as overreaching, and is often used by athletes during a typical training cycle to enhance their performance (Halson and Jeukendrup, 2004). This acute bout of overtraining, when accompanied by a decrease in training and an appropriate recovery period, can lead to physiological overcompensation and improved performance (Hoffman and Kaminsky, 2000). Chronic overtraining, also known as overtraining syndrome, can occur when excessive training loads are not followed by adequate recovery time.

The initial stages of overtraining syndrome are generally accompanied by subjective feelings of fatigue and staleness, which then procede to a decrease in performance (Hoffman and Kaminsky, 2000). It has also been suggested that intrinsic sympathetic activity, receptor sensitivity to catecholamines and adrenal sensitivity to adrenocorticotropic hormone (ACTH) decrease in the overtraining state, resulting in performance incompetence and high fatigue ratings (Uusitalo, Uusitalo and Rusko, 2000). Other physiological findings affiliated with overtraining syndrome include glycogen deficit, catabolic/anabolic imbalance, neuroendocrine imbalance, amino acid imbalance, autonomic imbalance, altered mood state, increased rate of infections, and suppressed reproductive function (Lehmann, Lormes, Opitz-Gress, Steinacker, Netzer, Foster and Gastmann, 1997). The suffering athlete may also have an increased basal metabolic rate, loss of body weight associated with a negative nitrogen balance, as well as a delayed exercise pulse-rate to resting pulse-rate recovery (Hartmann and Mester, 2000).

Although a number of physiological, hormonal, biochemical, and psychological factors have been proposed as potential markers of overtraining, these factors have generally been examined using an aerobic model. Research using an anaerobic model is still lacking. The development of a monitoring and testing program may be easier to accomplish when the testing consists of performance tests that coaches and athletes are familiar with and can be performed easily on the practice field or court, as opposed to complex laboratory and/or invasive testing (Hoffman and Kaminsky, 2000). Filaire, Bernain, Sagnol and Lac (2001) also suggested that in order to prevent overtraining and to ensure that the conditioning program results in performance improvements, it is necessary to include regular performance tests as a component of the training program.

Statement of the Problem:

Several methods of monitoring training and overtraining in athletes have been used in past research. Field data self reports of mood state and feelings of self-worth, heart rate and blood pressure variability, aerobic capacity tests, submaximal step tests and performance tests have been used in the past. On the other extreme, extensive laboratory testing that involves the monitoring of such biomarkers as creatine kinase, myosin, testosterone, cortisol, and muscle glycogen have also been successfully used as markers of overtraining. Several of these laboratory methods involving testosterone and cortisol have become quite reliable, but yet complicated and expensive for athletic programs. These chemical tests are available to identify the overtraining syndrome after it has already occurred, but cannot be used for prevention. The need is for a quick, easy, inexpensive, and most importantly, reliable method of monitoring and/or predicting overtraining. However, this method has yet to be developed and validated.

Purpose:

The purpose of this project was to determine if maximal vertical jump height correlates with resting heart rate, exercise heart rate, hours of sleep and overall mood state in females during the course of a collegiate soccer season, and can therefore be used as a marker and/or predictor of overtraining in female college soccer players.

Research Hypothesis:

Maximal vertical jump height of the athlete will be strongly correlated with mood state questionnaire data, resting and submaximal heart rates, and hours of sleep.

Limitations:

1. There is an inherent error associated with all instrumentation.
2. The sample of subjects used for this study was not randomly selected. All subjects were member of The University of Montana varsity women's soccer team.
3. Mood state questionnaires were representative of feelings and/or symptoms that are associated with the overtraining syndrome. Properly assigning numerical units to quantify subjective feelings of the athlete is a task that will never be perfected.
4. Debilitating injuries and/or minor aches and pains are inevitable during the course of an intense collegiate soccer season. Numerous data points are missing due to the fact that on certain occasions athletes were instructed by coaches and athletic trainers not to participate in the days date collection due to aches and pains associated with the competitive season.
5. All in-season data collection took place on Tuesday mornings between 6:30am-7:00am. On several occasions, the subjects only arrived home late Sunday evening or early Monday morning from weekend travel games in which they left for on Thursday. On other occasions, the team may have been

in town for home games or off from competition. Therefore, physical and mental stress associated more with traveling than physical conditioning may have occurred. Travel patterns were not consistent throughout the season and data collection.

6. Menstruation periods, or lack of, were not monitored throughout the study. Certain phases of the menstrual cycle may influence both feelings of self-worth and overall mood state, as well as physical performance.
7. There was no clinical assessment of overtraining conducted during this study and there was no true diagnosis of the overtraining syndrome attempted during this study.

Delimitations:

The focus of this study was aimed towards determining if there is a correlation between maximal vertical jump height and mood state questionnaire data, resting and submaximal heart rates, and hours of sleep in National Collegiate Athletic Association Division I female college soccer players. The results may not be generalizable to other populations that are not similar to those of the sample used.

Definition of Terms:

Overreaching: An accumulation of training and/or non-training stress resulting in *short-term* decrement in performance capacity with or without related physiological and psychological symptoms of overtraining in which restoration of performance capacity may take from *several days to several weeks* (Halson and Jeukendrup, 2004).

Overtraining: An accumulation of training and/or non-training stress resulting in *long-term* decrement in performance capacity with or without related physiological and psychological symptoms of overtraining in which restoration of performance capacity may take *several weeks or months* (Halson and Jeukendrup, 2004).

Overtraining Syndrome: A serious problem marked by decreased performance, increased fatigue, persistent muscle soreness, mood disturbances, and feeling 'burnt out' or 'stale' (Uusitalo, 1991).

Chapter Two:

Review of Literature

Vertical Jump and Overtraining:

In 1990, Callister, Callister, Fleck and Dudley conducted the first study of its kind in which 15 national or international level judo athletes (men n = 8, women n = 7) were trained to a point of deliberate overtraining. Several physiological and performance responses were assessed during weeks 2, 4, 8, and 10 of the 10-week training protocol. Submaximal and maximal aerobic power, resting systolic and diastolic blood pressures, resting, submaximal, and maximal heart rates, exercising blood lactate levels, and vertical jump performance did not change significantly with increases in training volume during the deliberate state of overtraining. Data suggests that overtraining may affect some, but not all, aspects of performance.

Hoffman, Fry, Howard, Maresh, and Kraemer (1991) looked at strength, speed, and endurance changes in male athletes during the course of a Division I collegiate basketball season. Nine male athletes (mean age 18.8 ± 0.7 years) were used as subjects, and measured variables during the season were T-test, vertical jump, 27-meter sprint, and several tests of maximal strength. Results showed that vertical jump height significantly decreased in-season when compared to pre-season testing.

Fry, Morton, Garcia-Webb, Crawford, and Keast (1992) used five subjects that were exercised to an intentional overtrained state to determine decreases in performance. After 10 days of two-a-day exercise sessions, there was a significant drop in time to exhaustion on a treadmill at 18 km/hour and 1% grade.

Bosco, Tihannyi and Viru (1996) investigated the relationship between field fitness tests and blood levels of testosterone and cortisol in soccer players. Testosterone/cortisol ratio disturbances, specifically increases in cortisol, have been accepted as biomarkers of overtraining (Maso, Lac, Filaire, Michaux and Robert, 2004; Sims, 2001; Stone, Keith, Kearney, Fleck, Wilson and Triplett, 1991; Foster, 1998; Meeusen, Piacentini, Busschaert, Buyse, De Schutter and Stray-Gundersen, 2004). Thirty-two professional male soccer players were used as subjects in this study. Field tests that were used were vertical jump, 30-meter sprint, and 12-minute run, representing power, speed, and aerobic capacity, respectively. As hypothesized, increases in cortisol showed to be correlated with a decrease in performance on the field tests while increases in testosterone showed to be correlated with increased performance on the tests.

Chicharro et al (1998) conducted research looking at overtraining markers including hematological and hormonal parameters, aerobic and anaerobic tests, and strength and power in special military units. Forty-two conscripts from special units of the Spanish Army served as subjects. No significant differences were found in maximal vertical jump height between the overtrained group and the non-overtrained group after an intense 8-week training protocol, However, a significant improvement in vertical jump performance was found in the non-overtrained group after the training period, but there was no significant improvement in the overtrained group after the training period. Researchers suggested that vertical jump tests could be used to detect early states of overtraining.

In 2004, Kraemer et al conducted a study involving the monitoring of male collegiate soccer players during a Big Ten soccer season. Subjects consisted of 25 athletes including starters (mean age 19.91 ± 0.9 years) and non-starters (mean age 18.71 ± 0.9 years). Measures of physical performance that were conducted were isokinetic and isometric strength, sprint speed, and vertical jump. Body composition, as well as hormonal concentrations (testosterone, cortisol), were also monitored throughout the season. Data was collected for each variable pre-season, four times during the season, and post-season. Isokinetic leg strength decreased during the course of the soccer season for starters (S) and nonstarters (NS). There was no difference in isometric leg strength or sprint speed for either the S or NS groups. There was a significant decrease in vertical jump performance in S from baseline to the end of the competitive season (trial 5). There was no difference for NS. Significant increases in testosterone levels were observed during the season for S and NS. There were no significant changes in plasma cortisol concentrations during the course of the season, with the exception of trial 4 for S.

Overtraining Research:

Uusittalo, Huttunen, Hanin, Uusitalo and Rusko (1998) identified elevated cortisol levels in athletes that were deliberately trained to the point of overtraining. Fifteen female endurance athletes served as subjects for this study, and the training protocol lasted for 6-9 weeks, dependent on how long it took each individual to show signs of overtraining. The researchers suggested that hormone responses to exercise load are superior in indicating heavy training-induced stress when compared with resting hormone levels.

Further analysis of the previous study was conducted by Uusitalo, Usistalo and Rusko (2000) that investigated changes in $VO_{2\,max}$, as well as heart rate and blood pressure variability during heavy training and overtraining in the female athlete. Subjects were monitored for changes in $VO_{2\,max}$, heart rate and blood pressure variability in an intended state of overtraining (n = 9), or as a control (n = 6). Of the nine overtrained athletes, five of them had a 4-9% decrease in $VO_{2\,max}$, one was injured, one dropped out due to illness, and the other two subjects felt distressed but did not show a decrease in aerobic capacity. Heart rate and blood pressure variability both increased in the overtrained state. Six athletes also experienced amenorrhea during the course of the deliberate overtraining protocol.

A case study was conducted by Hedelin et al (2000) on a highly trained adolescent cross country skier in which heart rate variability was used an indicator of overtraining. Increases in high-frequency power determined the overtraining status. The athlete was diagnosed with overtraining syndrome after experiencing decreased performance in competition, breathlessness during training sessions, and an increased depression and tension scores in the profile of mood states assessment (POMS).

Hoffman and Kaminsky (2000) used several performance tests including the T-drill, 27-meter sprint, line drill, and 1RM strength tests (squat and bench press) to monitor overtraining in 12 elite youth basketball players (mean age 16.0 ± 0.0 years). Testing was conducted once a month for a five-month period of competition and practice. Athletes were also required to complete training logs in which both volume and intensity of practices and competitions were monitored. The 27-meter sprint appeared to be the most sensitive test for highlighting players who were fatigued. Dramatic decreases in sprint performance were noticed during months of the highest volume of training.

Heart Rate as a Marker of Overtraining:

Anecdotal reports suggests that morning resting heart rates, submaximal heart rates, and recovery heart rates can be used to calculate Fatigue Index, which correlate with an athlete's feeling about current training, his or her performance during training, as well as the occurrence of upper respiratory infections in the athletes. (Gaskill, personal communication based on personal experiences with coaching world-class Nordic skiers during the years of 1982-1987).

Results found by Hill et al (doctoral dissertation) also showed that morning resting and submaximal heart rates, or Stamina Index Test, appear to serve as valid self assessment tools to monitor training and overtraining. Eighteen biathlon and Nordic skiers (eleven females and seven males) served as subjects in the study. Results showed that a low recovery heart rate, low resting heart rate, low Stamina Index Test, and good overall feelings by the subject were associated with more sleep as well as fewer colds amongst the subjects.

Uusitalo (1999) also discussed that variance in resting and submaximal heart rates can serve as markers of overtraining. Increased heart rates during a submaximal load are suggestive that the athlete may be experiencing the first signs of the overtraining syndrome. Also, an increase or decrease in resting morning heart rate more than normal individual variation may also be a beginning sign of the overtraining syndrome.

According to Wildland Firefighter research conducted by Gaskill et al (2001), an increase of fatigue index of 30 to 40 beats per minute suggests that the athlete needs a day of reduced work, or training, stress. This increase of fatigue index (30 beats per minute +) puts the individual at a higher risk for depressed immune function and upper respiratory track infections. Both of these criteria are symptoms of the beginning stages of the overtraining syndrome.

Somerville (Masters thesis, 2005) monitored training status in adolescent swimmers with the use of the Fatigue Index Test and found it to be a useful tool. Athletes that was determined to be in the overtraining state demonstrated high mean hear rates during the step test used to determine Fatigue Index. Ranges in heart rates were generally smaller in the group in which training was determined as “effective”.

Chapter Three

Methodology

Setting:

All testing took place at The University of Montana South Campus Soccer Field.

Subjects:

Twenty-three healthy female college soccer players (mean age 19.4, standard deviation ± 1.3 years) were used as subjects for this study. A longitudinal study design was used to monitor subjects during the entire official 2-week pre-season training camp and throughout the 10-week National Collegiate Athletic Association collegiate soccer season consisting of regular training sessions and 17 games. Prior to participating in the study, players underwent physical examinations and were cleared of any medical conditions. The study was approved by the institutional review board for use of human subjects. All players received an orientation of the testing protocol prior to the beginning of the study. All subjects gave their written informed consent to participate in the study.

Approach to the Problem:

Subjects were monitored over the course of the entire season, starting with the beginning of official pre-season practices on August 10th, through the culmination of the regular season on October 30th. Measures of physical performance (two-minute step test, maximal vertical jump) and mood state questionnaires were administered eight times during pre-season camp and nine times over the course of the competitive season. All pre-season tests were administered from 7:00-7:30am before any of the days practice sessions. All in-season testing was conducted on Tuesday mornings from 6:30-7:00am before morning practices. Throughout the monitoring, the players continued to participate in regular team practices that consisted of speed, agility, and skill drills, simulated game play, and an in-season maintenance strength program that was performed twice a week. Subjects did not adjust their diets or lifestyle during the course of this study.

Questionnaires:

State-of-Mind Scale:

Subjects were instructed to read each item carefully and to use the given 1-8 scale to rate each item listed regarding to how they are feeling at this particular moment right here and now. The scale ranged from definitely false (1) to definitely true (8) with mostly, somewhat and slightly true and false options also available for selection. Questions were related to the subjects' ability to get out of a jam, their energy towards pursuing goals, ways around their problems, feelings of self-worth, ways to reach their goals, and whether or not they were currently reaching those goals that they have set for themselves.

State Feeling Scale:

Subjects were instructed to read each item carefully and to be honest when answering the questions. They were to identify specifically how the list of adjectives related to how they were feeling right here and now. Ten adjectives were listed and included energized, stressed, tired, determined, strong, irritable, inspired, focused, frustrated, and upset. A 1-5 scale representing not at all (1), a little (2), moderately (3), quite a bit (4), and extremely (5) was used to answer how the subjects were feeling. Both the State Feeling Scale and State-of Mind scale are modified, shorter versions of the POMS. Test-retest reliability for the POMS has proved it a valid and reliable mood state questionnaire (Cella et al, 1989).

Other Variables:

Subjects were also asked to report the hours of sleep that they had the night prior to testing, their rating of how they were felling overall this morning, as well as their feeling towards the prior week of workouts and games. Ratings were on a Likert-type scale of 1-10 with 1 meaning very, very tired and 10 meaning very, very rested for the scale of feeling this morning, and 1 meaning very, very easy and 10 meaning very, very hard in terms of difficulty of the prior week's workouts.

Physical Performance Testing:

Step Test/Fatigue Index:

Headsets were used to direct the subjects through the fatigue index protocol everyday to standardize the testing. Prior to starting the step test, subjects sat and recorded resting heart rates using a Polar 810 Heart Rate Monitor (Polar Electro, Inc., Woodbury, NY). A metronome was set at 120 bpm and stepping was performed in an up-up-down-down fashion. An eight-inch step was used and the test was conducted for two minutes. At the completion of the two minutes of stepping, subjects recorded exercising heart rates.

Vertical Jump:

Maximal vertical jump height with a preparatory countermovement was measured using a Just Jump (Probotics, Inc., Hunstville, AL) vertical jump mat. The subjects started from an upright standing position on a platform and were allowed to bend their knees before starting to push upwards. One to five jumps were allowed until the subject believed it was maximal height and the best jump was considered for statistical analysis. Vertical jump heights were calculated by the Just Jump system based on the subjects' time in flight.

Statistical Analysis:

Group means and standard deviations for the descriptive variables were calculated. Individual correlations between maximal vertical jump height and resting heart rate, exercise heart rate, hours of sleep and overall mood state were completed for each subject in order to test the hypothesis.

Chapter Four

Manuscript

Using the Maximal Vertical Jump Test to Evaluate Training and Fatigue in Collegiate Soccer Players, a Series of Case Studies

ABSTRACT

An effective and simple mode for coaches to monitor training and fatigue in his or her athletes in the team sport setting has yet to be developed. It is imperative for coaches to avoid overtraining their athletes, and to help them achieve peak physical performance at the time of competition. PURPOSE: The purpose of this study was to use the maximal vertical jump test (VJ) to identify patterns related to overreaching and overtraining in female collegiate soccer players. METHODS: Twenty-three members of The University of Montana women's soccer team (age 19.4±1.3 years) served as subjects for this study. Subjects were monitored for 12 weeks during the NCAA collegiate soccer season consisting of regular training sessions and 17 games. Data collection occurred on a daily basis during pre-season training and weekly during the regular season. VJ, resting (RHR) and submaximal exercise heart rates (EHR), hours of sleep, and mood state questionnaire data were collected 17 times during the season. RESULTS: Mean data shows a positive correlation between VJ and hours of sleep ($r = 0.45$), positive affect ($r = 0.41$) and positive mood state ($r = 0.41$). A negative correlation was found between VJ and negative mood state ($r = -0.48$). There was no significant correlation between VJ and RHR or EHR. Individually, a strong, positive correlation was shown for six players between VJ and hours of sleep, five players for VJ and positive affect, and six players for VJ and positive mood state. A strong, negative correlation was found between VJ and negative mood state for five players. CONCLUSION: Findings of this examination suggest that in a team sport setting there is individual variability in response to internal and external stressors during the course of the season. Athletes require individualized training programs in addition to frequent monitoring by coaches to avoid overtraining.

Key Words: Overtraining, overreaching, overtraining syndrome

INTRODUCTION

Competitive soccer is an activity that requires an athlete to possess high levels of aerobic endurance, speed, agility, power, and skill. Past research that focused on the physical demands of soccer has led investigators to define soccer as an intermittent, high-intensity exercise (Dupont et al. 2004; Krustrup et al., 2005; Siegler et al. 2003). The intermittent exercise performed in soccer involves a change in speed and/or direction every four to six seconds (Mohr et al. 2005). As a consequence of the physical demands of soccer, conditioning programs require that aerobic capacity, strength, power, speed, and speed endurance be developed as fundamental components of physical conditioning (Kraemer et al., 2004). It is imperative for athletes to train knowledgably in order to peak at the time of competition and avoid the detrimental effects of overtraining.

Overtraining effects are a result of an imbalance of time spent in training and competition compared to recovery time. An acute bout of overtraining is defined as overreaching, and is often used by athletes during a typical overload training cycle to enhance their performance (Halson and Jeukendrup, 2004). This acute bout of overtraining, when accompanied by a decrease in training and an appropriate recovery period, can lead to physiological overcompensation and improved performance (Hoffman and Kaminsky, 2000). Chronic overtraining, also known as overtraining syndrome, can occur when excessive training loads are repeatedly not followed by adequate recovery time.

The initial stages of overtraining syndrome are generally accompanied by subjective feelings of fatigue and staleness which then proceed to a decrease in performance (Hoffman and Kaminsky, 2000). It has also been suggested that intrinsic sympathetic activity, receptor sensitivity to catecholamines and adrenal sensitivity to ACTH decrease in the overtraining state, resulting in performance incompetence and high fatigue ratings (Uusitalo et al., 2000). Other physiological findings affiliated with overtraining syndrome include glycogen deficit, catabolic/anabolic imbalance, neuroendocrine imbalance, amino acid imbalance, autonomic imbalance, altered mood state, increased rate of infections, and suppressed reproductive function (Lehman et al., 1997). The suffering athlete may also have an increased basal metabolic rate, loss of body weight associated with a negative nitrogen balance, and delayed exercise pulse-rate to resting pulse-rate recovery (Hartmann and Mester, 2000).

Although a number of physiological, hormonal, biochemical, and psychological factors have been proposed as potential markers of overtraining, these factors have generally been examined using aerobic training models. Anaerobic models of training are still lacking. The greatest need for athletes is the identification of simple, reliable, and effective markers of approaching overtraining, before the decrements in performance occur. The development of tests to monitor and evaluate training programs may be easier to accomplish when the evaluation is via performance tests that coaches and athletes can perform easily on the practice field or court, as opposed to complex laboratory and/or invasive testing (Hoffman and Kaminsky, 2000). Filaire et al. (2001) also suggested that in order to prevent overtraining and to ensure that the conditioning program is resulting in performance improvements, it is necessary to include regular performance tests as a component of the training program. Ideally these tests could be used to both monitor progress and reduce overtraining syndrome.

Several methods of monitoring training and overtraining in athletes have been used in past research. Variables as simple as self reports of mood state and feelings of self-worth, heart rate and blood pressure variability, aerobic capacity tests, submaximal step tests, and performance tests have been evaluated. Additional laboratory testing has involved the monitoring of such biomarkers as creatine kinase, myosin, testosterone, cortisol, and muscle glycogen. While many of these laboratory methods are reliable, they remain complicated, expensive, and require time for appropriate laboratory assays rendering them non-feasible for most athletic programs. A quick, easy, inexpensive, and most importantly reliable method of monitoring and/or predicting overtraining has yet to be determined in either an aerobic or anaerobic model.

Past research has correlated resting and exercising heart rates to overtraining (Gaskill et al, 1987, 2000; Hedelin et al, 2000; Hill et al, 2000; Somerville et al, 2005), as well as changes in mood state to overtraining syndrome (Callister et al, 1990; Lehman et al, 1997; Filaire et al, 2001). Decreased performance on physical tests have also been shown to be related to overtraining syndrome (Bosco et al, 1996; Chicharro, 1998; Hoffman and Kaminsky, 2000). However, there still is the need for a simpler and quicker quantitative test to monitor training.

The purpose of this project, based on prior work (Chicharro et al, 1998; Bosco et al, 1996) was to determine if maximal vertical jump height correlates with resting heart rate, exercising heart rate, hours of sleep and overall mood state in females during the course of a collegiate soccer season. If changes in maximal vertical jump height are found to be related to these other variables, future research may be conducted to use maximal vertical jump height as a marker and/or predictor of overtraining in female college soccer players. It was hypothesized that all variables monitored will be strongly correlated with maximal vertical jump height.

METHODOLOGY

Subjects:

Twenty-three healthy National Collegiate Athletic Association (NCAA) Division I female college soccer players (mean age 19.4, standard deviation ± 1.3 years) were used as subjects for this study. A longitudinal study design was used to monitor subjects during the entire official 2-week pre-season training camp and throughout the 10-week NCAA collegiate soccer season consisting of regular training sessions and 17 games. Prior to participating in the study, players underwent physical examinations and were cleared of any medical conditions. The study was approved by the institutional review board for use of human subjects. All players received an orientation of the testing protocol prior to the beginning of the study. All subjects gave their written informed consent to participate in the study.

Approach to the Problem:

Subjects were monitored over the course of the entire season, starting with the beginning of official pre-season practices on August 10th, through the culmination of the regular season on October 30th. Measures of physical performance (two-minute step test, maximal vertical jump) and mood state questionnaires were administered eight times during pre-season camp and nine times weekly over the course of the competitive season. All pre-season tests were administered from 7:00-7:30am before daily practice sessions. All in-season testing was conducted on Tuesday mornings from 6:30-7:00am immediately prior to morning practice. Throughout the monitoring, the players continued to participate in regular team practices that consisted of speed, agility, and skill drills, simulated game play, and an in-season maintenance strength program that was performed twice a week. Subjects did not adjust their diets or lifestyle during the course of this study.

State-of-Mind Scale:

Subjects were given handouts with several mood state questions that were related to the subjects' ability to get out of a jam, their energy towards pursuing goals, ways around their problems, feelings of self-worth, ways to reach their goals, and whether or not they were currently reaching those goals that they have set for themselves. A copy of the State-of-Mind scale can be seen in Figure 1. Subjects were instructed to read each item carefully and to rate each item (1-8 scale) listed regarding how they are feeling at this particular moment right here and now. The scale ranged from definitely false (1) to definitely true (8) with mostly, somewhat and slightly true and false options also available for selection

State Feeling Scale:

The next set of questions that the subjects were asked to answer included a set of ten adjectives that were listed and included energized, stressed, tired, determined, strong, irritable, inspired, focused, frustrated, and upset. Subjects were instructed to read each item carefully and to be honest when answering the questions. They were to identify specifically how the list of adjectives related to how they were feeling right here and now. A 1-5 scale representing not at all (1), a little (2), moderately (3), quite a bit (4), and extremely (5) was used to answer how the subjects were feeling. A copy of the State Feeling Scale can be seen in Figure 1.

Both the State Feeling Scale and State-of Mind scale are modified, shorter versions of the Perception of Mood State questionnaire (POMS). The POMS has been proved to be a valid and reliable mood state questionnaire (Cella et al, 1989).

Other Questionnaire Variables:

Subjects were also asked to report the hours of sleep that they had the night prior to testing, their rating of how they were felling overall this morning, as well as their feeling towards the prior week of workouts and games. Ratings were on a Likert-type scale of 1-10 with 1 meaning very, very tired and 10 meaning very, very rested for the scale of feeling this morning, and 1 meaning very, very easy and 10 meaning very, very hard in terms of difficulty of the prior week's workouts. A copy of the questionnaire can be seen in Figure 2.

Step Test:

In order to evaluate physical fatigue and recovery, a subsequent step test was administered to evaluate heart rate response to physical and mental stressors. Prior to the step test, subjects sat for two to three minutes and recorded resting heart rates using a

Polar 810 Heart Rate Monitor (Polar Electro, Inc., Woodbury, NY). A metronome was set at 120 bpm and stepping was performed in an up-up-down-down fashion. An eight-inch step was used and the test was conducted for two minutes. At the completion of the two minutes of stepping, subjects recorded exercising heart rates. Headsets were used to direct the subjects through the fatigue index protocol everyday to standardize the testing.

Vertical Jump:

The dependent variable, maximal vertical jump height with a preparatory countermovement was measured using a Just Jump (Probotics, Inc., Hunstville, AL) vertical jump mat. The subjects started from an upright standing position on a platform and were allowed to bend their knees before starting to push upwards. One to five jumps were allowed until the subject believed they had reached their maximal height. The best jump was considered for statistical analysis. Vertical jump heights were calculated by the Just Jump software based on the subjects' time in flight.

Statistical Analysis:

Team data represented by group means and standard deviations for the descriptive variables were calculated. Individual correlations between maximal vertical jump height and resting heart rate, exercise heart rate, hours of sleep and overall mood state were completed in order to test the hypothesis for each subject. The frequency of significant relationships for each variable compared to VJ was noted to serve as a rough estimate as to the potential that VJ has to be a predictor for fatigue and overtraining syndrome. Additionally, the average standard deviation of the mean of the individual correlations was calculated.

RESULTS

Team mean values and standard deviations of field test variables are presented in Table 1. Team date shows a positive correlation between VJ and hours of sleep (r = 0.45), positive affect (r = 0.41) and positive mood state (r = 0.41). A negative correlation was found between VJ and negative mood state (r = -0.48). There was no significant correlation between VJ and resting heart rate or exercising heart rate.

Heart rate data showed that six players had positive correlations between VJ and resting heart rate, but two players showed negative correlations. Exercising heart rate and VJ had three players with positive correlations and three players with negative correlations. Data showed that five players had a strong positive correlation ($r > 0.40$) between VJ and positive affect from the modified POMS. Six players showed a strong positive correlation between VJ and positive mood state, and five players showed a strong negative correlation between VJ and negative mood state from the modified POMS. Hours of sleep data showed that six players had a strong positive correlation between VJ and hours of sleep, while two players showed a negative correlation between VJ and hours of sleep. A summary of the number of correlations are shown in Table 2. Individual player correlations are shown on Graphs 1-6.

DISCUSSION

In agreement with past research (Chicharro et al 1998; Bosco et al, 1996), this examination suggests that simple performance tests such as the maximal vertical jump test may be used to detect the early states of the overtraining syndrome in some athletes. Significant correlations between maximal vertical jump height and mood state questionnaire data, as well as vertical jump and hours of sleep were found in this project. Although no direct biomarker of overtraining was analyzed, changes in mood state and lack of sleep have been accepted as warning signs of the overtraining syndrome (Uusitalo et al., 2000; Sims, 2001, Bosco et al, 1996).

Heart rate data collected in this research showed that six players had positive correlations between VJ and resting heart rate, but two players showed negative correlations, as seen in Graph 1. Exercising heart rate was positively correlated with VJ for three players and negatively correlated with three players. These data are shown in Graph 2. Inconsistency in heart rate could be the result of poor standardization procedures prior to the measurements. The athletes' mode of transportation to the data collection varied, and numerous players on any given day walked or rode bicycles to the soccer field for data collection. For the resting heart rate measurement, some relaxation time was given. However, the protocol used was not an accurate representation of the subjects' resting heart rate due to the previously mentioned mode of transportation problem. Other factors not taken into consideration were ambient temperatures prior to taking heart rates, as well as stimulant use. Both of these factors may have an affect on resting heart rate. Recommendations for future research of this kind would encourage proper instruction to the subjects beforehand to perform the fatigue index test independently, immediately after waking each morning.

Mood state data showed that five players had a strong positive correlation ($r > 0.40$) between VJ and positive affect from the modified POMS. Six players showed a strong positive correlation between VJ and positive mood state, and five players showed a strong negative correlation between VJ and negative mood state from the modified POMS. Hours of sleep data showed that six players had a strong positive correlation between VJ and hours of sleep, while two players actually showed a negative correlation between VJ and hours of sleep. Researchers would hypothesize that an athlete would perform better in certain tests such as VJ when they are in a positive mood state, as opposed to feeling worn out and depressed. This holds true for several subjects, but again there was a lack of consistency throughout all of the athletes on the team. Hours of sleep correlations between VJ also showed inconsistent results.

The lack of correlations found between VJ and the other variables may be due to the lack of consistency in the dependent variable, the VJ. As seen in Graph 7, pre-season camp data showed smaller variances in maximal vertical jump height, while in-season data is inconsitent. The researchers question the effort provided by subjects in the test, and a more thorough, professional testing protocol should be considered for future research. Data collection of any kind in the team setting is very challenging.

This descriptive examination in the use of the maximal vertical jump test to monitor fatigue in female collegiate soccer players appears to provide an alternative method for warning trainers and coaches of a potential overtraining syndrome in some individuals. Although there were no clinical measurements used in this project, it does provide an interesting question as to whether simple performance tests such as the maximal vertical jump may be used by coaches in the future to monitor fatigue and prevent overtraining syndrome amongst his or her athletes. Various physiological, hormonal, and biochemical factors may serve as markers of overtraining, but may not be easily accepted by coaches due to time and financial considerations.

The subjective questionnaires used in this examination may also serve as a valid way to monitor training status in the team sport setting. Individual events such as track and field, swimming, or weightlifting allow for the athlete and coach to monitor objective measures such as time, distance, or weight to determine decrements in performance. However, this does not hold true in a team sport setting such as in soccer. This idea is demonstrated by the high volume of research found on overtraining in endurance athletes, compared with the scarcity of studies that have examined overtraining in team sports.

PRACTICAL APPLICATIONS

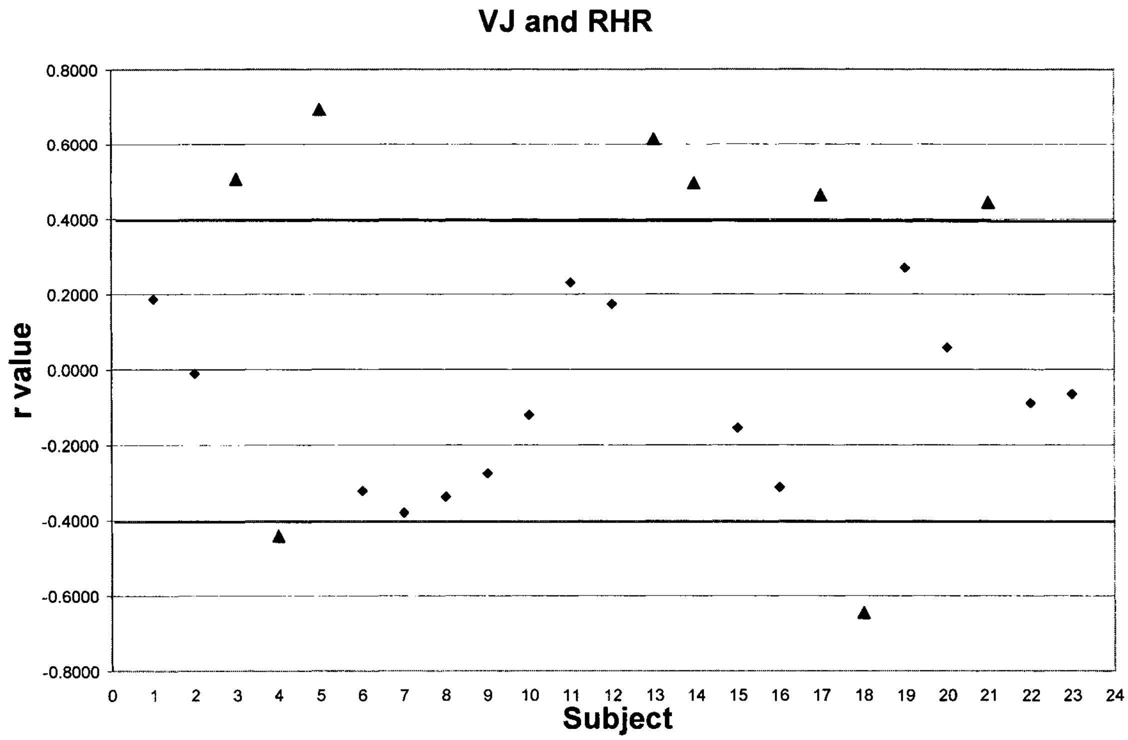
Despite the limitations of a case study design, these data give support to the importance of individualized training and monitoring for the prevention of overtraining and the promotion of performance enhancement. It is likely that individualized methods of monitoring training and fatigue are necessary in the same means that individualized training programs are necessary for optimal improvement in performance. Further research is necessary for development of a simple, practical overtraining model for use by coaches, physicians, trainers, and researchers to predict, prevent, and diagnose debilitating overtraining in the athletic population. Based on the individual data found in this study, it is suggested that athletes require individualized training programs in addition to frequent monitoring to prevent overtraining and promote improvements in performance.

Table 1. Team means and standard deviations for field test variables.

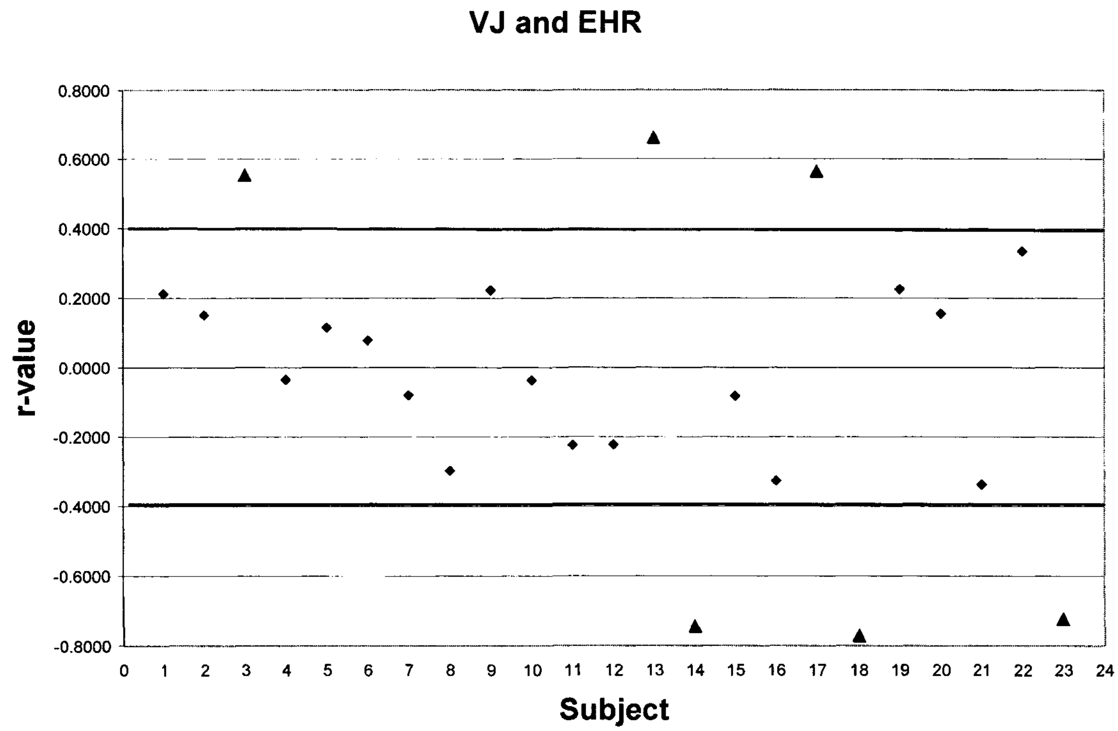
Variable	n	Mean ± SD
Maximal Vertical Jump (in)	23	17.7 ± 0.41
Resting Heart Rate (bpm)	23	77.7 ± 3.05
Exercising Heart Rate (bpm)	23	123.9 ± 3.44
Hours of Sleep (hrs)	23	7.2 ± 0.7
Positive Affect	23	6.12 ± 0.28
Positive Mood State	23	3.23 ± 0.23
Negative Mood State	23	2.11 ± 0.21

Table 2. Incidences of strong correlations ($r > 0.40$) to show the variance in individual correlations.

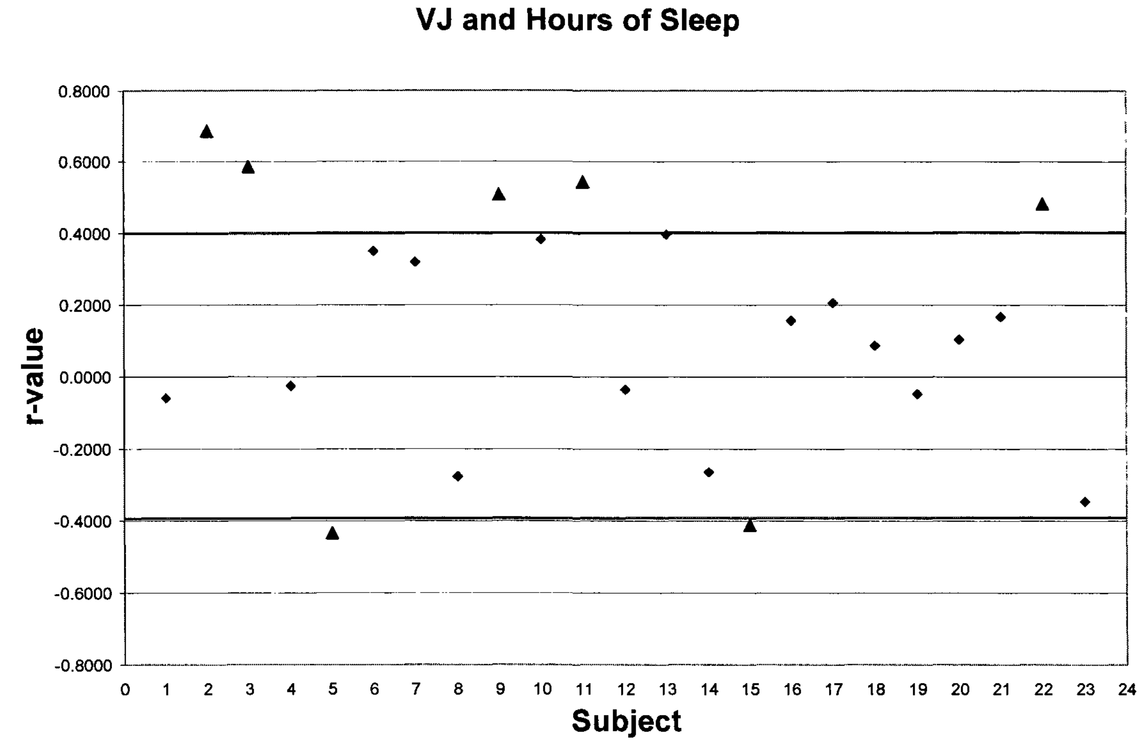
Variable	# pos. correlations	# neg. correlations	mean correlation ± SD
Resting Heart Rate (bpm)	6	2	0.04 ± 0.38
Exercising Heart Rate (bpm)	3	3	-0.03 ± -0.40
Hours of Sleep (hrs)	6	2	0.13 ± 0.33
Positive Affect	5	2	0.13 ± 0.33
Positive Mood State	6	1	0.05 ± 0.33
Negative Mood State	2	5	-0.13 ± 0.39



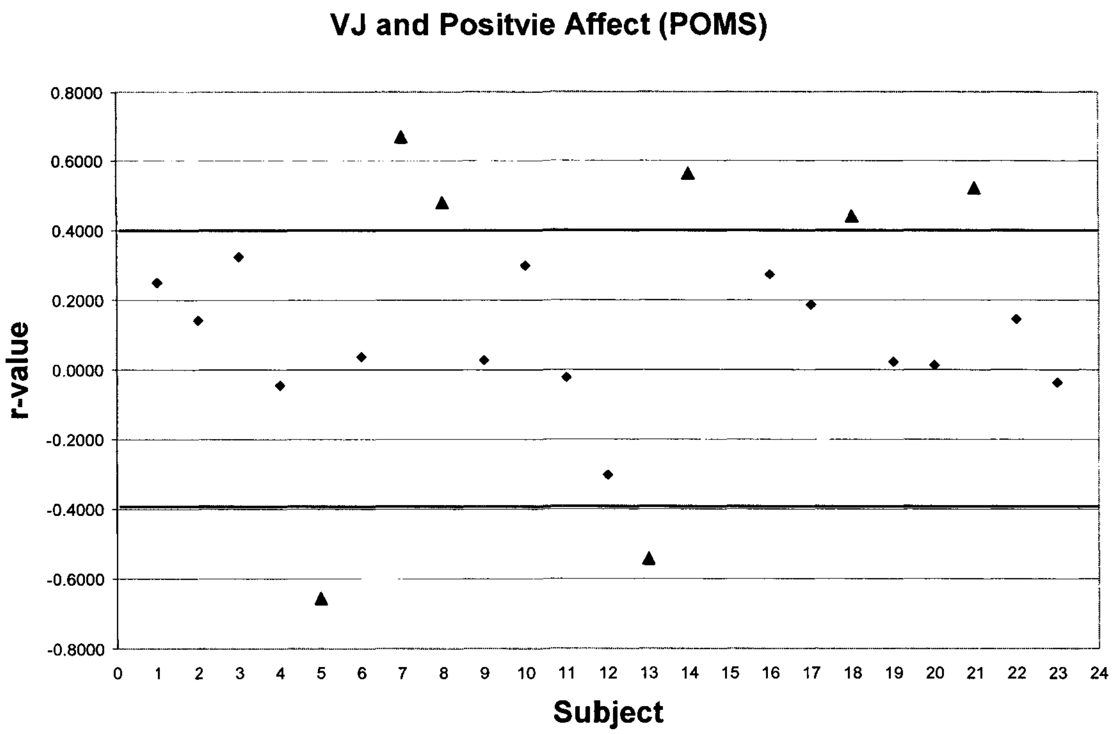
Graph 1: Correlation between maximal vertical jump height (VJ) and resting heart rate (RHR) for all subjects. ▲ = Significant (r > -.40).



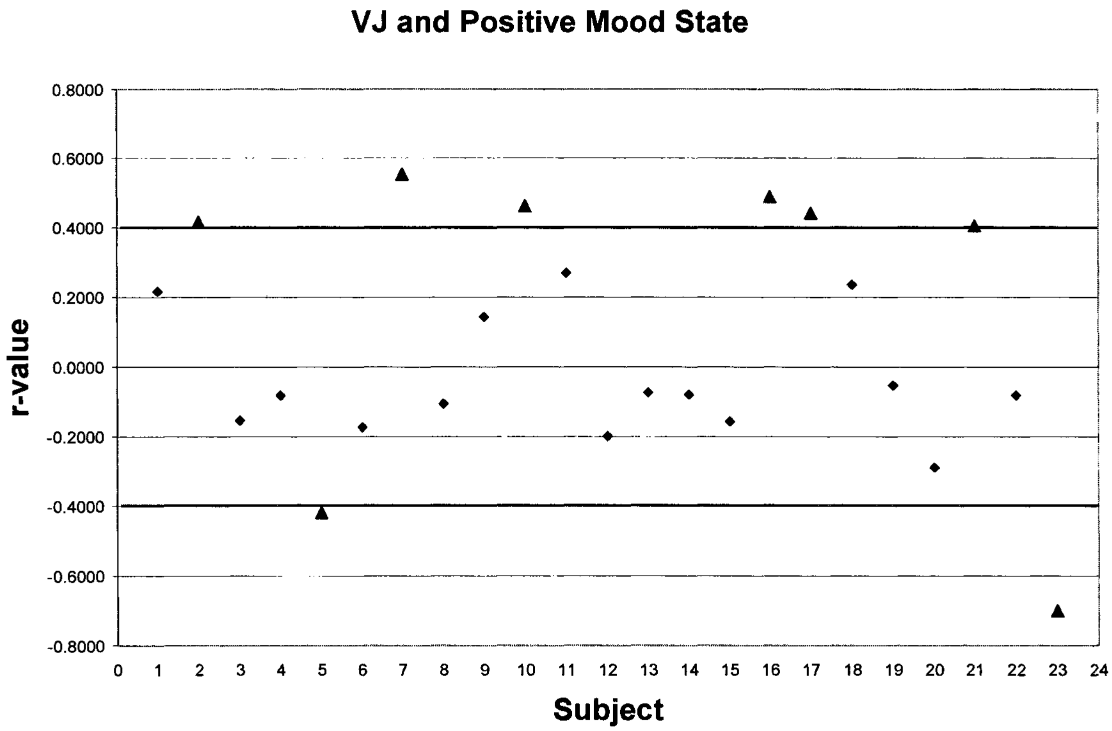
Graph 2: Correlation between maximal vertical jump height (VJ) and exercising heart rate (EHR) for all subjects. ▲ = Significant (r > -.40).



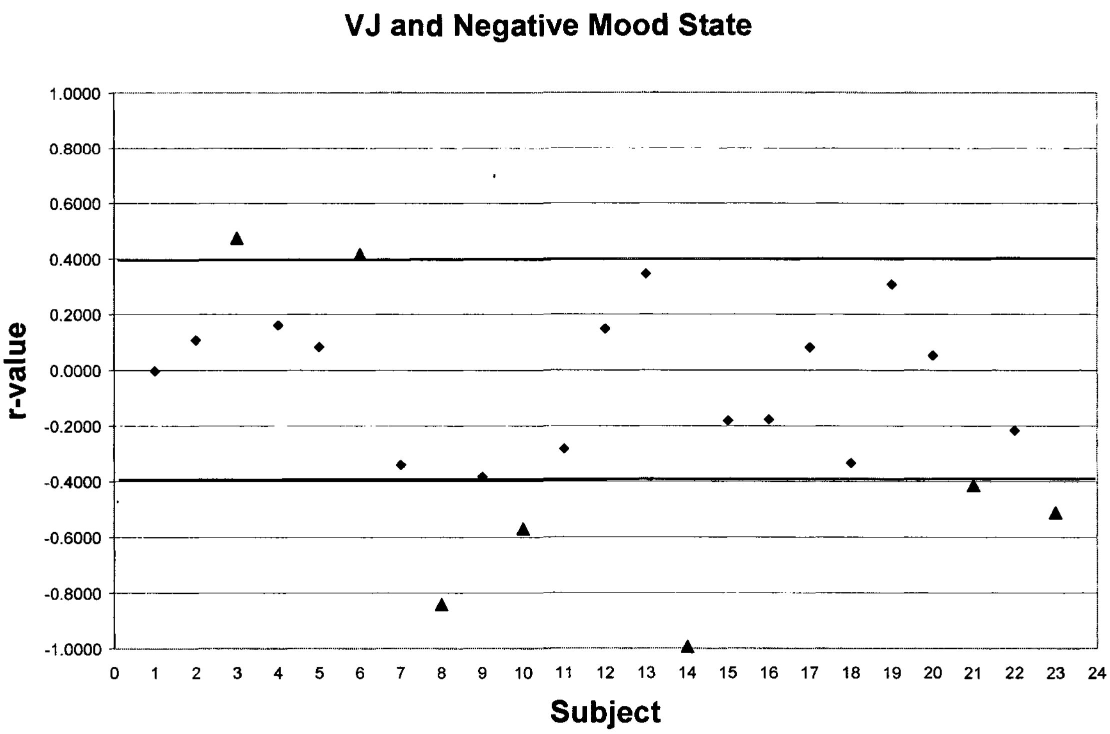
Graph 3: Correlation between maximal vertical jump height (VJ) and hours of sleep the night prior to testing for all subjects. ▲ = Significant (r > .40).



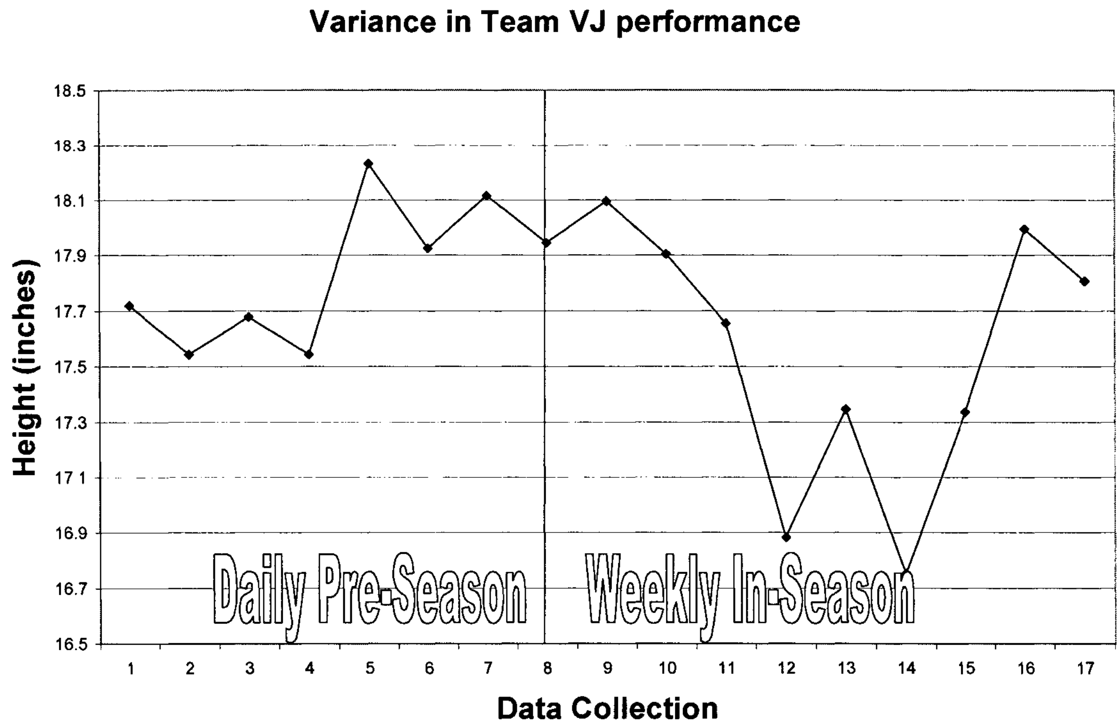
Graph 4: Correlation between maximal vertical jump height (VJ) and positive affect (POMS) for all subjects. ▲ = Significant (r > .40).



Graph 5: Correlation between maximal vertical jump height (VJ) and positive mood state for all subjects. ▲ = Significant (r > .40).



Graph 6: Correlation between maximal vertical jump height (VJ) and negative mood state for all subjects. ▲ = Significant (r > -.40).



Graph 7: Inconsistencies in maximal vertical jump performance during the season.

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ID #______ **DATE:__________________**

How many hours of sleep did you get last night?____________

STATE-OF-MIND SCALE

Read each item carefully. Using the scale shown below, please select the number that best describes *how you think about yourself right now* and put that number in the blank before each sentence. Please take a few moments to focus on yourself and what is going on in *your life at this moment.* Once you have this "here and now" set, go ahead and answer each item according to the scale below:

1	2	3	4	5	6	7	8
Definitely False	Mostly False	Somewhat False	Slightly False	Slightly True	Somewhat True	Mostly True	Definitely True

______ 1. If I should find myself in a jam, I could think of many ways to get out of it.

______ 2. At the present time, I am energetically pursuing my goals.

______ 3. There are lots of ways around any problem that I am facing right now.

______ 4. Right now, I see myself as being pretty successful.

______ 5. I can think of many ways to reach my current goals.

______ 6. At this time, I am meeting the goals that I have set for myself.

STATE FEELING SCALE

Read each item and then mark the appropriate answer in the space provided. **Right now, to what extent are you experiencing the following feelings?** PLEASE BE HONEST!

1	2	3	4	5
not at all	a little	moderately	quite a bit	extremely

________ energized ________ irritable

________ stressed ________ inspired

________ tired ________ focused

________ determined ________ frustrated

________ strong ________ upset

RESTING HR______________ VERTICAL JUMP____________

EXERCISE HR_____________ 40-YD SPRINT______________

FILL OUT EVERY MORNING

ID # ____________ **Name:** ______________________________________

DATE: ________________

How would you rate yesterday's workout?

1	2	3	4	5	6	7	8	9	10
Very Very Easy	Very Easy	Somewhat Easy		Moderate			Somewhat Hard	Very Hard	Very Very Hard

Physically, how are you feeling this morning?

1	2	3	4	5	6	7	8	9	10
Very Very Tired	Very Tired	Somewhat Tired		Moderately Tired			Somewhat Rested	Very Rested	Very Very Rested

ATHLETE CONSENT FORM
Use of Performance Testing for Monitoring Overtraining in Division I Female College Soccer Players

HUMAN PERFORMANCE LABORATORY
THE UNIVERSITY OF MONTANA

Participant ______________________ ID#______ Today's Date: _____/_____/____
(Print Name) Month Day Year

STUDY DIRECTOR(S): Jonathan Berdanier (406) 546-2138
Steven Gaskill, Ph.D. (406) 243-4268

SPECIAL INSTRUCTIONS TO THE POTENTIAL SUBJECT

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

PURPOSE OF THE RESEARCH

You are being asked to take part in a research project that will help to understand how changes in several different performance tests are correlated to state-of-mind questionnaires. This research will be studying three measures that may enable coaches to better determine when athletes are training too much and increasing their risk of overtraining and illness. Group mean data that is collected during this research will be kept confidential and all individuals' data will be analyzed using an assigned ID number. Group means will be shared with the Head Coach and his staff weekly and at the completion of the season for the sole purpose of enhancing performance and to reduce the negative symptoms that may occur due to overtraining. Information that you share with the Principal Investigator will only be shared with the coaching staff as group means, and will have no implication of your status on the team. The goal is to simply allow you as the athlete to take advantage of the knowledge of the investigators and to help the team peak at the time of competition and reduce the symptoms associated with overtraining.

PROCEDURES

- Prior to any activity, the project director will meet with the team and explain the process that is going to take place. The entire consent form will be reviewed with them and explained. It will be made clear that participation is voluntary, but is encouraged by myself as well as the coaching staff to enhance their training routine and to avoid any negative effects from intense training.
- Read and sign this consent form
- Once a week during the season, you, as a subject will be asked to perform the following procedures taking about 10 minutes:

- Put on a digital heart rate monitor and record resting heart rate. Then perform the 2-minute step-test that was previously explained by the principal investigator and record your heart rate at the completion of the test.
- Perform a maximal vertical jump. Jump height will be determined based on flight time using a jump pad.
- Run a 40-yard sprint as fast as you can.

➢ Other information that participants will be asked to record and hand in weekly on a form that will be supplied:
- How healthy participants are feeling each day.
- How hard (tiring) participants rate the practice each day.
- Participants' competitive results as determined by the Head Coach's data.

Data will be collected at the beginning of every Tuesday morning practice. The study will continue weekly for the remainder of the soccer season.

PAYMENT

Subjects will receive no monetary compensation for participating in this research.

RISKS OR DISCOMFORTS

There will be no expected risks or discomforts resulting from the subject's participation in this study. Proper warm-up time will be allowed prior to the 40-yard sprint. There are no invasive measures. All data will be kept confidential, except it will be shared with the coaching staff weekly and at the completion of the season. There is no added time to the soccer practice each week. Soccer practices are not being changed in any way for this study. If at any time the participant is encountering any discomfort with the research, they may contact the Principal Investigator to discuss these matters. The participant may quit at any time without penalty.

BENEFITS

There are possible benefits associated with participation in this study. The step test, vertical jump, and sprint data will be collected and analyzed for each athlete throughout the varying training periods. The data may aid both the coach and athlete in developing and designing better training programs in the future. Subjects may have access to all of their data upon request.

The benefits to scientific knowledge may be the addition of a simple, non-invasive set of tests that coaches can use to monitor overtraining and optimizing training stress for individual athletes.

CONFIDENTIALITY

Data will be kept confidential and during analysis, subjects' records will be kept within the Human Performance Lab and will be locked under the direction of the Principal

Investigator during the entire period of data collection. Subject numbers will be used during all analyses and no individual data will be reported. Group mean data will be reviewed by the Head Coach and his staff weekly and following the season to be used to enhance the training programs of the athletes. The data will not be used in a negative manor to criticize the actions and habits of the athletes. In any publications, presentations, or reports given to the Head Coach, only group data will be reported, or if individual examples are used, no names or means of identifying the individual subject will be mentioned.

COMPENSATION FOR INJURY

Although we do not foresee any risk in taking part in this study, the following liability statement is required in all University of Montana consent forms. This statement does not apply to injury caused during activities related to the regular athletic practice.

"In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement or compensation pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claims representative or University Legal Counsel."
(Reviewed by University Legal Counsel, July 6, 1993)

VOLUNTARY PARTICIPATION/WITHDRAWAL

- You have the right to withdraw from the study at any time and for any reason.

QUESTIONS

You may wish to discuss this with others before you agree to take part in this study. If you have any questions about the research now or during the study contact: Jon Berdanier, 546-2138, or Steve Gaskill, 243-4268. If you have any questions regarding your rights as a research subject, you may contact the Chair of the IRB through The University of Montana Research Office at 243-6670.

SUBJECT'S STATEMENT OF CONSENT

I have read the above description of this research study and all my questions have been answered to my satisfaction. Furthermore, I have been assured that a member of the research team will also answer any future questions I may have. I voluntarily agree to take part. I understand I will receive a copy of this consent form.

____
Printed Name of Participant

______________________________ ________ ________
Athlete's Signature Age Date