Spring 2010

Monitoring Drop Jump Height and Psychological Measures throughout Competitive in-Conference Division 1 Collegiate Basketball Season "An Exploratory Study"

Michelle Dyke

MONITORING DROP JUMP HEIGHT AND PSYCHOLOGICAL MEASURES

THROUGHOUT A COMPETITIVE IN-CONFERENCE DIVISION 1 COLLEGIATE

BASKETBALL SEASON "AN EXPLORATORY STUDY"

by

MICHELLE VAN DYKE

(Under the Direction of Jim McMillan)

ABSTRACT

Purpose: The purpose of this study was to examine the physiological and perceived stress and recovery response in Division 1 women basketball players across a competitive in-conference basketball season. ***Methods:*** 9 female Division 1 female collegiate basketball players volunteered and completed 5 testing sessions throughout in-conference play. The team was separated into starters (S) (n= 5;mean ± SD;19.4±1.5 y) and non-starters(NS)(n= 4;mean ± SD;19.2±0.5 y) Testing began during conference play and consisted of two drop jump trials and completion of the Recovery-Cue seven (RC7). Subjects also completed the Recovery-Stress questionnaire (REST-Q) on weeks 1 and 5. ***Results:*** A significant increase ($P < .05$) was observed in team mean RC7 scores from week 4 to week 5. No significant differences were found in jump height; however, there was a trend ($p = .058$) for starters' jump height to decrease from week 1 to week 5.No significant differences were found in global stress, global recovery or recovery-stress scores in S or NS. Starters' had higher scores on all scores throughout the season when compared with NS. ***Conclusion:*** Although no statistical differences were found, a performance decrease of 14.5% may have practical importance when dealing with collegiate athletes. Future research may need to consider analyzing individual player's results as opposed to the team as a whole in order to find significant differences. The use of a simple performance test and the use of a psychological assessment are very practical tools that can be used on a continuous basis to monitor athletes.

INDEX WORDS: Overtraining, Basketball, Drop Jump, Recovery, Psychological, Physiological

MONITORING DROP JUMP HEIGHT AND PSYCHOLOGICAL MEASURES THROUGHOUT A COMPETITIVE IN-CONFERENCE DIVISION 1 COLLEGIATE BASKETBALL SEASON "AN EXPLORATORY STUDY"

by

MICHELLE VAN DYKE

B.S., Shepherd University, 2008

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

Fulfillment

of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA

2010

MONITORING DROP JUMP HEIGHT AND PSYCHOLOGICAL MEASURES

THROUGHOUT A COMPETITIVE IN-CONFERENCE DIVISION 1 COLLEGIATE

BASKETBALL SEASON "AN EXPLORATORY STUDY"

by

MICHELLE VAN DYKE

Major Professor:	Jim McMillan
Committee:	Stephen J. Rossi
	Thomas A. Buckley

Electronic Version Approved:
May 2010

ACKNOWLEDGMENTS

I would like to thank Dr. Jim McMillan, Dr. Stephen Rossi and Dr. Thomas Buckley for your patience and continuous support during this process. I will never know why you chose me as a graduate student, but I will forever be grateful for the opportunity to learn and grow under your guidance.

I would also like to thank my family, Lorene, Arnold and Amanda. This educational journey would not have been possible without your encouragement and unwavering support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figures

INTRODUCTION

Successful training requires finding the balance between optimal training loads and recovery to ensure maximal performance while avoiding symptoms of overtraining.[1,2] Overtraining syndrome (OTS) is defined as "an accumulation of training and/or non-training stress resulting in a long-term performance decrement with or without related physiological and psychological symptoms of maladaptation.[3] Restoration of performance following OTS may take several weeks or months.[3] Symptoms of OTS come about when training stress outweighs recovery.[1] OTS is generally a result of a combination of personal, occupational and environmental stressors.[4] Decrements in performance, alterations in homeostatic levels of biochemical markers and changes in psychological measures have all been reported in athletes following periods of heavy training loads without appropriate recovery interventions.[5] Physiological stress is the primary cause of OTS; however, high exposures to low psychological and social stress can also contribute to OTS.[6] In addition, the amount and occurrence of psychological and physiological symptoms of overtraining are dependent on each athlete's ability to handle stress, suggesting the need to monitor for overtraining with more than one test.[1,5,6]

In the game of basketball, no single feature makes a player consistently successful.[7] Basketball players must possess an athletic build, anaerobic and aerobic capacity, mental toughness, speed/agility, technical skill, tactical intelligence, team discipline, and good coaching.[7] Female U.S. collegiate basketball players run an average of 13.6 sprints and jump 26.7 times.[8] These repetitive bouts of higher intensity activity in combination with limited rest periods results in depleted muscle glycogen stores, significant decreases in upper body and lower body strength throughout a full season.[9,10] During the competitive season, basketball games are generally played twice a week with starters receiving a majority of the playing time.[10,11] Due to this schedule, recovery time between competitions is limited, resulting in lowered performance over time and increases risk of over- use injuries.[1,2]

Monitoring athletes' ability to recovery from training and competitive stressors throughout a season has been previously researched.[10,11] Previous studies have utilized performance tests as indicators of fatigue and possible pre-cursors to OTS.[10,11] Performance measures such as maximum oxygen uptake, maximum bench press, maximum leg press, sprint speed, agility and vertical jump heights have been used.[10,11] The vertical jump is a measure of muscular power and plays a critical role in the execution of many athletic skills.[12,13] Specifically, the drop jump, said to be most like jumps performed in athletic events, has been shown to directly correlate with straight ahead speed and change of direction speed.[14] The drop jump also utilizes the stretch shortening cycle, which is essential in any sport that involves running, jumping, and rapid changes.[12]

Studies examining an athlete's psychological state throughout a season are limited. Morgan et al. (1987) reported changes in the Profile of Mood States (POMS) in swimmers during a competitive season.[15] The POMS reflects general rather than sport specific recovery activities of athletes, which are said to be imperative in restoration of pre-training levels of physiological and psychological states.[16] The Recovery-Stress Questionnaire (REST-Q) is a psychometric instrument that attempts to address general and sport specific aspects of stress and recovery efforts of an athlete.[1,16] The REST-Q has been used on athletes during times of intensified training and is sensitive to changes in stress and recovery levels of athletes in accordance with changes in training volume.[16] Kellmann and

Günther (2000) administered the REST-Q 76 to a group of rowers during training camp and found that stress-scale scores increased while recovery-stress scales decreased with synonymous increases and decreases in training load.[16]

Tessitore et al. (2008) suggests that in order to maintain a high level of physical performance, an optimal balance between training load and recovery is required. Coaches must utilize effective recovery mechanisms to keep athletes performing at high levels.[17] Studies using multi-level approaches to monitor markers of possible OTS on team sports which require multiple competitions per week is limited.[18] Another limitation in the current research is that monitoring of OTS is not done during a competitive season when recovery time is limited.[18] Therefore, the purpose of this study was to examine the physiological and perceived stress and recovery response in Division 1 women basketball players across a competitive in-conference basketball season.

METHODOLOGY

Subjects

Nine Division 1 female basketball players were divided into 2 separate groups based on playing time. Starters, S, played 73% of in-conference game time minutes and consisted of 5 players (age= 19.4±1.5 yr; height= 179.4±10.6 cm; weight= 81.0±10.9 kg; BMI= 25.2±3.5 kg/m^2). Non-starters, NS, played the remaining 17% of game time minutes and consisted of 4 players (age= 19.2±0.5 yr; height= 163.1±14.3cm; weight= 74.18±6.5kg; BMI= 28.0±1.1 kg/m^2). Prior to data collection, all volunteers read and signed a university approved informed consent. All participants were free from any injury that limited them from actively participating in the collegiate season.

Data Collection Time Points

Week 1	Drop Jump Trials (2), Recovery Cue Seven and Recovery-Stress Questionnaire
Week 2	Drop Jump Trials (2) and Recovery Cue Seven Questionnaire
Week 3	Drop Jump Trials (2) and Recovery Cue Seven Questionnaire
Week 4	Drop Jump Trials (2) and Recovery Cue Seven Questionnaire
Week 5	Drop Jump Trials (2), Recovery Cue Seven and Recovery-Stress Questionnaire

Instrumentation

A ratings of perceived exertion scale (RPE) was used to quantify each subject's workload on a daily basis.[19] Using RPE to calculate workload has been shown to be a valid tool in assessing training loads for team athletes.[19] The RPE (0-10, with 0 meaning, "rest" and 10 meaning "maximal" effort) scores reflect a specific training session and/or basketball related activity in which the athlete took part. Workload was calculated by multiplying the reported RPE score by the duration in minutes of each training session. A non-conducting force plate (AMTI Advanced Medical Tech Inc, Model OR6-5 Watertown, MA), 400 x 600mm, mounted directly on a concrete subfloor and level with the floor was used to collect kinetic data. The AMTI force plate is a valid and reliable tool for measuring drop jump heights from a 30cm box.[20] Motion Monitor (Coumbiaville, MI) software from Innovision System Inc was used to transcribe drop jump data and all force plate data was sampled at 1000 H_Z.[20]

Subjects completed a Recovery-Stress Sport Questionnaire (REST-Q) at week 1 and week 5. The goal of the REST-Q was to assess the recovery-stress state of an athlete (REST-Q MANUAL) The reliability of the Recovery-Stress Sport Questionnaire is reported as 0.83.[21]A Recovery Cue Seven (RC7) question questionnaire was used to assess each athlete's level of psychological distress.[22] The RC7 consists of seven items that utilize a Likert scale from 0-6 in an attempt to measure perceived exertion, perceived recovery, and recovery efforts of the athlete.[22] Research is limited on the questionnaire's validity and reliability; however, the RC7 uses four scales from the valid and reliable Recovery-Stress Sport Questionnaire.[21] The RC7 was designed to monitor early warning signs of possible overtraining effects on a continual basis all the while being able to provide immediate feedback to coaches and athletes about current stress and recovery states.[22]

Procedures

Subjects were asked to report their rate of perceived exertion everyday to their athletic trainer following a strength and conditioning session, practice or game during the months of January, February and March. Subjects reported to the biomechanics lab once a week for 5 consecutive weeks, beginning in January (competitive season) and ending in March (pre-conference tournament), on the day following a mandatory day off from any basketball related activities to perform 2 drop jump trials. For a warm-up, athletes rode a stationary bike for 3 minutes and then completed a self-selected dynamic flexibility warm up prior to the drop jump trials.[20] While riding the stationary bike, subjects were asked to complete a Recovery-Cue seven questionnaire. Subject's completed the RC7 without any distractions or interference from researchers or other athletes.

Drop jumps were performed on a single 400 x 600mm force plate. The test began with subjects standing on top of a 30 cm wooden box. They were instructed to step forward off of the box without stepping down or jumping off. On contact with the force plate, they were told to think of the force plate as a "hot plate" and to jump up as high and as quickly as possible. From that point, the subjects were told to stick their landing, and stand as motionless as possible for a minimum of seven seconds.[20] Arm position was not controlled in an attempt to keep the jump natural for the athlete.[20] The athletes performed 2-drop jumps and the higher of the two was used in data analysis.

Jump height was used to analyze the performance of each subject's drop jump. Jump height, calculated as 9.81 x Flight Time^2 /8, has been described as a critical factor for performance in team sports.[13,20,23] In addition, the drop jump appears to possess high levels of face validity to actual sprinting, an activity that female basketball players do more than 10 times a game, and significantly correlates with change of direction speed.[8,14,24,25] The drop jump utilizes the stretch shortening cycle which has been shown to be a functional tool in evaluating possible fatigue of the muscular system.[26,27]

Statistical Analysis

A 2 (Starters and Non-Starters) X 5 (Weeks) repeated measures ANOVA was used to detect any significant differences in workload over time. A 2 (Starters and Non-Starters) x 5 (Weeks) repeated measures ANOVA was used to detect any significant differences in jump heights over time. A Paired Samples T-Test was used to detect any significant changes in Recovery-Stress, Global Stress and Global Recovery scores from time point one to time point two. A 2 (Starters and Non-Starters) X 5 repeated measures ANOVA was used to detect any significant differences in mean recovery cue seven scores over time. Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Results

Weekly Workloads

Figure 1 illustrates mean weekly workloads of starters and non-starters. The product of session reported RPE and training duration was defined as workload. A typical training week consisted of 2-3 weight training sessions, 4-5 practices and 1-2 competitive games. The highest training load occurred during week 1 with a team mean of 948.89 ± 51.22. The lowest training load occurred during week 2, with a team mean workload of 690.56 ± 56.70. There was a significant decrease in training load as a group from week 1 to week 2 (948.89 ± 51.22; 690.55 ± 56.73, P ≤.000) and from week 2 compared to week 3 (690.55 ± 56.70; 828.33 ± 56.46, P ≤.001). The significant decrease in workload from week 2 to week 3 occurred because week 2 consisted of only one game in addition to an extra day off from any mandatory basketball related activities.

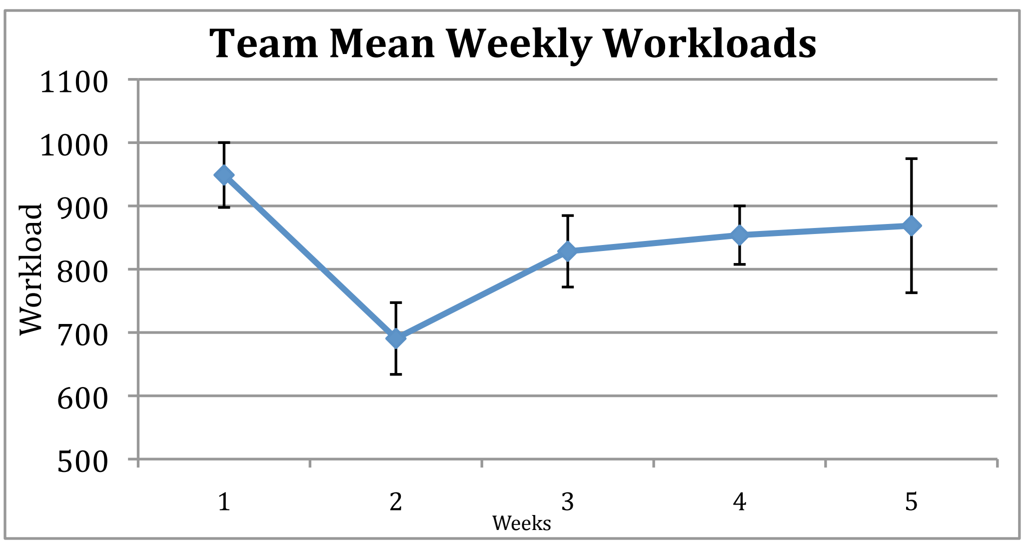

Figure 1: Reported weekly workloads (RPE x duration of training in minutes) Values are mean ± SD. No significant differences were found between groups. *Significant difference from week 1 to week 2 (p =.000) as a team. *Significant difference from week 2 to week 3 (p =.001) as a team.

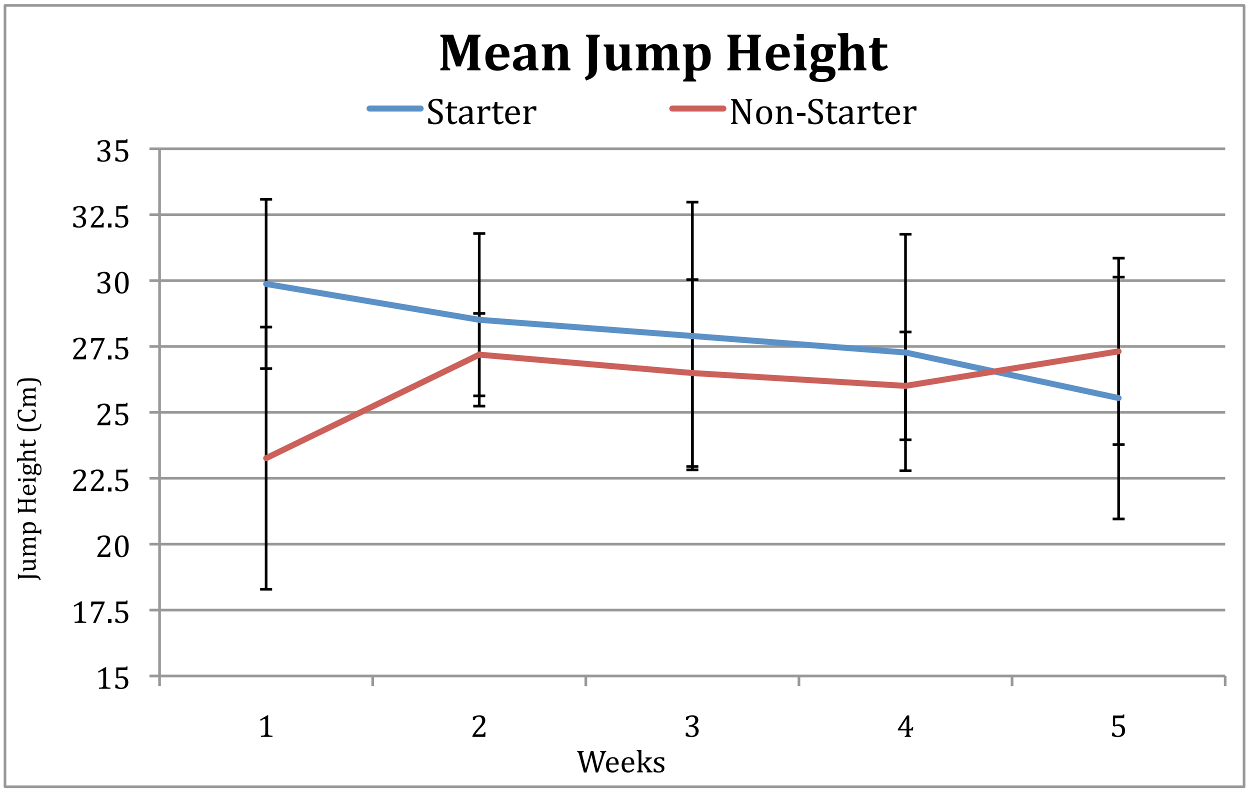

Figure 2: Performance on drop jumps in weeks 1 through 5. Values are mean ± SD. No significant differences were found between groups or from week to week

Drop Jump Heights

Figure 2 illustrates the drop jump heights over the 5 week period of in-conference competitive season. No significant differences were found between groups from week to week. However, starters consistently showed decreases in jump heights as the season progressed, recording the lowest jump height at week 5. Starters' experienced a 14.5% decrease in mean jump height from week 1 to week 5. Contrary to the drop jump heights of the starters, non-starters' experienced a 17% increase in jump height from week 1 to week 5.

Recovery-Stress Questionnaire

Figures 3 and 4 show mean global and recovery stress scores of starters and non-starters at conference play (T1) and at pre-conference tournament (T2) time points. A paired sample T-test revealed no significant differences in global stress or global recovery in either group from T1 to T2. Starters' global stress scores (total of all stress scales) did increase slightly from 21.00 ± 4.75 at T1 to 22.05 ± 6.66 at T2.The non-starter group saw a decrease from 23.19 ± 5.18 at T1 to 20.88 ± 5.04 at T2. Global recovery scores, which reflect the sum of all 10 recovery scales, increased in starters from 26.60 ± 6.34 at T1 to 26.65 ± 6.04 at T2. Non-starters showed a similar trend as their global recovery scores decreased from 23.19 ± 5.18 at T1 to 20.88 ± 5.04 at T2. Figure 5 illustrates mean recovery-stress scores of starters and non-starters. The recovery-stress score represents the difference between total recovery and total stress. No significant difference was found between T1 and T2 for either group. Starters' recovery-stress score decreased from 6.60 ± 8.31 at T1 to 4.60 ± 12.15 at T2. Opposite of starters, the non-starters group experienced an increase from 0.50 ± 6.63 at T1 to 1.25 ± 10.51 at T2.

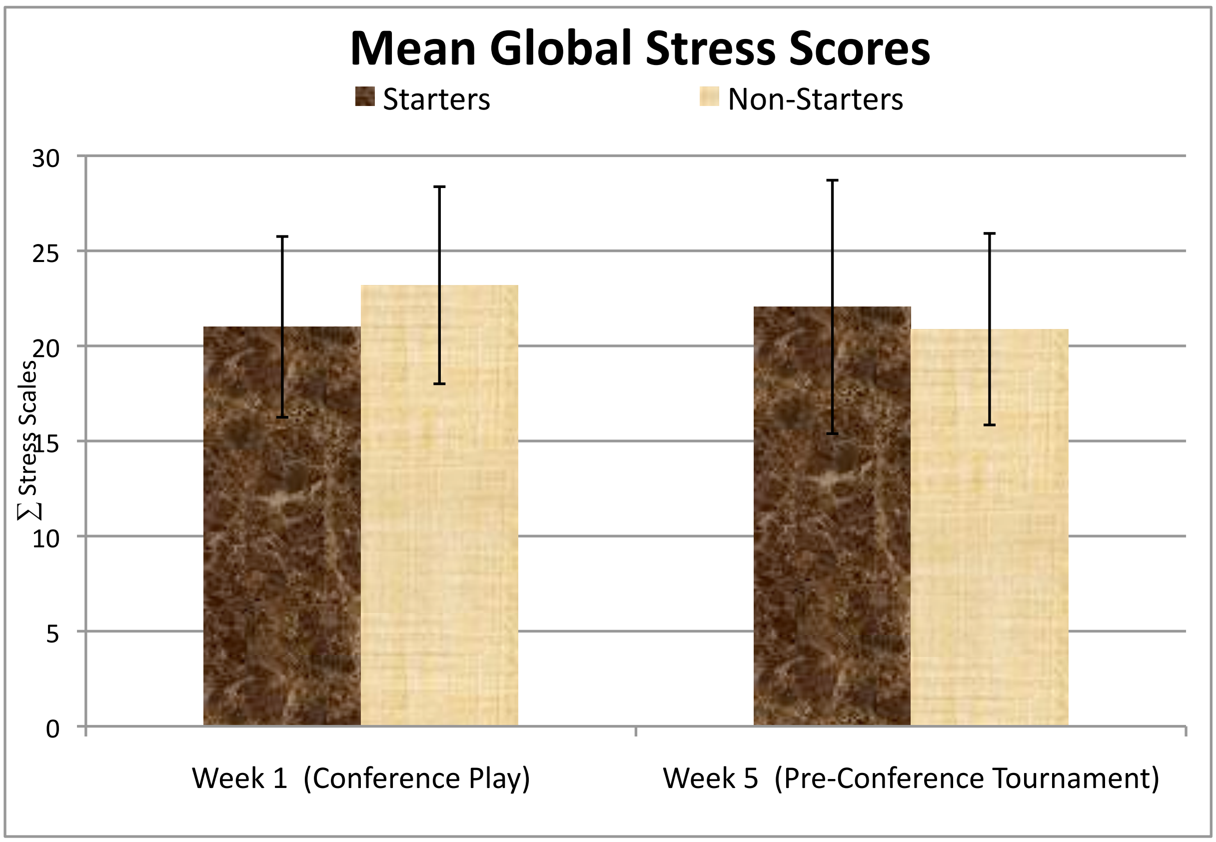

Figure 3: Starters and non-starters mean global stress (∑ of stress scales) for the two time points. Values are mean ± SD. No significant differences were found between the two time points for either group.

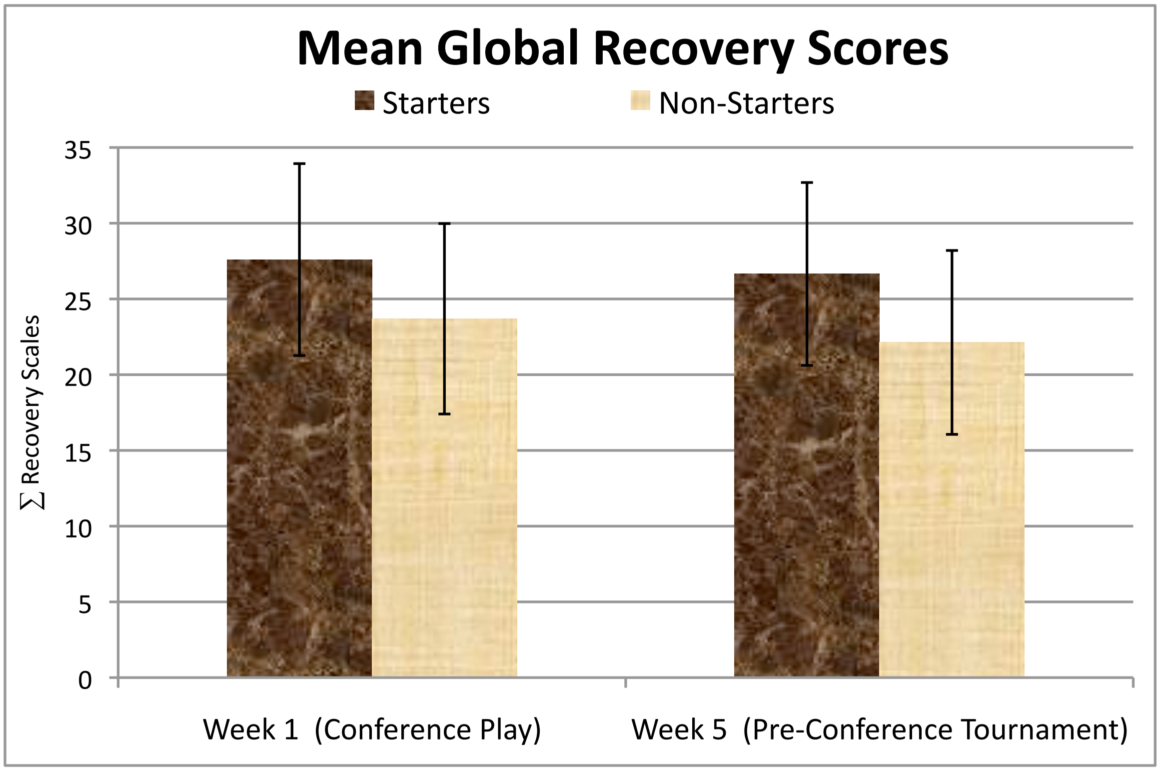

Figure 4: Starters and non-starters mean global recovery (∑ of recovery scales) for the two time points. Values are mean ± SD. No significant differences were found between the two time points for either group.

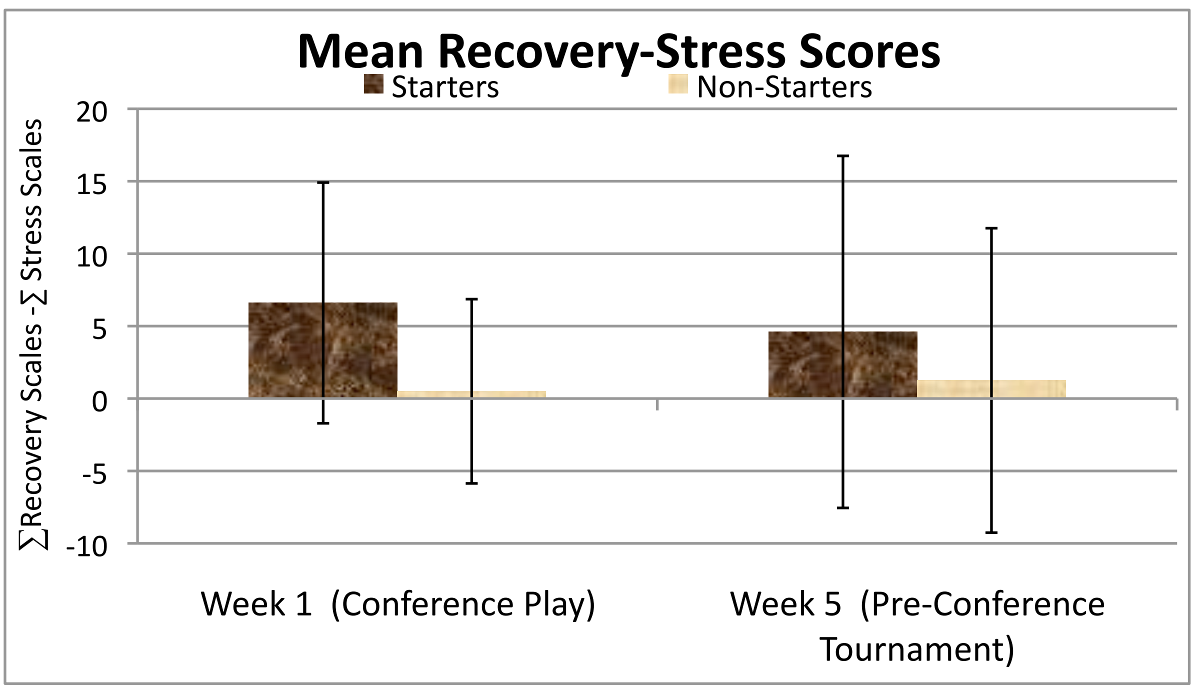

Figure 5: Starters and non-starters mean recovery-stress state (total recovery – total stress) for the two time points. Values are mean ± SD. No significant differences were found between groups or from time point one to time point two.

Recovery-Cue Seven Questionnaire

Figure 6 represents mean total recovery-cue seven scores of starters and non-starters. A repeated measures ANOVA revealed a significant difference from week 4 to week 5 (p =.048) for the overall group (n =9). The mean score for week 4 was 4.71 ± 3.27 while the mean score for week 5 rose to 5.43 ± 3.60. Increases in scores on the recovery-cue seven indicate that the athletes were more recovered.

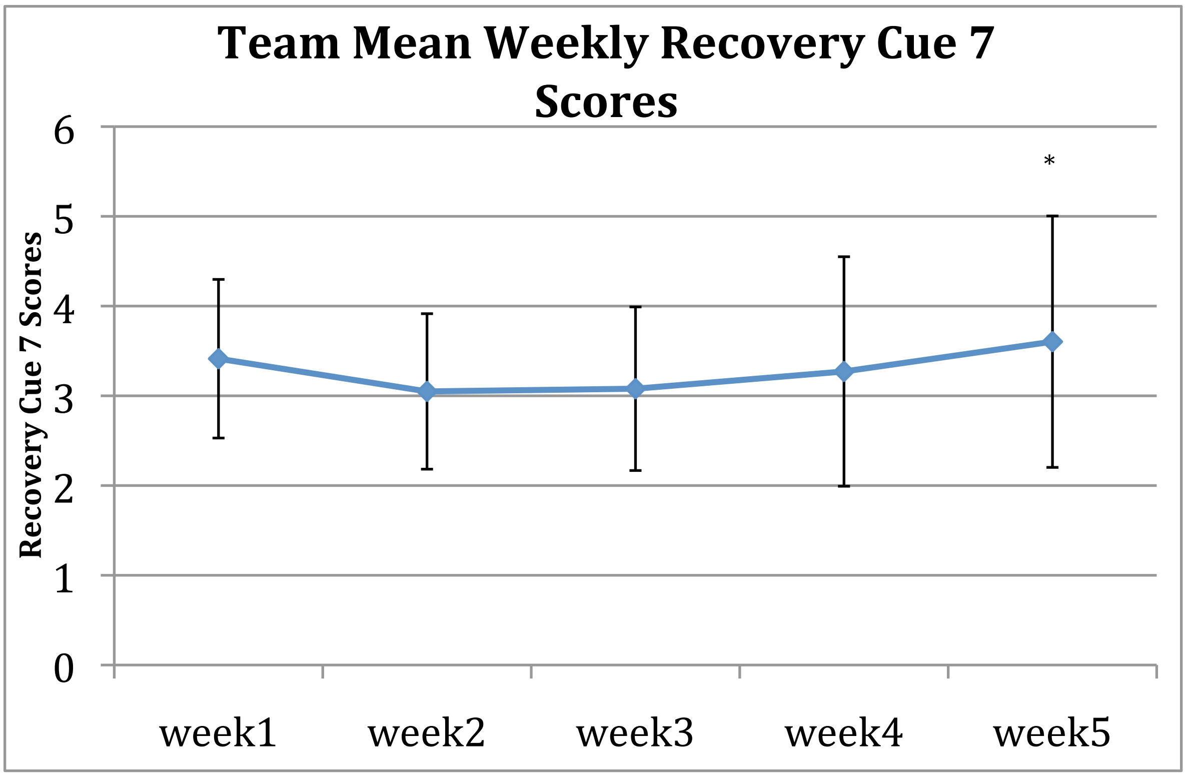

Figure 6: Starters and non-starters mean recovery-cue seven scores for weeks 1 through 5. Values are mean ± SD. No significant differences were found between groups. *Significant (p =0.48) difference between week 4 and week 5 as a team.

Discussion

The purpose of this study was to monitor drop jump heights and perceived stress and recovery responses throughout a Division I in-conference competitive basketball season. The main findings from this study show that performance decrements will occur as the season progresses in players who receive the most playing time. Also, stress levels in starters will remain higher than non-starters throughout an in-conference season. Lastly, this study reveals that the Recovery-Cue seven is capable of detecting changes in recovery levels of a team throughout a competitive in-conference season.

It was hypothesized that starters would experience a larger decrement in drop jump height as the season progressed. The hypothesis is supported as starters' mean drop jump height fell by 14.5%, while non-starters' increased their jump height by 17%. Decreases in jump heights towards the latter part of a season have been noted and can somewhat be expected as the season progresses.[10,11] Kraemer et al. (2004) found significant decreases in starter jump heights when compared to non-starter jump heights following a Division 1 collegiate soccer season.[11] The present study found similar percent decreases as Kraemer et al. (13.8% vs. 14.5%); however, due to the small subject size of our starters group, no statistical significance was seen. The noticeable decrease in starter jump heights is likely due to playing substantially more minutes over the course of the season than the non-starters. It should be noted that Kraemer et al. did utilize a vertical jump rather than a drop jump that was used in this study. Kuipers (1998) states that decreases in performance of as little as 3 to 6% can be the difference between winning and losing in sports.[28] The increase in non-starters' performance as the season progressed agrees with previously published work[9]. Caterisano et al. (1997) found that while Division I basketball starter's leg strength significantly decreased throughout the season, non-starters leg strength did not. The reasoning behind the consistent measurements of performance in non-starters may be due to a greater amount of rest and recovery.[9] Caterisano et al. (1997) notes that non-starters are not generally involved in the high intensity activity of playing in games as are the starters.[9] In contrast to the findings of the current study, increases in jump heights throughout a season have also been noted.[29-31] Häkkinen (1993) found significant increases in maximal vertical jump height when female collegiate basketball players participated in explosive strength training during the competitive season.[29] Marques (2008) had elite female volleyball players participate in plyometric training two times a week and found significant increases in jump height during the season.[30] These studies suggest that female athletes have the ability to increase explosive performance capacity during a competitive season with the use of an in-season specific explosive type strength training.[29] Subjects in the present study participated in a two-day a week maintenance resistance-training program that did not include high intensity explosive strength training, which may explain the lack of noticeable improvement in explosiveness as demonstrated in the drop jump.

It was also hypothesized that global stress scores would increase while global recovery scores would decrease in both starters and non-starters as the season progressed. Higher stress scores indicate a higher level of perceived stress while higher recovery scores indicate higher recovery activities.[21] The recorded global stress score of starters was highest at T1. Time point one represents the week of highest training load. This agrees with previously published studies.[16, 32-34] Gonzalez-Boto et al. (2008) found global stress score to be highest during maximal training loads.[33] Coutts et al. (2007) reported highest global stress scores in triathletes who participated in an intensified training program when compared to triathletes who participated in a less intensive training program.[32] The global recovery scores of starters increased as the season progressed. The reason for this is unknown, but may be attributed to decreases in training load and global stress scores. Coutts et al. (2007) found recovery scores to be highest when training loads were decreased and when stress scores were lower.[32] Non-starter global stress and global recovery scores remained stable throughout the season, suggesting no significant increases or decreases in stress or recovery. The researchers hypothesize that this may be attributed to data collection starting during stressful in-conference play rather than at the beginning of season, when stress levels may have been lower.

The fourth hypothesis stated that recovery-stress scores of starters and non-starters would decrease as the season progressed. The recovery-stress score is the difference between all recovery scales (10) and all stress scales (9). The starters' experienced a decrease in recovery-stress scores; whereas, non-starters saw an increase. The reasoning for this is because starters global stress and global recovery scores increased. Non-starters global stress scores decreased while global recovery scores remained constant throughout the season. It should be pointed out that in the present study recovery-stress scores at T1 were lower than what has previously been reported in triathletes and rugby players.[32,35] The lower recovery-stress scores occurred because of higher reported global stress scores along with lower reported global recovery scores in comparison to other studies. Coutts et al. (2007) and Hartwig et al. (2009) used an all male population; whereas, an all female population was used in the current study.[32,35] It has been suggested that males and females view stressful situations differently.[36] Sigmon et al. (1995) had males and females complete questionnaires in an attempt to quantify coping and cognitive appraisal of selected situations.[36] Females tended to perceive stressful situations as more unpleasant than males, which may explain the increase in global stress scores in this study versus previous studies.[36, 37] In addition, Gan (2009) explained that a higher level of perceived stress exists when level of skill in sport is important for success.[32,38] Basketball is a sport that requires a great deal of skill and may contribute to increased levels of stress in this study. Low recovery scores, such as those reported in the present study, indicate a lack of recovery activities.[21] Incomplete recovery appears to occur frequently in athletes, even though the ability of bodily systems (i.e. neuromuscular system, endocrine system) to recover and regenerate following a practice or competition has an impact on subsequent physical performance.[11] Subjects used in the present study were full-time college students. The lack of recovery can be attributed to sources of stress outside the sport (i.e. educational factors, emotional stress, and insufficient rest time) which are said to negatively impact an athlete's ability to recover.[33]

The last hypothesis was that scores of the recovery-cue seven (RC 7) would decrease as the season progressed in both starters and non-starters. The goal of the RC 7 is to quantify an athlete's perceived exertion, perceived recovery and recovery efforts from the previous week of training.[22] RC 7 scores from week 4 to week 5 significantly ($p = 0.48$) increased. Higher scores on the RC7 indicate that the athlete feels confident about his or her level of recovery from the previous week of training.[22] The increase in recovery scores following a heavy training period contrasts what has previously been published.[33,34,39] Steinacker et al. (2000) found recovery scores to be lowest following heavy training periods.[39] In addition to Steinacker, Coutts et al. (2007) and Gonzalez-Boto (2008) saw recovery scores decrease at the end of highest training loads in triathletes and swimmers[32,33] The reason for the increase in recovery is unknown. REST-Q scores indicated increases in stress for starters at week 5 with minimal changes in recovery efforts, which usually implies lower recovery efforts but that was not indicated by the RC7. This significant increase from week 4 to week 5 may be due to the fact that the RC7 is not valid or reliable when measuring recovery efforts. On another note, the RC7 was administered weekly, which may have been too frequently for the subjects to honestly answer each question.

In summary, both starters and non-starters were exposed to the same amount of training time, yet the inability of the starter's to produce force consistently through the weeks may be due to the greater amount of physical stress evoked during significantly higher amount of game time minutes.[11] As mentioned previously, fatigue at the latter part of the season is nothing new to athletes and is to be expected. However, if a strategic plan can be put in place to minimize the amount of fatigue, mentally and/or physically, that players are experiencing, it will improve players chances of entering the most important part of the season less fatigued.

CONCLUSION

Although no statistical significant differences were found, a performance decrease of 14.5% may have practical importance when dealing with collegiate athletes. Future research may need to consider analyzing individual player's results as opposed to the team as a whole in order to find significant differences. The use of a simple performance test and the use of a psychological assessment are very practical tools that can be used on a continuous basis to monitor athletes.

Practical Applications

This study is the first to describe performance changes in addition to changes in recovery-stress questionnaire and recovery-cue seven scores during a competitive in-conference collegiate basketball season. Monitoring of collegiate athletes with practical, yet sport-specific tests may be the key to preventing performance decrements or negative changes in recovery-stress state. This study has indicated that a competitive in-conference collegiate season will affect starters and non-starters differently. While the demands of training and fatigue are unavoidable throughout the course of a season, one must implement a reliable and valid series of tests that can minimize the amount of fatigue and/or the effects of that fatigue on performance and psychological profiles. Coaches, strength and conditioning coaches and athletic trainers may need to consider the difference in demands that are placed on starters versus non-starters throughout a season and implement a more intensive recovery program for players experiencing higher than normal levels of stress.

REFERENCES

1. Kentta G, Hassmen P. Overtraining and recovery. A conceptual model. *Sports Med.* Jul 1998;26(1):1-16.
2. Bishop P, Jones, E., Woods, K. Recovery From Training: A Brief Review. *Journal of Strength and Conditioning Research.* 2008;22(3):1015-1024.
3. Kreider R, Fry, A., O'Toole, M. Overtraining in Sport: Terms, Definitions, and Prevalence. In: Kreider R, Fry, A., O'Toole, M., ed. *Overtraining in Sport*. Champaign: Human Kinetics; 1998:vii-ix.
4. Meeusen R, Duclos, M., Gleeson, M., Rietjens, G., Steinacker, J.,Urhausen, A. Prevention, diagnosis and treatment of the Overtraining Syndrome. *European Journal of Sport Science.* 2006;6(1):1-14.
5. Kuipers H, Keizer HA. Overtraining in elite athletes. Review and directions for the future. *Sports Med.* Aug 1988;6(2):79-92.
6. Fry RW, Morton AR, Keast D. Overtraining in athletes. An update. *Sports Med.* Jul 1991;12(1):32-65.
7. Kilinc F. An Intensive Combined Training Program Modulates Physical, Physiological,Biomotoric, and Technical Parameters In Women Basketball Players. *Journal Of Strength and Conditioning.* 2008;22(6):1769-1778.
8. MacLean JC. *Refinement of time-motion study procedures.*, University of New Brunswick; 1984.
9. Caterisano A, Patrick,B.,Edenfield,W.,Batson,M. The Efffects of a Basketball Season on Aerobic and Strength Parameters Among College Men: Starters vs. Reserves. *Journal Of Strength and Conditioning Research.* 1997;11(1):21-24.
10. Hoffman J, Fry, A., Howard, R., Maresh, C., Kraemer, W. Strength, Speed and Endurance Changes During the Course of a Division 1 Basketball Season. *Journal of Applied Sport Science Research.* 1991;5(3):144-149.
11. Kraemer W, French, D., Paxton, N., Hakkinen, K., Volek, J., Sebastianelli, W. et al. Changes In Exercise Performance And Hormonal Concentrations Over A Big Ten Soccer Season In Starters And Nonstarters. *Journal Of Strength and Conditioning.* 2004;18(1):121-125.
12. National Strength and Conditioning Association: Strength and Conditioning Professional Standards and Guidelines. *Strength & Conditioning Journal.* 2009;31(5):14-38 10.1519/SSC.1510b1013e3181b1519c1534c.
13. Ashley CD, Weiss LW. Vertical Jump Performance and Selected Physiological Characteristics of Women. *The Journal of Strength & Conditioning Research.* 1994;8(1):5-11.
14. Bissas A, Havenetidis, K. The Use Of Various Strength-Power Tests As Predictors Of Sprint Performance. *Journal of Sports Medicine and Physical Fitness.* 2008;22(3):1015-1024.
15. Morgan W, Brown, D., Raglin, S., O'Connor, P., Ellickson, K. Psychological monitoring of overtraining and staleness. *Br J Sports Med.* 1987;21:107-114.

16. Kellmann M, Gunther KD. Changes in stress and recovery in elite rowers during preparation for the Olympic Games. *Med Sci Sports Exerc.* Mar 2000;32(3):676-683.
17. Tessitore A, Meeusen, R., Pagano, R., Benvenuti, C., Tiberi, M., Caparanica, L. Effectiveness Of Active Versus Passive Recovery Strategies After Futsal Games. *Journal of Strength and Conditioning Research.* 2008;22(5):1402-1412.
18. Kreider R, Fry, A., O'Toole, M. Overreaching and Overtraining in Endurance Athletes. In: Kreider R, Fry, A., O'Toole, M., ed. *Overtraining in Sport*. Champaign: Human Kinetics; 1998:4-17.
19. Coutts A, Reaburn,A.,Murphy,M. et al. Validity of the session-RPE method for determining training load in team sport athletes. *J Sci Med Sport.* 2003;6:525.
20. Flanagan EP, Ebben WP, Jensen RL. Reliability of the Reactive Strength Index and Time to Stabilization During Depth Jumps. *The Journal of Strength & Conditioning Research.* 2008;22(5):1677-1682 1610.1519/JSC.1670b1013e318182034b.
21. Kallus KW, Kellmann, M. *Recovery-Stress Questionnaire For Athletes: User Manual*. Champaign: Human Kinetics; 2001.
22. Kellmann M, Patrick, T., Botterill, C., Wilson, C. The Recovery-Cue and Its Use In Applied Settings: Practical Suggestions Regarding Assessment and Monitoring of Recovery. In: Kellmann M, ed. *Enhancing Recovery: Preventing Underperformance In Athletes*. Champaign: Human Kineticss; 2002:219-229.
23. Holm D, Stalbom, M., Keogh, J., Cronin, J. Relationship Between The Kinetics And Kinematics Of A Unilateral Horizontal Drop Jump To Sprint Performance. *Journal of Strength and Conditioning Research.* 2008;22(5):1589-1596.
24. McInnes SE, Carlson JS, Jones CJ, McKenna MJ. The physiological load imposed on basketball players during competition. *J Sports Sci.* Oct 1995;13(5):387-397.
25. Young WB, James,R.,Montgomery,I. Is muscle power related to running speed with changes of direction? *Journal of Sports Medicine and Physical Fitness.* 2002;42(3):282-288.
26. Gollhofer A, Komi,PV.,Miyashita,M.,Aura,O. Fatigue duing stretch-shortening cycle exercises: changes in mechanical performance of human skeletal muscle. *International Journal Of Sports Medicine.* 1987;8(2):71-78.
27. Hennessy L, Kilty, J. Relationship of the Stretch-Shortening Cycle to Sprint Performance in Training Female Athletes. *Journal of Strength and Conditioning Research.* 2001;15(3):326-331.
28. Hicks A, Kent-Braun,J.Ditor,D. Sex Differences in Human Skeletal Muscle Fatigue. *Exerc. Sports Sci. Rev.* 2001;29(3):109-112.
29. Kuipers H. Training and overtraining: an introduction. *Med Sci Sports Exerc.* Jul 1998;30(7):1137-1139.
30. Hakkinen K. Changes in physical fitness profile in female basketball players during the competitve season including explosive type strength training. *The Journal of Sports Medicine and Physical Fitness.* 1993;33(1):19-26.
31. Marques M, Tilaar, R., Vescovi, J., Gonzalez-Badillo, J. Changes In Strength And Power Performance In Elite Senior Female Professional Volleyball Players During The In-Season: A Case Study. *Journal Of Strength and Conditioning.* 2008;22(4):1147-1155.

32. Newton R, Rogers R, Volek J, Hakkinen K, Kraemer WJ. Four Weeks of Optimal Load Ballistic Resistance Training At the End of Season Attenuates Declining Jump Performance of Women Volleyball Players. *The Journal of Strength & Conditioning Research.* 2006;20(4):955-961.
33. Coutts AJ, Wallace LK, Slattery KM. Monitoring changes in performance, physiology, biochemistry, and psychology during overreaching and recovery in triathletes. *Int J Sports Med.* Feb 2007;28(2):125-134.
34. Gonzalez-Boto R, Salguero A, Tuero C, Gonzalez-Gallego J, Marquez S. Monitoring the effects of training load changes on stress and recovery in swimmers. *J Physiol Biochem.* Mar 2008;64(1):19-26.
35. Anderson L, Triplett-McBride T, Foster C, Doberstein S, Brice G. Impact of training patterns on incidence of illness and injury during a women's collegiate basketball season. *J Strength Cond Res.* Nov 2003;17(4):734-738.
36. Hartwig TB, Naughton G, Searl J. Load, stress, and recovery in adolescent rugby union players during a competitive season. *J Sports Sci.* Aug 2009;27(10):1087-1094.
37. Sigmon S, Stanton,A.,Snyder,C.R. Gender Differences in Coping: A further Test of Socialization and Role Constraint Theories. *Sex Roles.* 1995;33:9-10.
38. Rowlands R. Stress agender. *Occupational Health.* 2008;60(6):26.
39. Gan Q, Anshel,M. Sources of Acute Stress Among Chinese College Athletes as a Function of Gender and Skill Level. *Journal of Sport Behavior.* 2009;32(1):36-52.

APPENDIX A

REVIEW OF LITERATURE

Introduction

Research has shown that there is a dose-response relationship between training and performance, which leads most coaches and athletes to believe that increased training is the ultimate prescription for improvement.[5,6,34,39,40] Due to inter-individual variability in adaptations to stimuli, no single training load is suitable for all athletes; training loads must be specific to each athlete's unique situation.[1] Training volumes below what an athlete needs for improvement may not result in desired physiological adaptations; whereas, training volumes above what an athlete needs, may have a negative impact.[1] If the balance between appropriate training stress and adequate recovery is not met, the risk of suffering from overtraining syndrome is heightened.[1,6,33,34,41] OTS not only stems from stresses associated with sport training and competition, but also from sources outside the sport, such as psychological stress, poor diet, or social and occupational factors.[33,40,42] Athletes suffering from OTS may exhibit signs and symptoms of psychological, physiological, immunological or biochemical disturbances.[1,4-6,41,43] An athlete who suffers from a combination of these symptoms that go untreated, may ultimately end up quitting their respective team and/or sport.[41,44]

Monitoring Overreaching

Overreaching is a planned phase of training in which workloads are purposefully increased to create a 'supercompensation' effect.[4,6,55] Overreaching is considered far less severe than overtraining because recovery can easily be achieved within a few days.[4,41,45] The "supercompensation" effect comes about after an appropriate period of recovery and allows an athlete to exhibit enhanced performance when compared with baseline results.[4,41,45] The built in recovery time allows an athlete's physiological responses to become balanced with the increased training-related stresses.[4,41,45]

A study completed by Stone, M. and Fry, A. (1998) subjected 24 national-class and several world-class level weightlifters to a month long (27 day) period of overreaching.[46] A 1RM snatch test along with standing heart rate, blood pressure, venous blood samples and vertical jump measurements were taken on days 5(T1), 12(T2), and 27(T3). Training consisted of large muscle exercises such as squats, overhead lifts, the snatch, clean and jerk and their variations. Volume (repetitions x load) on normal training days (days 2-3 and 13-26) consisting of 0-2 workouts per day, ranged from 5,000 to 12,000kg with a relative intensity of 79% 1RM for target sets. During the high volume phase (days 6-11), subjects trained 3-4 times a day and volume ranged from 15,000kg to 35,000kg per training day with a relative intensity of 76% 1RM for target sets. Performance from T1 (day 5) to T2 (day 12) was expected to decrease due to increased demands of training; however, performance tests of vertical jump (T1: 56.9 ± 7.6cm, T2: 58.7 ± 8.3cm) and the snatch test (T1: 89.8 ± 15.5kg, T2: 91.7 ± 13.0kg) improved. The reason for the increases in performance is unknown, as they did not agree with previous investigations. The authors suggest that the subjects used in their study were at an elite training level and that could be the possible cause for performance increases rather than decreases as a result of intensive training. This study illustrates that when properly monitored, overreaching can be beneficial to performance in well-trained athletes.[46,42,47]

A study done by Coutts et al. (2007) aimed to determine if overreaching could be diagnosed through performance, physiological, biochemical and psychological measures.[32] Sixteen well-trained male triathletes were randomly assigned to an intensified training group (IT) or a normal training group (NT). Initially, each group took part in a three week low volume, low intensity training protocol to ensure all subjects were free from fatigue. The NT group completed a four-week self-selected physical training program, which allowed subjects to determine their own training loads and volumes. The IT group completed a pre-planned four-week physical training program that resulted in a 290% greater load than the NT group. Training consisted of swimming, biking and running. The swimming consisted mainly of interval training while the biking included long rides (>2hr), hill repetitions and bike to run transition training. The run training included either a 3-km run time trial or high intensity interval training.[32] Both groups experienced a 2-week taper following the 4-week training program. During the taper, training volume was reduced every two days, beginning with a 45% reduction and ending with a 5% reduction from the previous taper percent.[32] Maximal oxygen uptake, a 3-km running time trial (3-km RTT), biochemical markers (free testosterone, cortisol, ACTH, prolactin, urea, creatine kinase, full blood count, plasma volume changes, nocturnal urinary and catecholamine) and psychological measures (REST-Q) were all assessed over the course of the study. Weekly measures of the 3-km RTT were taken and on three different occasions, biochemical makers and REST-Q measures were taken. A significant decrease in 3-km RTT (3.7 ± 7.5%) was found in the IT group, with 6 out of 8 subjects showing decrements in performance.[32] No significant changes were observed in hormonal variables during the overload training period between either group. The psychological measure, REST-Q, showed a significant increase ($P < .05$) in total stress and reduction in total recovery in the IT group compared to the NT group. Following the taper period, the IT group experienced a significant decrease in total stress and increase in total recovery compared to the NT group.[32] These findings suggest that performance measures and monitoring an athlete's recovery-stress state via a psychological assessment is important for athletes who train intensely and require additional recovery time so that overreaching does not lead into OTS.[32]

Physiological, psychological, and hormonal distresses will occur with overreaching.[32] It appears evident that the use of performance-based test along with appropriate psychological assessments will provide the most beneficial information regarding an athlete's response to this intentional increase in training.[6,32]

Monitoring Overtraining

Callister et al. (1990) investigated the responses of elite judo athletes to 4 weeks of regular training and 6 weeks of overtraining.[48] Fifteen national and international level judo players took part in 10 weeks of training that were divided into 3 different phases. Phase I (weeks 1-4) was considered a baseline phase and subjects performed their regular regimens of judo and interval resistance training. In phase II (weeks 5-8), the volumes of interval and resistance training were increased by 50% while maintaining training intensity. The last phase, phase III (weeks 9-10), included interval and resistance training volumes that were reduced to phase 1 levels while judo training volume doubled (100%). Judo training sessions were performed 5 days a week and lasted for 2.5 hours. Interval training consisted of running on a 400-m track or cycling on an ergometer two times a week.[48] Resistance workouts were performed 3 days a week and consisted of a circuit (leg press, leg extensions, leg curls, military press, bench press, lat pulls, arm curls, upright rows, wrist curls) or a conventional (power cleans, squats, deadlifts, bench press) resistance training program. Testing took place in weeks 2, 4, 8 and 10 and consisted of concentric isokinetic strength, peak and submaximal oxygen consumption, vertical jump, 5 x 50-m sprints, 3 x 300-m sprints, nighttime resting blood pressure and resting heart rate measurements. Results indicated that isokinetic force output increased significantly during phase 1, but no significant changes were found in phase II. Force output of the elbow flexors (6-12%) and knee flexors (6-12%) significantly decreased in phase III. Three hundred meter sprint times significantly increased during phase I (1.6%; weeks 2-4) and phase II (1.2%; weeks 4-8), thus sprint times decreased over the duration of the study.[48] The ability to lift maximal loads during resistance training sessions did not decrease noticeably in phase III; however, there was also no tendency to show improvement despite a reduction in training volume. Vertical jump measures went unchanged throughout the study. No significant changes were found in resting blood pressure or resting heart rate. Performance in practice, reported subjectively by the coach, was also adversely affected as training volumes increased.[48] Although a manifestation of regularly noted characteristics of overtraining were not seen in this study, the authors suggested at that time that few studies had examined overtraining in anaerobic sports and that it is possible for athletes to develop symptoms other than those characterized to date.[48] The authors also mentioned that the physiological symptoms of overtraining which an athlete develops are specific to the type of training or event in which the athlete participates.[48]

Sympathetic and Parasympathetic Overtraining

It is hypothesized that two forms of overtraining exists, sympathetic and parasympathetic.[1,49] The sympathetic form occurs during the early stages of overtraining.[1,49] As overtraining progresses, the sympathetic system becomes inhibited, causing the parasympathetic system to then take over.[1,49] The sympathetic form of overtraining elicits noticeable symptoms; whereas, symptoms of the parasympathetic suggest good health and are slightly misleading.[5,49] Team sports and sprint events have noted sympathetic overtraining on a more frequent basis than endurance athletes, who typically encounter the parasympathetic form.[1,49,50]

Hendelin et al. (2000) conducted a case-study to determine whether spectral analysis of heart rate variability (HRV) could confirm the increased parasympathetic activity suggested in the overtraining syndrome.[51] After a period of several months of intensive training, a 16-year old cross country skier experienced central fatigue, reduced performance at standardized bike work, early breathlessness during training sessions on top of performance decrements in competition.[51] Blood testing for infections, pulmonary function and exercise ECG were all normal/negative during this time. Resting ECG recordings revealed that high frequency heart rate (HFHRV) variability was increased (98 nu) in OT and then decreased (81 nu) after recovery. HFHRV for the skier was also higher during OT when compared to control subjects. Resting heart rate was recorded as 59 bpm while the skier was overtrained versus 62 bpm when the skier was fully recovered. Cortisol, hemoglobin, white blood cells, ferritin were all within normal ranges. The investigator did find that levels of luteinizing hormone (LH) was reduced and below normal (1.4 $IU \cdot L^{-1}$ vs. 2.3 $IU \cdot L^{-1}$) when overtrained. Profile of mood states changed from an “iceberg” shape with a global score of 110 to a global core of 132, which was due to increases in tension, anger and depression scores.[51] Due to the changes in the skier’s increased parasympathetic activity and altered mood state he was thought to be in an overtrained state and urged to rest. After a recovery period of two-months, he was able to perform at prior work capacity level. The findings from this study suggest that remarkably high, high frequency heart rate variability seen while in the supine position at the time of overtraining is indicative of increased parasympathetic activity.[51]

In a second study, Portier, H. (2001) measured the effects of intense endurance training on autonomic balance through a spectral analysis study of heart rate (HR) and systolic blood pressure (SBP).[52] The authors looked at seven subjects over two situations in which runners typically take part, a period of relative rest and a period of intense training followed by a half-marathon or marathon competition. The initial first period consisted of a 3-week light training phase of two 45-minute training sessions. The second period lasted 12 weeks and was an intensive preparation period that consisted of 9-10 weekly training sessions. After the second training period, subjects either completed a half-marathon or a full marathon. A VO_2 max test and a tilt test were done at the end of each training phase.[52] Assessment of cardiac autonomic regulation was assessed by spectral analysis of HR and BP variability. Results indicated that there was no significant difference in resting heart rate between the relative rest period and intensive training period; however, a significantly lower heart rate (-3.8 bpm) response to tilting to the vertical during the intensive training period was found. Systolic (112.6 ± 9.6mm Hg vs. 105.6 ± 6.8mm Hg) and diastolic (65.3 ± 3.1mm Hg vs. 59.2 ± 3.6mm Hg) blood pressure readings were significantly lower following the training period. Heart rate variability increased on tilting regardless of the period considered. Conversely, change to vertical position after intensive training decreased by 25% ($p < 0.05$). The training period also included smaller variances for supine and tilt, showing that intensive endurance training leads to reduced variability of HR.[52] In conclusion, the authors attributed the suppressed level of sympathetic activity in conjunction with the high level of parasympathetic activity to the intense endurance training of the subjects.[52]

Sympathetic and parasympathetic overtraining syndromes exhibit different signs and symptoms.[1,49] All in all, depicting signs and symptoms of overtraining in athletes can be very difficult, but endurance athletes will typically find themselves showing signs of parasympathetic overtraining; whereas, anaerobic athletes will typically exhibit symptoms of sympathetic overtraining.[1,49]

Effects Of Recovery On Sport Performance

The ability of bodily systems (e.g., neuromuscular system, endocrine system) to recover and regenerate following composite stresses has an influence on subsequent physical performance.[21,53] Recovery can be defined as "an inter- and intra-individual multilevel (e.g. psychological, physiological, social) process in time for the re-establishment of performance abilities" and is dependent upon the absence of stress.[21] Stress is defined as a destabilization or deviation from the norm in a biological/psychological system.[21] Recovery occurs on several levels (e.g., physiological level, psychological level, social level, sociocultural level and environmental level) and ends when a psychophysical state of restored efficiency and homeostatic balance is reached.[21] Lack of recovery is a main contributor towards an athlete suffering from OTS, yet the effectiveness of different recovery interventions following daily training sessions remains unclear.[1,54,55]

Tessitore et al. (2008) aimed to explore the effectiveness, if any, of the recovery interventions mostly use or recommended in team sports.[55] The authors examined the effects of recovery interventions on performances, subjective feelings of recovery, lifestyle factors, and hormonal levels of the players. Ten male futsal players were selected based on their participation in the Italian Futsal championships as well as in the European college futsal tournament. Each subject participated in 5 testing sessions. Subject's height, body mass, percentage body fat and VO_2-max was measured at the first session. Measures of catecholamines and cortisol were taken to help provide information about the physiological and psychological stress levels of the athletes.[55] A questionnaire was also given to assess the recovery-stress state (REST-Q) of the athlete following the futsal games. Vertical jump, countermovement jump and a 10-m sprint measurement was taken pre and post game. The selected recovery interventions that were used in this study lasted 20 minutes and included of seated rest, low-intensity dry land aerobic exercises (8 minutes of jogging, 8 minutes of walking and running sideways and backward and 4 minutes of stretching), shallow water aerobic exercises (8 minutes of jogging, 8 minutes of walking and running sideways and backward and 4 minutes of stretching) or electrostimulation (rectus femoris, vastus medialis and vastus lateralis) while in the supine position.[55] No significant differences were found between the active and passive recovery interventions on anaerobic performance, hormones, rating of muscle pain, recovery-stress state or on amount of sleep.[55] No significant differences were found on sleep quality between the recovery interventions. Although no significance was found, the athlete's attributed higher effectiveness to the electrostimulation and water cool-down where as seated rest was thought of as the least effective.[55] The authors' note that since recovery is strictly related to the previous exercise stress, it is not advisable to transfer information derived from other team sports played by different rules, tactics or movement patterns.[55]

In a different study, King, M. and Duffield, R. (2009) looked at the effects of passive recovery, active recovery as well as cold water immersion and contrast water therapy on exercise performance during an intermittent-sprint exercise protocol repeated on consecutive days.[53] Ten female netball players took part in 2 sessions that included an intermittent-sprint exercise protocol separated by a 24-h recovery interval. After completing session 1, the subjects were randomly assigned to participate in one of four recovery interventions. The first intervention, passive recovery, consisted of subjects having to remain seated in a designated area of the gym. The active recovery (ATC) protocol has the subjects perform low intensity exercise while the cold water immersion (CWI) method had subjects immerse themselves two times in an ice bath at 9.3 ± 1.6° C up to the iliac crest for 5 minutes followed by 2.5 minutes seated at air temperature. The fourth intervention, contrast water therapy (C_TWT), had the subjects alternate between cold water (9.7 ± 1.4° C) for 1 minute and a warm (39.1 ± 2.0° C) shower for 2 minutes. This procedure was repeated 5 times and each intervention took a total of 15 minutes.[53] Performance measures of 5 countermovement vertical jumps (VJ) in 20 seconds followed by 5 x 20-m sprints were taken pre and post sprint-intermittent exercise to examine the effect of the recovery intervention on performance. Capillary blood was collected from the hyperemic ear for the measurement of lactate, pH and bicarbonate. Along with blood, heart rate and skin temperature was measured after warm-up, after performance tests, during each rest interval, after exercise and after the recovery intervention. No significant differences between recovery methods were found in the 20-m sprint or VJ (p = 0.6-0.9, 0.8-0.9 for 20-m sprint and VJ respectively). There were no significant differences between conditions in heart rate at any time point in session 1 and 2. Following cold water immersion in session 1, skin temperature was significantly decreased (p <.01) where as lactate was significantly reduced post intervention following C_TWT compared to ATC (2.6 ± 1.0 $mmoL^{-1}$ and 3.9 ± 1.3 $mmoL^{-1}$, respectively).[53] No significant differences were found for pH. Self-reported ratings of muscle soreness from pre to post-exercise were significantly lower after CWI and C_TWT when compared to ACT. It appears the limited and minor benefits are seen between conditionings when using different recovery protocols. Nevertheless, the authors state that including one of these four protocols may assist in the maintenance of performance in intermittent-sprint exercise performance compared to passive recovery.[53]

Recovery is an individualized phenomenon, thus when recommending recovery protocols, an individual's specific ability to cope with and recover from stress must be taken into consideration, as some individuals are able to manage higher levels of stress than others.[1,21,42] Increasing an athlete's ability to recover, not only means that he or she can return to competition and or training in peak condition, but that the athlete will have an improved ability to withstand increasing training volumes without incurring the negatives of overtraining.[2]

Biochemical Responses To Sport

Endocrine and biochemical parameters have been used as potential markers of overtraining.[56,57] Hooper et al. (1995) examined 14 elite swimmers (5 males and 9 females) over a 6-month preparation training period.[57] The subjects participated in 10 to 12 workouts a week and kept a daily log of distance swam along with a subjective assessment of training intensity based on a 7-point scale. Subjects were tested five times during the season: (a) early-season (2-3 wk after the season commenced); (b) midseason (during intense training, 12 wk into the season); (c) late-season (18 wk into the season); (d) during tapering (3-5 d before competition); and (e) post-competition (1-3 d after competition). Urinary protein, resting metabolic rate, resting blood pressure, resting heart rate, resting blood lactate and multiple blood variables were all examined for significant changes from time point to time point. On each testing day, subjects swam a 400-m warm-up and a self-selected dynamic flexibility routine. Following the warm-up, subjects swam a 200-m freestyle at 80% of their best pace and measurements of hear rate were taken every 15s while VO_2 was estimated using a regression analysis. Blood pressure was measured 2 and 7 minutes after the end of the swim and lactate concentrations were measured 5 minutes after the 200-m freestyle. After 20 minutes, subjects were asked to swim a 100-m or 400-m maximal effort freestyle dependent upon each subject's distance raced in competition.[57] The exact testing procedures used during the submximal 200-m swim, were used following the maximal effort 100-m or 400-m swim. Classification of staleness/overtraining syndrome was made based on performance decrements, subjective feelings of poor recovery and frequency of illness. Results indicated that 3 of the 14 swimmers were classified as stale. The stale swimmers showed poorer times for the maximal effort swim from early to late season (0.7 ± 0.7%, range = 0.03 to 2.0%), which was significantly different from the improvement (-3.1 ± 0.3%, range = -1.7 to -3.8%) demonstrated by the nonstale swimmers.[57] Stale swimmers also showed poorer performance times when compared to previous race times (2.4 ± 1.4%, range = 1.1 to 3.9%) while the nonstale swimmers once again showed improvement in competitive performance (-1.1 ± 1.9%, range = -4.5 to 1.8%).[57] A regression analysis revealed that subject muscle soreness, epinephrine, swim training volume, stress and neutrophil number accounted for 87% of the variance in predicting staleness. The authors note that plasma catecholamines, epinephrine and norepinephrine, may provide an objective means of diagnosing overtraining syndrome in conjunction with the athlete's self-assessment of well-being.[57] Another suggestion of the authors is that the collection and analysis of catecholamines in the blood is expensive and time consuming, thus may not provide a practical long-term method of monitoring athletes.[57]

Hoffman et al. (1999) examined hormonal and biochemical changes in basketball players during a 4-week training camp before the European Championships.[56] 10 male basketball players were tested before the initial practice (T1) and following 9 (T2), 17 (T3), and 28 (T4) days of practice. At each testing session, resting blood samples were taken and subjects were asked to complete a training questionnaire containing a series of questions looking at appetite, sleep quality, level of soreness and perception of practice intensity using a 5-point rating scale[56]. Plasma creatine kinase (CK), urea, testosterone, cortisol, luteinizing hormone (LH), thyroid stimulation hormone (TSH), triiodothyronine (T_3) and free thyroxine (FT_4) were all assessed through blood samples. No significant changes from T1 in testosterone (14.2 ± 5.6 nmol□L^{-1}) or LH (4.2 ± 1.6 IU□mL^{-1}) were observed. A significant difference in cortisol was observed between T1 (260 ± 91 nmol□L^{-1}) and T4 (457 ± 99 nmol□L^{-1}). No significant changes from T1 were found in urea, creatine phosphokinase or TSH. With the exception of cortisol, it appears that the biochemical markers used in this study were not sensitive enough to recognize changes in subjects physiological state throughout the course of a 28-day training period.[56]

In a third study, Hoffman et al. (2005) looked at changes in biochemical indices of muscle damage and hormonal markers of stress during a competitive intercollegiate football season.[58] Twenty-one Division III football players were divided into a starters (S) and nonstarters (NS) group. Each subject had blood drawn on 5 different occasions throughout the football season: preseason football training camp (T1), 10 days after the last day of training camp (T2) and at weeks 3 (T3), 7 (T4) and 10 (T5) of the competitive season. Serum testosterone, cortisol, myoglobin concentrations and serum creatine kinase were all examined from the blood samples. No changes in resting total testosterone were observed in either group during the season, suggesting that manipulations to training load and volume allowed for adequate recovery.[58] Cortisol concentrations at T2 were significantly lower than seen at T3-T5 for both S and NS. The reduction in cortisol did not appear to stem from a reduction in physical stress but more likely due to the anticipatory level at the start of preseason football camp.[58] The testosterone/cortisol ratio was also significantly lower at T2 ($p < .05$) than at any other time for both groups. Creatine kinase concentrations were significantly higher at T2 than T1 (5.5 fold higher) and T3-T5 for S and NS with a group effect at T2. Increases in creatine kinase were to be expected due to the intense nature of a football training camp and the significant differences between the groups may be attributed to the higher number of repetitions taken at practice.[58] This study indicates that elevated levels of creatine kinase reflect high-intensity exercise and that the response pattern of the noted biochemical markers suggest a degree of skeletal muscle sensitization to repeated traumas that occur during a season.[58]

Vertical Jump Implications On Performance Variables

The vertical jump is a measure of lower body power and is important in almost every sport.[59] In particular, the drop-jump has been shown to be a predictor of sprint speed, change of direction as well as dynamic leg strength.[59,23,60]

Holm, D. et al. (2008) investigated the relationship between the kinematics and kinetics of a single leg horizontal drop jump (SLDJ) to sprint performance.[23] Twenty men from various sports competing at the regional level in New Zealand completed a sprint and jump test within the same testing session. Prior to jumping, the subjects jogged for 5-10 minutes, performed a number of lower body dynamic stretches and took part in submaximal sprints and jumps.[23] All subjects completed a minimum of 3 25-m sprints where time was recorded at 5, 10 and 25 meters. The SLDJ was performed with both the right and left legs. The subjects stepped off of a 20 cm box with hand on hips, landed on the specified leg, jumped for maximum horizontal displacement and landed on two feet.[23] A rest period of 1 minute was given between each jump and the order of the jumps was randomized in a block fashion. For each subject, the two longest SLDJ were identified and the mean values for contact time (CT), anterior-posterior impulse (impulse AP), vertical impulse (impulse V), mean vertical ground-reaction force (mean VGRF) and reactivity coefficient (RC) were calculated.[23] The two best sprint times for every subject for each sprint distance (0-5, 0-10, 0-25, 5-10, 10-25 m) were used for analysis.[23] Jump distance was significantly correlated to sprint time across all measured distances. The strongest correlation was found between 10-m sprint time and jump distance/height (r = -0.64 to -0.65).[23] The authors imply that the significant correlations between sprint and SLDJ are because both activities involve unilateral ground contacts, high stretch-shortening cycle loads and the production of horizontal and vertical forces.[23,61]

Hennessy, L. (2001) set out to extend the examination of the relationship between commonly used stretch-shortening cycle (SSC) actions and sprint performances in female athletes.[27] Seventeen nationally ranked women took part in a 2-day testing protocol. Day 1 included tests that measured height, body mass, countermovement jump (CMJ) for vertical distance, bounce drop jump (BDJ) from a 30 cm box for vertical distance, BDJ index (centimeters/seconds) and a 5-step bound (5B-consisted of 5 dynamic horizontal bounds) for horizontal distance. Sprints of 30 and 100-m were completed on day 1, whereas the 300-m sprint was completed on day 2.[27] Results indicated that among the SSC performance variables, the closes relationships were seen between the BDJ index and CMJ ($r = 0.62$, $p < 0.05$). The CMJ displayed a significantly consistent relationship across 30-m ($r = -0.60$), 100-m ($r = -0.64$) and 300-m ($r = -0.55$) sprint times. The BDJ index displayed relationships of -0.79 ($p < 0.05$), -0.75 ($p < 0.05$) and -0.49 ($p > 0.05$) across 30-m, 100-m and 300-m distances. The 5B test displayed significance at the 300-m distance ($r = -0.54$). A regression analysis revealed that the BDJ index accounted for 63% of variance in the 30-m sprint and 55.7% of total variance in the 100-m sprint.[27] The authors conclude by suggesting that improving an athlete's jump height while decreasing ground contact time during the drop jump will result in improved sprint speed of distances less than 100-m.[27]

Monitoring Workload In Relation To Performance

The Ratings of Perceived Exertion scale was created to allow for simple non-invasive and valid estimations of exercise intensity and training loads.[34,62-65] Monitoring training loads is an integral part of a successful training program because careful manipulation of training intensity and recovery is essential for optimal performance.[62,64]

Day, M. et al. (2004) investigated the reliability of the session rating of perceived exertion (RPE) scale to quantify exercise intensity over a 7 day period in which lifting protocol was labeled high intensity (H), moderate-intensity (M) and low intensity (L).[62]

The resistance sessions consisted of squat, bench, curl, press and pushdowns. Each lifting protocol was performed twice and day 1 consisted of an educational session on how to use the CR-10 RPE scale. Nineteen subjects completed the study and had over 6 months of experience with resistance training. Following an exercise specific warm-up, subjects performed the exercises according to the intensity of repetitions required for the session.[62] Subjects were then asked to rate their perceived exertion following the completion of each working set based on the CR-10 RPE scale. Subjects were also asked for their RPE at the thirty-minute mark following the completion of their workout. Results indicated that performing 15 repetitions of a lighter resistance was perceived to be less difficult than performing 10 and 5 repetitions of heavier intensities. Perceived as the most difficult, was when subjects performed the least number of repetitions at the highest absolute intensity.[62] Based on the findings from this study, session RPE appears to be a reliable method of quantifying training intensity based on the corresponding RPE values with increases in training intensity.[62]

In a second study, Anderson et al. (2003) monitored training patterns throughout a basketball season, with the use of a 0-10 ratings of perceived exertion scale, in an attempt to determine if a relationship existed between workload and injury.[34] Over a 20-week season, twelve female Division III collegiate basketball players participated in this study. Each subject was asked to answer a questionnaire comprised of questions in relation to the subjects' session RPE and any current illnesses or injuries suffered. An injury was defined as any circumstance in which the athlete received an evaluation from a certified athletic trainer and required limiting practice for a minimum of one day.[34] An illness was defined as any circumstance in which the athlete or MD felt the athlete was unable to perform the drills as directed by the coach. Session load was calculated by taking the product of training duration in minutes and session RPE and correlations were used to see the strength of relationship between training loads and injury or illnesses. A moderately positive correlation ($p < 0.01$; $r = 0.675$) was found between workload and injury. The investigators found distinguishable spikes in training load and the number of injuries during the first week of practice as well as during the first week back from an extended break from basketball related activities. It appeared evident that the athletes' bodies were not ready for the start of the season or for the first week of training following an extended break from basketball training. Illnesses fluctuated in an unpredictable manner, thus no correlation was found.[34]

Foster et al. (1998) proposed a link between training load, strain felt by the athlete during training and monotony of practices as being indicators of possible overtraining.[34,66] Training loads should be evaluated by coaches when developing training plans because training loads have been shown to impact a team's performance.[34,66]

Recovery-Stress Questionnaire 76

The Recovery-Stress Questionnaire 76 (REST-Q) is a 77-item questionnaire (76 plus one warm up attempt) that attempts to systematically reveal the recovery-stress state of an athlete.[21,35] The recovery-stress state indicates the extent to which athletes are physically and/or mentally stressed, whether that athlete is capable of using individual strategies for recovery as well as which strategies are being used.[21] The REST-Q uses a multidimensional approach towards assessing the stress and recovery efforts of an athlete based on the theoretical model that an increase in stress demands an increase in recovery and that the balance between stress and recovery is dependent upon an athlete's ability to cope with stress as well as use effective recovery strategies.[21,41] Scoring of the REST-Q is done by calculating the mean of the scores on each of the 19 scales.[21] Higher scores on the stress-related scales indicate higher levels of subjective stress while higher scores on recovery-related scales imply good recovery habits.[21,35] While the calculation of an overall single score that combines stress and recovery scales is strongly prohibited, each individual set of scales (i.e. general stress-oriented scale, general recovery-oriented scale, sport specific stress and recovery oriented scales) can be combined to form scale scores and provide specific starting points for interventions.[21] General stress/recovery scales and sport-specific stress/recovery scales can also be combined to configure a "Global Stress" and "Global Recovery" score.[21] The recovery-stress state score is calculated by subtracting total stress from total recovery.[21,41] Interpretation of REST-Q scores should refer to a reference group of the athletes or to intra-individual changes over time.[21]

Kellman and Günther (2000) attempted to monitor the recovery-stress state of elite rowers during high-altitude training camp prior to the Olympics.[16] They administered the REST-Q to the 11 rowers four times during a three-week training camp and an additional fifth time to the 8 rowers who were scheduled to compete in the Olympics.[16] The rowers took part in intense, highly intense endurance training, strength training, speed training as well as regenerative exercises and it was expected that changes in endurance training would mirror in the scales of the REST-Q.[16] They found a significant trend in higher minutes of training and higher scores on *Somatic Complaints* ($F(1, 10) = 9.65$; $P < .05$), *Lack of Energy* ($F(1, 10) = 7.22$; $P < .05$, and *Fitness/Injury* ($F(1, 10) = 8.31$; $P < 0.05$) scales (12). These results show that psychological measures were highly reflective upon increases in endurance training while recovery scores were simultaneously being lowered.[16]

In an additional study, Gonzalez-Boto, A. et al. (2008) looked to investigate whether the REST-Q would be a useful tool in detecting overreaching in its early stage and if it could be used to evaluate effects of changes in training load during a 6-week training period in swimmers.[33] The researchers monitored nine well-trained swimmers over a 6-week training period that was divided into four phases.[33] Phase one (T_1) of the training consisted of low volume (3,200 m/day) and low intensity (60-70% VO_{2max}) training. Volume increased 35% to 5,000 m/day and intensity increased to 70-80% VO_{2max} during phase two (T_2). Phases three (T_3) and four (T_4) saw a reduction in volume to 3,900 m/day and 3,200 m/day respectively; however, intensity during T_3 rose to 90-100% VO_{2max} and T_4 ended with swimmers training over anaerobic threshold.[33] The REST-Q was given at four different points during training in an attempt to record changes in swimmers recovery-stress states induced by the four different training phases.[33] During the initial low intensity-volume training period higher scores were revealed on the recovery-oriented scales (*General Well-Being* 4.44 ± 1.10*, Social Recovery* 4.41 ± 1.16 *and Being In Shape* 4.35 ± 0.80) than on stress related scales.[33] During T_2 when training volume increased by 35%, there were significant increases in *Injury* (3.06 ± 1.27 $P < 0.05$) and *Emotional Exhaustion* (1.16 ± 0.71 $P < .05$) and a significant decrease in the sport specific recovery scale *Self-Efficacy* (2.78 ± 1.07 $P < .05$). Scores from T_3 to T_4, in which there were decreases in training volume, did not elicit any significant changes. When the recovery-stress state (total recovery - total stress) was calculated, a significant time effect was found ($F_{3,35} = 5.12$, P

<0.001) indicating that the recovery-stress state significantly decreased during the time when training volume was at its highest.[33]

Jürimäe, J. et al. (2004) set out to find specific diagnostic markers of heavy training stress using performance, perceived-recovery-stress state and stress hormonal values and if there were any relationships between these markers in rowers.[67] They took 21 national-level male rowers during a six-day training period that included a 100% average increase in training load when compared with their previous four week training period. Training was broken down into 85% low-intensity endurance training, high-intensity anaerobic training made up 5% and 10% consisted of resistance training. Changes in stress and recovery after heavy training in rowers.) Resting blood samples (testosterone and cortisol), rowing performance (2,000 meter rowing ergometer test) and recovery-stress state (REST-Q) of rowers were assessed before (T_1) and after (T_2) the six-day training period.[67] After the six-day training period the rowers' 2,000 meter performance test time significantly increased (T_1 396 ± 10.8 secs; T_2 406 ± 11.9secs, $P < 0.05$). Similar to studies mentioned beforehand, the recovery-stress state of rowers changed during the heavy training period with significant increases in *Fatigu*e (T_1 2.0 ± 0.9; T_2 2.8 ± 1.2, $P < 0.05$), *Somatic Complaints* (T_1 1.4 ± 0.8; T_2 2.1 ± 0.9, $P < 0.05$) and from the sport specific stress scale *Fitness/Injury* (T_1 1.9 ± 0.7; T_2 2.7 ± 1.3, $P < 0.05$). Significant decreases were found in the *Success* (T_1 3.4 ± 1.1; T_2 2.8 ± 0.6, $P < 0.05$), *Social Relaxation* (T_1 3.5 ± 1.2; T_2 2.9 ± 0.8, $P < 0.05$), *Sleep Quality* (T_1 4.4 ± 1.1; T_2 3.8 ± 0.9, $P < 0.05$), *Being in Shape* (T_1 3.9 ± 1.8; T_2 2.9 ± 1.1, $P < 0.05$) and *Self-Efficacy* (T_1 3.2 ± 1.2; T_2 3.5 ± 1.1, $P < 0.05$) from the recovery-oriented scales. Testosterone significantly decreased from T_1 to T_2 (17.6 ± 5.2 to 13.2 ± 4.7 $nmol{\bullet}l^{-1}$, $P < 0.05$) but no significant changes occurred in cortisol levels (496.4 ± 82.1 vs.

519.0 ± 59.2 nmol•l^{-1}). Significant relationships ($P < 0.05$) between increased training volume and *Fatigue* (r =0.49), *Somatic Complaints* (r= 0.50) and *Sleep Quality* (r= 0.58) at the end of the training period. It should be noted that cortisol changes from T_1 to T_2 were not statistically significant; however, significant relationships ($P < 0.05$) were observed between cortisol and the *Fatigue* scale (r= 0.48) when measured at the end of the heavy training period.

All in all, the REST-Q appears to be a sensitive enough tool to mirror changes in training loads with changes in an athlete's recovery-stress state and may help to prevent the occurrence of overtraining.[21,33,33,67]

Monitoring Athletes Throughout A Season

Basketball players typically participate in training programs that are designed to improve work capacity, strength, power, flexibility and speed.[10,68,69] However, once official basketball practices begin, the number of training sessions is drastically reduced or even eliminated.[10] Häkkinen, K. (1993) suggested that in order to maintain explosive strength, the magnitude of both strength and explosive training stimuli should be given careful attention during the entire course of the competitive season.[29,30] In addition to Häkkinen's idea, Kroll,W. (1983) stated that significant losses in conditioning will occur within two to four weeks if a maintenance program is not implemented.[70] A maintenance period of as little as once a week during the competitive season has been shown to retain strength levels in baseball players.[71,72]

Groves, B. and Gayle, R. (1993) conducted a study on Division 1 men basketball players in an attempt to generate performance related physiological profiles for male intercollegiate basketball players engaged in year-round strength training and to assess the effects of these changes on the interrelationships of the variables.[73] Eight male basketball players were tested on body weight, body composition, the Maragaria-Kalamen Stair Test, vertical jump and bench press on four different occasions.[73] The first testing session (T1) took place on the first day of the fall semester, T2 occurred during the second week in October, before official basketball practice began while T3 came after the last regular season game and the last week of April made up T4. The athletes participated in a four days a week (split-routine) pre-season training program where training volume was set at 4 sets of 3 to 5 reps anywhere between 85-95% of their 1RM. Once basketball practice started, training loads decreased to 60-85% of 1RM and volume changed to 3 sets of 12-15 reps but players were still lifting four days a week.[73] After games began, players were scheduled to perform lifting sessions as much as possible as long as a 24-hour window between lifting and a game existed. They found significant increases in bench press from T1 to T4 (199.4 ± 42.5; 226.9 ± 32.7 $P < .05$) as well as significant decrease in percent body fat (11.5 ± 1.8; 9.2 ± 2.0 $P < .05$). Vertical jump height did not display significant changes between any time points; however, it is worth stating that the highest mean jump heights were recorded during T2 and T3. Both T2 and T3 reflect the effects of pre- and in-season basketball training when basketball training intensity and frequency are markedly greater. This study reveals that a properly planned year-round strength training program has beneficial effects on upper body strength and percent body fat.[73] And although no significant improvements were seen in Margaria-Kalamen Stair Test scores or vertical jump heights, there was no evidence of negative effects due to a year-round, in-season strength training program.[73]

In contrast to Groves, B. and Gayle, R.'s study, Hoffman et al. (1991) examined strength (1RM bench press), maximal isometric and dynamic strength (isokinetic dynamometer and squat), speed (27-meter sprint), agility (T-test), aerobic endurance (1.5 mile run) and vertical jump in nine Division 1 male basketball players where in-season strength training was non-existent.[10] Players were assessed at the beginning of pre-season resistance training program (RTP), prior to the start of practice (PRES), midseason (MS) and post-season. The three days a week pre-season strength and conditioning sessions ranged in volume and loads of 3-4 sets of 8-25 reps depending on the exercise, lasted a total of 5-weeks and then was discontinued. Significant decreases ($P < .05$) were found in strength, speed and vertical jump tests at MS when compared to PRES scores (*dynamic squat*: PRES 140.6 ± 21.0kg; MS 126.5 ± 19.4kg; *27-meter sprint*: PRES 4.01 ± 0.21sec: MS 4.10 ± 0.17sec;*vertical jump height:* PRES 64.5 ± 9.7cm: MS 58.7 ± 5.2cm). The authors stated that the 5-week pre-season training program was too short for any serious adaptations to occur strength wise and any strength gains made during the pre-season were due to neural adaptation.[10] Due to the anaerobic and aerobic demands of basketball, an athlete can expect to maintain his aerobic conditioning level based on the consistency in recorded times of the 1.5 mile run, even in the absence of a resistance training program.[10]

Similar to those athletes in the study conducted by Hoffman et al., Santos, E. et al. (2009) attempted to identify and compare the effects of both detraining and reduced training program application in explosive strength levels of adolescent basketball players.[71] Fifteen basketball players who had previously taken part in the same 10-week in-season training complex training program were assigned to a detraining group (DTR) or a reduced training group (RT). Both groups maintained involvement in basketball practice but the

DTR group ceased participation in the complex training while the RT group reduced complex training from two days to one day a week.[71] Subjects were tested on squat jump (SJ), countermovement jump (CMJ), Abalakov test (ABA), depth jump (DJ-from a 40cm platform), mechanical power (MP) and medicine ball throw (MBT-seated) at the end of the initial 10-week complex training program (T0) in addition to 4(T4), 8(T8), 12(T12) and 16(T16) weeks after the initial 10-week program. There were no significant group-by-time interactions for measured variables. Data from this study suggest that maintenance of explosive strength values during a 16-week period of either detraining or reduced training is possible.[71] Findings of this study contradict the decrease in performance variables of basketball players who did not participate in regular strength training in the study done by Hoffman el al.[10,71] It appears that maintenance of strength throughout the season may be dependent upon the training age of the athletes, the intensity of strength training sessions, if there are any and on the intensity of basketball practices mandated by the sport coach.

Lastly, Kraemer, J. et al. (2004) investigated the physiological and performance changes that take place over a Big Ten season in college soccer players. Twenty-five Division 1 collegiate male soccer players divided into starters (S) and non-starters (NS), were monitored throughout an 11-week competitive season that consisted of 19 games.[11] Physical performance measures of isokinetic and isometric strength, sprint speed and vertical jump as well as body composition measures and hormonal concentrations of testosterone and cortisol were taken six times during the course of the season. Baseline testing (T1) was performed 1 week before the first competitive game, 4 assessments were made during the season at weeks 3, 7, 8 and 9 (T2-T5) and the last assessment (T6) was made 1 week following the end of the competitive period. Throughout the season athletes took part in two days a week of supervised strength and conditioning sessions using loads of up to 75-85% of 1RM. A significant decrease in isokinetic leg strength decreased from T1 to T6 when measured at 1.05 rad·sec^{-1} in both S (T1: 240.31 ± 11.12; T6: 211.48 ± 8.43 P <.05) and NS (T1: 227.40 ± 10.60; T6: 204.73 ± 7.40 P <.05). Measures of isometric strength showed no significant changes during the season for either group.[11] S showed a significantly (P <.05) slower 20-yd sprint speed between T1 (under 2.75seconds) and T5 (over 2.85 seconds) while NS showed no significant differences. Vertical jump height decreased significantly in the S group only, when comparing T5 (44-46 cm) to T1 (50-52 cm). Testosterone levels showed significant increases at T6 (~23%) when compared to T2 (18.2 nmol/L vs. 13.95 nmol/L). Starters showed a significant increase in testosterone at T6 (~29%) when compared to T1 (17.2 nmol/L vs. 12.25 nmol/L). No significant changes in plasma cortisol concentrations were found during the course of the season. In conclusion, both groups experienced reductions in exercise performance that were more prominent during the latter stages of the competitive season.[11] Overall, starters showed greater decrements in performance in sprint speed (+ 4.3%) and vertical jump height (-13.8%). Performance decrements may be due to the fact that starters showed high levels of cortisol and low levels of circulating testosterone caused by playing significantly more game minutes than non-starters.[11]

The ability of a player to maintain strength and power throughout the course of a season, appears dependent upon each programs individual attitude towards strength and conditioning during the competitive season.[10,11,29,30,71-73]

Problems In Monitoring For Overtraining

Studies have recommended using different physiological, psychological, immunological and biological markers to distinguish between acute fatigue, overreaching and overtraining.[1,33] However, other reports state that the value of these physiological and biochemical markers is still very unclear.[1,50] Diagnosis of overtraining is very difficult because there's no simple diagnostic test.[5,6] Overtraining is an individual phenomenon in which symptoms differ from person to person.[1,5] Declaring that an athlete is suffering from overtraining can only be made by excluding all other possible influences on changes in performance and mood state; no objective proof of overtraining exist[6, 41] Distinguishing between preceding markers or early warning signs with prognostic value and symptoms with diagnostic value is extremely difficult and thought to be one of the most complicated tasks in sport science.[1,41] It is suggested that different metabolic and hormonal parameters as well as psychometric scales may be used to evaluate response to heavy training and quality of recovery.[1,4,6,32] Shephard and Shek (1998) conclude that psychological measures provide simple and effective methods for monitoring training versus suggested physiological or immunological markers.[1] On the other hand, athletes of similar physical ability may have different responses to training stimulus, thus only one measure of stress may by insufficient.[1,5,74]

Many studies use different terminology to discuss overreaching and overtraining states of athletes, which creates a large barrier when trying to move forward in this area of research.[1,41,75,76] Terminology differences usually exist between research studies examining physiology and psychology responses to training and competition[1] Physiological studies will use the term overload to describe the training process, whereas a psychological study done uses the term overtraining.[1,6] Flynn, M. (1998) states that there must be a point where terminology is consistent and does not add to the confusion surrounding an already difficult topic and that investigators should willing to use synonyms, or clearly define the terms that they use in their research.[76]

Aside from the concern that many studies have focused on only one specific category of overtraining responses (e.g., immunology), only a few studies are available in which a group of athletes has been monitored for a prolonged period, such as a full season.[22,42] Kalda et al. (2004) used a REST-Q to assess sprinters and jumpers recovery-stress state before an indoor track championship and an outdoor track championship. Participants completed a REST-Q one day before the indoor and outdoor track championships. Scores on the *Fatigue* scale (r =-.74) and *Emotional Exhaustion* (r= -.79) correlated significantly with International Amateur Athletic Federation (IAAF) approved earned team points during the indoor championships.[77] Results of the Outdoor championships significantly correlated significantly with *Somatic Complaints* (r =-.70) and *General Well-Being* (r= .63) scales. An individual analysis indicated that there were large differences on the pre-competition REST-Q scale scores for the athlete with good performance (-0.20sec on 60m race) and for the athlete whose performance was a disappointment to her (+0.18sec on 60m race). The successful sprinter showed a more positive recovery-stress state, indicated by lower scores on almost all stress-related scales (*General Stress:* Successful sprinter 0.55 vs. 2.80 non-successful sprinter, *Fatigue:* 0.25 vs. 2.50, *Emotional* Stress; 1.00 vs. 2.00) in addition to higher scores on recovery-related scales (Sleep *Quality:* 4.75 vs. 2.00, *Being in Shape*: 2.20 vs. 1.75, *Self-Efficacy:* 3.25 vs. 2.20).[77] This study monitored athlete’s recovery-stress state was only done before competition and not during training for the competition; however, had the athlete's recovery-stress state been monitored throughout training, levels of performance may have been improved. Results from Kalda, J et al, Kellmann and Günther, suggest that positive scores on the recovery-stress scales indicate better outcomes in competition.[16,77] Once again, this study highlights the gap in research in regards to monitoring only individual sports.[1,16,33,78] Being part of a team may increase symptoms of overtraining due to the added stress that comes with being a part of a team.[33]

Summary

The overtraining syndrome is stated as exhibiting signs of physiological and/or psychological disturbances. Numerous studies have attempted to monitor athlete's responses to increased training loads in hopes of finding clear markers of overtraining.[1,33,67] No clear performance, psychological or biochemical maker appears to signify the possibility of overtraining in every athlete. More research is needed to find appropriate markers for overtraining in team-oriented sports when competitions take place more than once a week.[5,33] However, in attempts to correctly identify the possibility of overtraining in the present day, coaches, researchers as well as strength and conditioning specialists, must schedule sport-specific tests along with psychological assessments at regular intervals during a training period or season.

APPENDIX B

Hypothesis

The following null hypotheses will be examined:

$H_O 1$ = There will be no significant difference in drop jump height in starters or non-starters throughout the competitive season.

$H_0 2$ = There will be no significant difference in Recovery-Stress scores in starters or non-starters from pre to post testing.

$H_0 3$ = There will be no significant difference in Global Stress scores in starters or non-starters from pre to post testing.

$H_0 4$ = There will be no significant difference in Global Recovery scores in starters or non-starters from pre to post testing

$H_0 5$ = There will be no significant difference in Recovery-Cue Seven scores in starters or non-starters throughout the competitive season

APPENDIX C

Operational Definitions:

Overtraining- An accumulation of training or non-training stress resulting in long-term decrement in performance capacity with or without related physiological and psychological signs and symptoms of overtraining in which restoration of performance capacity may take several weeks or months (Kreider, R. 1998).

Overreaching- An accumulation of training and non-training stress resulting in a short-term performance decrement in performance capacity with or without related physiological signs and symptoms of overtraining in which restoration of performance capacity may take from several days to several weeks (Kreider, R. 1998).

Recovery- Recovery can be defined as "an inter- and intra-individual multilevel (e.g. psychological, physiological, social) process in time for the re-establishment of performance abilities" and is dependent upon the absence of stress (Kellmann 2001).

Stress- A destabilization or deviation from the norm in a biological/psychological system (Kellmann 2001)

Recovery-Stress State- An indication of the extent to which athletes are physically and/or mentally stressed, whether that athlete is capable of using individual strategies for recovery as well as which strategies are being used (Kellmann 2001)

APPENDIX D

Delimitations

This study will have the following delimitations:

1. All subjects were apparently healthy female collegiate basketball players from a Division 1 University in Southeastern, United States.
2. Monitoring of athletes occurred during conference play only.
3. Drop jump was performed in a laboratory setting.
4. The results of using apparently healthy female collegiate basketball players may not represent female athletes in other sports.

Limitations

The research may be limited by the following:

1. The subjects of this study were selected from a sample of convenience.
2. The limited subject sample size.
3. The use of a small force plate may have altered subject's drop jumping technique.

Assumptions

1. Subjects completed Recovery-Stress Questionnaires honestly.
2. Subjects reported Ratings of Perceived Exertion honestly.
3. Subjects gave complete effort on every drop jump trial.
4. Subjects had no injury or illness that would influence drop jump.
5. All equipment used in the biomechanics laboratory was operating properly.

APPENDIX E

COLLEGE OF HEALTH AND HUMAN SCIENCES

DEPARTMENT OF HEALTH AND KINESIOLOGY

INFORMED CONSENT

Monitoring Changes in Drop Jump Height and Psychological Measures Throughout A Competitive Division 1 Women's Basketball Season

1. **Principal Investigators**: Michelle Van Dyke, B.S., Graduate Student, 478-1976, mv00269@georgiasouthern.edu, Jim McMillan, Ed.D., Associate Professor, 478-1926, jmcmillan@georgiasouthern.edu, Stephen Rossi, Ph.D, Assistant Professor, 478-0775, srossi@georgiasouthern.edu, and Thomas Buckley, Ed.D, Assistant Professor, 478-5268, tbuckley@georgiastouhern.edu, Department of Health and Kinesiology, P.O. Box 8076, Statesboro, GA 30460

2. **Purpose of the Study:** The purpose of this study is to monitor changes in drop jump height as well as changes in recovery cue 7 questionnaire scores throughout a competitive Division 1 women's basketball season.

3. **Procedures to be followed:** You will report your rate of perceived exertions based on a 0-10 rating scale. A score of 0 will indicate "rest" or that you put forth no effort; whereas, a score of 10 will indicate a "maximal" effort by you during either practice or competition. You will report 6 times during the study for a total time commitment of about one hour. You will be asked to fill out a recovery-cue seven questionnaire, perform a drop jump on a force plate once a month beginning in January and ending after the competitive season is over, you will be asked to fill out a recovery-cue seven questionnaire once a week and perform a drop jump on a force plate once a week. Prior to the study, you will be asked to read and sign a university approved informed consent form.

4. **Discomforts and Risks**: Possible risks of muscle strains, ankle sprains and ACL injuries could occur during the drop jump tests. Other studies have used the same height box (30cm) for the drop jump without experiencing any injuries during jumps.

5. **Benefits:** The present study hopes to further the literature related to the role that a full competitive season plays on results on a performance test as well as a recovery-cue questionnaire. This study also hopes to present stable and reliable method for assessing an athlete's training state throughout a season.

6. **Duration/Time:** You will report 6 times during the study for a total time commitment of about one hour. In January, you will report once a week to fill out a recovery-cue seven questionnaire and perform 2 drop jumps on a force plate. .

7. **Statement of Confidentiality:** All scientific and personal data collected on subjects for presentation purposes will be kept confidential and stored in a locked file drawer in Hollis 2121A. This information will be available only to the principal investigators. Your identity will not be revealed in publications or presentations that result from this study so as to protect your privacy and confidentiality. All data will be reported as means and standard errors.

8. **Right to Ask Questions:** You have the right to ask questions and have those questions answered. If you have questions about this study, please contact Michelle Van Dyke, B.S., Graduate Student, 478-1976, mv00269@georgiasouthern.edu, Dr. Jim McMillan, Ed.D, Associate Professor, 478-1926, jmcmillan@georgiasouthern.edu, Stephen Rossi, Ph.D, Assistant Professor, 478-0775, srossi@georgiasouthern.edu, or Thomas Buckley, Ed.D. Assistant Professor, 478-5268, tbuckley@georgiasouthern.edu, Southern University Office of Research Services and Sponsored Programs at 912-478-7758.

9. **Compensation:** There is no compensation for participating in the present research project.

10. **Voluntary Participation:** Your participation in this study is entirely voluntary. If you decide to participate, you are free to withdraw your consent and to stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

11. **Penalty:** If you decide not to participate, you will not be penalized, and you will not lose any benefits or services to which you are otherwise entitled.

12. You must be 18 years of age or older to consent to participate in this research study. If you consent to participate in this research study and to the terms above, please sign your name and indicate the date below.

You will be given a copy of this consent form to keep for your records.

Title of Project: Monitoring Drop Jump Heights and Recovery Cue 7 Questionnaire Scores Throughout A Competitive Division 1 Women's Basketball Season

Principal Investigators: Michelle Van Dyke, B.S., Graduate Student, 478-1976, mv00269@georgiasouthern.edu, Jim McMillan, Ed.D, Associate Professor, 478-1926, jmcmillan@georgiasouthern.edu, Stephen Rossi, Ph.D, Assistant Professor, 478-0775, srossi@georgiasouthern.edu, Thomas Buckley, Ed.D. Assistant Professor, 478-5268, tbuckley@georgiasouthern.edu

______________________________ ______________________

Participant Signature Date

I, the undersigned, verify that the above informed consent procedure has been followed.

______________________________ ______________________

Investigator Signature Date

APPENDIX F

ID Number: _______________

1. How much effort was required to complete my workouts last week?

hardly any effort	6	6	6	6	6	6	6	6	6	6	6	6
	5	5	5	5	5	5	5	5	5	5	5	5
	4	4	4	4	4	4	4	4	4	4	4	4
	3	3	3	3	3	3	3	3	3	3	3	3
	2	2	2	2	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	1	1	1	1
excessive effort	0	0	0	0	0	0	0	0	0	0	0	0
week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

2. How recovered did I feel before my workouts last week?

energized and recharged	6	6	6	6	6	6	6	6	6	6	6	6
	5	5	5	5	5	5	5	5	5	5	5	5
	4	4	4	4	4	4	4	4	4	4	4	4
	3	3	3	3	3	3	3	3	3	3	3	3
	2	2	2	2	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	1	1	1	1
still not recovered	0	0	0	0	0	0	0	0	0	0	0	0
week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

3. How successful was I at rest and recovery activities last week?

successful	6	6	6	6	6	6	6	6	6	6	6	6
	5	5	5	5	5	5	5	5	5	5	5	5
	4	4	4	4	4	4	4	4	4	4	4	4
	3	3	3	3	3	3	3	3	3	3	3	3
	2	2	2	2	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	1	1	1	1
not successful	0	0	0	0	0	0	0	0	0	0	0	0
week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

4. How well did I recover physically last week?

always	6	6	6	6	6	6	6	6	6	6	6	6
	5	5	5	5	5	5	5	5	5	5	5	5
	4	4	4	4	4	4	4	4	4	4	4	4
	3	3	3	3	3	3	3	3	3	3	3	3
	2	2	2	2	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	1	1	1	1
never	0	0	0	0	0	0	0	0	0	0	0	0
week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

(continued)

5. How satisfied and relaxed was I as I fell asleep in the last week?

always	6	6	6	6	6	6	6	6	6	6	6	6
	5	5	5	5	5	5	5	5	5	5	5	5
	4	4	4	4	4	4	4	4	4	4	4	4
	3	3	3	3	3	3	3	3	3	3	3	3
	2	2	2	2	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	1	1	1	1
never	0	0	0	0	0	0	0	0	0	0	0	0
week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

6. How much fun did I have last week?

always	6	6	6	6	6	6	6	6	6	6	6	6
	5	5	5	5	5	5	5	5	5	5	5	5
	4	4	4	4	4	4	4	4	4	4	4	4
	3	3	3	3	3	3	3	3	3	3	3	3
	2	2	2	2	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	1	1	1	1
never	0	0	0	0	0	0	0	0	0	0	0	0
week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

7. How convinced was I that I could achieve my goals during performance last week?

always	6	6	6	6	6	6	6	6	6	6	6	6
	5	5	5	5	5	5	5	5	5	5	5	5
	4	4	4	4	4	4	4	4	4	4	4	4
	3	3	3	3	3	3	3	3	3	3	3	3
	2	2	2	2	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	1	1	1	1
never	0	0	0	0	0	0	0	0	0	0	0	0
week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

From Kellmann, Patrick, Botterill, and Wilson, 2002, The Recovery-Cue and its use in applied settings: Practical suggestions regarding assessment and monitoring of recovery. In *Enhancing Recovery: Preventing Underperformance in Athletes* edited by Michael Kellmann, Champaign, IL: Human Kinetics.

APPENDIX G

R E S T Q - 76 Sport

Single Code: ______________________ Group Code: ______________________

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

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

Sport/Event(s): ____

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

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

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

For each statement there are seven possible answers.

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

Example:

In the past (3) days/nights

... I read a newspaper

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

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

Please do not leave any statements blank.

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

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

In the past (3) days/nights

1) ... *I watched TV*

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

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

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

3) ... *I finished important tasks*

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

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

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

5) ... *everything bothered me*

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

6) ... *I laughed*

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

7) ... *I felt physically bad*

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

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

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

9) ... *I felt physically relaxed*

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

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

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

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

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

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

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

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

In the past (3) days/nights

13) ... *I felt at ease*

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

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

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

15) ... *I had a headache*

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

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

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

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

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

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

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

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

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

20) ... *I felt uncomfortable*

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

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

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

22) ... *I felt down*

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

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

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

24) ... *I felt depressed*

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

In the past (3) days/nights

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

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

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

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

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

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

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

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

29) ... *I felt physically fit*

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

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

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

31) ... *I was lethargic*

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

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

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

33) ... *I had fun*

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

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

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

35) ... *I was overtired*

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

36) ... *I slept restlessly*

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

In the past (3) days/nights

37) ... *I was annoyed*

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

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

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

39) ... *I was upset*

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

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

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

41) ... *I made important decisions*

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

42) ... *I felt physically exhausted*

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

43) ... *I felt happy*

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

44) ... *I felt under pressure*

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

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

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

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

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

47) ... *I felt content*

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

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

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

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

In the past (3) days/nights

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

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

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

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

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

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

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

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

53) ... *I recovered well physically*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

In the past (3) days/nights

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

69) ... *I felt very energetic*

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

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

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

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

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

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

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

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

In the past (3) days/nights

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

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

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

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

75) ... *my body felt strong*

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

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

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

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

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

Thank you very much!

REFERENCES

1. Kentta G, Hassmen P. Overtraining and recovery. A conceptual model. *Sports Med.* Jul 1998;26(1):1-16.
2. Bishop P, Jones, E., Woods, K. Recovery From Training: A Brief Review. *Journal of Strength and Conditioning Research.* 2008;22(3):1015-1024.
3. Kreider R, Fry, A., O'Toole, M. Overtraining in Sport: Terms, Definitions, and Prevalence. In: Kreider R, Fry, A., O'Toole, M., ed. *Overtraining in Sport*. Champaign: Human Kinetics; 1998:vii-ix.
4. Meeusen R, Duclos, M., Gleeson, M., Rietjens, G., Steinacker, J.,Urhausen, A. Prevention, diagnosis and treatment of the Overtraining Syndrome. *European Journal of Sport Science.* 2006;6(1):1-14.
5. Kuipers H, Keizer HA. Overtraining in elite athletes. Review and directions for the future. *Sports Med.* Aug 1988;6(2):79-92.
6. Fry RW, Morton AR, Keast D. Overtraining in athletes. An update. *Sports Med.* Jul 1991;12(1):32-65.
7. Kilinc F. An Intensive Combined Training Program Modulates Physical, Physiological,Biomotoric, and Technical Parameters In Women Basketball Players. *Journal Of Strength and Conditioning.* 2008;22(6):1769-1778.
8. MacLean JC. *Refinement of time-motion study procedures.*, University of New Brunswick; 1984.
9. Caterisano A, Patrick,B.,Edenfield,W.,Batson,M. The Efffects of a Basketball Season on Aerobic and Strength Parameters Among College Men: Starters vs. Reserves. *Journal Of Strength and Conditioning Research.* 1997;11(1):21-24.
10. Hoffman J, Fry, A., Howard, R., Maresh, C., Kraemer, W. Strength, Speed and Endurance Changes During the Course of a Division 1 Basketball Season. *Journal of Applied Sport Science Research.* 1991;5(3):144-149.
11. Kraemer W, French, D., Paxton, N., Hakkinen, K., Volek, J., Sebastianelli, W. et al. Changes In Exercise Performance And Hormonal Concentrations Over A Big Ten Soccer Season In Starters And Nonstarters. *Journal Of Strength and Conditioning.* 2004;18(1):121-125.
12. National Strength and Conditioning Association: Strength and Conditioning Professional Standards and Guidelines. *Strength & Conditioning Journal.* 2009;31(5):14-38 10.1519/SSC.1510b1013e3181b1519c1534c.
13. Ashley CD, Weiss LW. Vertical Jump Performance and Selected Physiological Characteristics of Women. *The Journal of Strength & Conditioning Research.* 1994;8(1):5-11.
14. Bissas A, Havenetidis, K. The Use Of Various Strength-Power Tests As Predictors Of Sprint Performance. *Journal of Sports Medicine and Physical Fitness.* 2008;22(3):1015-1024.
15. Morgan W, Brown, D., Raglin, S., O'Connor, P., Ellickson, K. Psychological monitoring of overtraining and staleness. *Br J Sports Med.* 1987;21:107-114.

16. Kellmann M, Gunther KD. Changes in stress and recovery in elite rowers during preparation for the Olympic Games. *Med Sci Sports Exerc.* Mar 2000;32(3):676-683.
17. Tessitore A, Meeusen, R., Pagano, R., Benvenuti, C., Tiberi, M., Caparanica, L. Effectiveness Of Active Versus Passive Recovery Strategies After Futsal Games. *Journal of Strength and Conditioning Research.* 2008;22(5):1402-1412.
18. Kreider R, Fry, A., O'Toole, M. Overreaching and Overtraining in Endurance Athletes. In: Kreider R, Fry, A., O'Toole, M., ed. *Overtraining in Sport*. Champaign: Human Kinetics; 1998:4-17.
19. Coutts A, Reaburn,A.,Murphy,M. et al. Validity of the session-RPE method for determining training load in team sport athletes. *J Sci Med Sport.* 2003;6:525.
20. Flanagan EP, Ebben WP, Jensen RL. Reliability of the Reactive Strength Index and Time to Stabilization During Depth Jumps. *The Journal of Strength & Conditioning Research.* 2008;22(5):1677-1682 1610.1519/JSC.1670b1013e318182034b.
21. Kallus KW, Kellmann, M. *Recovery-Stress Questionnaire For Athletes: User Manual*. Champaign: Human Kinetics; 2001.
22. Kellmann M, Patrick, T., Botterill, C., Wilson, C. The Recovery-Cue and Its Use In Applied Settings: Practical Suggestions Regarding Assessment and Monitoring of Recovery. In: Kellmann M, ed. *Enhancing Recovery: Preventing Underperformance In Athletes*. Champaign: Human Kineticss; 2002:219-229.
23. Holm D, Stalbom, M., Keogh, J., Cronin, J. Relationship Between The Kinetics And Kinematics Of A Unilateral Horizontal Drop Jump To Sprint Performance. *Journal of Strength and Conditioning Research.* 2008;22(5):1589-1596.
24. McInnes SE, Carlson JS, Jones CJ, McKenna MJ. The physiological load imposed on basketball players during competition. *J Sports Sci.* Oct 1995;13(5):387-397.
25. Young WB, James,R.,Montgomery,I. Is muscle power related to running speed with changes of direction? *Journal of Sports Medicine and Physical Fitness.* 2002;42(3):282-288.
26. Gollhofer A, Komi,PV.,Miyashita,M.,Aura,O. Fatigue duing stretch-shortening cycle exercises: changes in mechanical performance of human skeletal muscle. *International Journal Of Sports Medicine.* 1987;8(2):71-78.
27. Hennessy L, Kilty, J. Relationship of the Stretch-Shortening Cycle to Sprint Performance in Training Female Athletes. *Journal of Strength and Conditioning Research.* 2001;15(3):326-331.
28. Kuipers H. Training and overtraining: an introduction. *Med Sci Sports Exerc.* Jul 1998;30(7):1137-1139.
29. Hakkinen K. Changes in physical fitness profile in female basketball players during the competitve season including explosive type strength training. *The Journal of Sports Medicine and Physical Fitness.* 1993;33(1):19-26.
30. Marques M, Tilaar, R., Vescovi, J., Gonzalez-Badillo, J. Changes In Strength And Power Performance In Elite Senior Female Professional Volleyball Players During The In-Season: A Case Study. *Journal Of Strength and Conditioning.* 2008;22(4):1147-1155.
31. Newton R, Rogers R, Volek J, Hakkinen K, Kraemer WJ. Four Weeks of Optimal Load Ballistic Resistance Training At the End of Season Attenuates Declining Jump

Performance of Women Volleyball Players. *The Journal of Strength & Conditioning Research.* 2006;20(4):955-961.
32. Coutts AJ, Wallace LK, Slattery KM. Monitoring changes in performance, physiology, biochemistry, and psychology during overreaching and recovery in triathletes. *Int J Sports Med.* Feb 2007;28(2):125-134.
33. Gonzalez-Boto R, Salguero A, Tuero C, Gonzalez-Gallego J, Marquez S. Monitoring the effects of training load changes on stress and recovery in swimmers. *J Physiol Biochem.* Mar 2008;64(1):19-26.
34. Anderson L, Triplett-McBride T, Foster C, Doberstein S, Brice G. Impact of training patterns on incidence of illness and injury during a women's collegiate basketball season. *J Strength Cond Res.* Nov 2003;17(4):734-738.
35. Hartwig TB, Naughton G, Searl J. Load, stress, and recovery in adolescent rugby union players during a competitive season. *J Sports Sci.* Aug 2009;27(10):1087-1094.
36. Sigmon S, Stanton,A.,Snyder,C.R. Gender Differences in Coping: A further Test of Socialization and Role Constraint Theories. *Sex Roles.* 1995;33:9-10.
37. Rowlands R. Stress agender. *Occupational Health.* 2008;60(6):26.
38. Gan Q, Anshel,M. Sources of Acute Stress Among Chinese College Athletes as a Function of Gender and Skill Level. *Journal of Sport Behavior.* 2009;32(1):36-52.
39. Steinacker JM, Lormes W, Kellmann M, et al. Training of junior rowers before world championships. Effects on performance, mood state and selected hormonal and metabolic responses. *J Sports Med Phys Fitness.* Dec 2000;40(4):327-335.
40. Kreider R, Fry, A., O'Toole, M. Monitoring and Preventing Overreaching and Overtraining in Endurance Athletes. In: Kreider R, Fry, A., O'Toole, M., ed. *Overtraining in Sport*. Champaign: Human Kinetics; 1998:47-68.
41. Jeukendrop A, Halson, S. Does Overtraining Exist? An Analysis of Overreaching and Overtraining Research. *Sports Medicine.* 2004;34(14):967-981.
42. Kreider R, Fry, A., O'Toole, M. *Overtraining in Sport*. Champaign: Human Kinetics; 1998.
43. Houmard JA, Johns RA. Effects of taper on swim performance. Practical implications. *Sports Med.* Apr 1994;17(4):224-232.
44. Gleeson M. Immune Function and Exercise. *European Journal of Sport Science.* 2005;4(3):52-65.
45. Steinacker JM, Lormes W, Reissnecker S, Liu Y. New aspects of the hormone and cytokine response to training. *Eur J Appl Physiol.* Apr 2004;91(4):382-391.
46. Kreider R, Fry, A., O'Toole, M. Increased Training Volume in Strength/Power Athletes. In: Kreider R, Fry, A., O'Toole, M., ed. *Overtraining in Sport*. Champaign: Human Kinetics; 1998:87-106.
47. Pistilli E, Kaminsky, D., Totten, L., Miller, D. Incorporating One Week of Planned Overreaching into the Training Program of Weightlifters. *Journal Of Strength and Conditioning* 2008;30(6):39-44.
48. Callister R, Callister.R.J., Fleck S, Dudley G. Physiological and performance responses to overtraining in elite judo athletes. *Medicine & Science in Sports & Exercise.* 1990;22(6):816-824.
49. Kuipers H. How Much Is Too Much? Performance Aspects of Overtraining. *Research Quarterly for Exercise and Sport.* 1996;67(3):S65.

50. Lehman M, Foster, C., Keul, J. . Overtraining in endurance athletes: a brief review. *Med Sci Sports Exerc.* 1993;26:854-861.
51. Hedelin R, Wiklund U, Bjerle P, Henriksson-Larsen K. Cardiac autonomic imbalance in an overtrained athlete. *Medicine & Science in Sports & Exercise.* 2000;32(9):1531-1533.
52. Portier H, Louisy,F.Laude,D.,Berthelot,M.,Guezennec,C. Intense endurance training on heart rate and blood pressure variability in runners. *Med Sci Sports Exerc.* 2001;33(7):1120-1125.
53. King M, Duffield, R. The Effects Of Recovery Interventions On Consecutive Days Of Intermittent Sprint Exercise. *Journal of Strength and Conditioning Research.* 2009;23(6):1795-1802.
54. Tessitore A, Meeusen, R., Cortis, C., Capranica, L. Effects of Different Recovery Interventions On Anaerobic Performance Following Preseason Soccer Training. *Journal of Strength and Conditioning Research.* 2007;21(3):745-750.
55. Tessitore A, Meeusen R, Pagano R, Benvenuti C, Tiberi M, Capranica L. Effectiveness of active versus passive recovery strategies after futsal games. *J Strength Cond Res.* Sep 2008;22(5):1402-1412.
56. Hoffman J, Epstein, S., Yaron, Y., Zigel, L., Einbinder, M. Hormonal and Biochemical Changes in Elite Basketball Players During a 4-Week Training Camp. *Journal of Strength and Conditioning Research.* 1999;13(3):280-285.
57. Hooper SL, Mackinnon, T., Howard, A., Gordon, R.. Bachmann. Markers For Monitoring Overtraining And Recovery. *Med Sci Sports Exerc.* 1995;27(1):106-112.
58. Hoffman J, Nichola, J., Ratamess, A., Faigenbaum, A. Biochemical and Hormonal Responses During An Intercollegiate Football Season. *Med Sci Sports Exerc.* 2005;37(7):1237-1241.
59. Klavora P. Vertical-jump Tests: A Critical Review. *Strength and Conditioning Journal.* 2000;22(5):70-75.
60. Barnes J, Schilling, B., Falvo, M., Weiss, L., Creasy, A., Fry, A. Relationship Of Jumping And Agility Performance In Female Volleyball Athletes. *Journal of Strength and Conditioning Research.* 2007;21(4):1192-1196.
61. Hunter J, Marshall, RN., McNair, PJ. Interaction Of Step Length And Step Rate During Sprint Running. *Med Sci Sports Exerc.* 2004;36:261-271.
62. Day ML, McGuigan MR, Brice G, Foster C. Monitoring exercise intensity during resistance training using the session RPE scale. *J Strength Cond Res.* May 2004;18(2):353-358.
63. Lagally KM, McCaw ST, Young GT, Medema HC, Thomas DQ. Ratings of perceived exertion and muscle activity during the bench press exercise in recreational and novice lifters. *J Strength Cond Res.* May 2004;18(2):359-364.
64. Sweet TW, Foster C, McGuigan MR, Brice G. Quantitation of resistance training using the session rating of perceived exertion method. *J Strength Cond Res.* Nov 2004;18(4):796-802.
65. Wallace L, Slattery, K., Coutts, A. The Ecological Validitiy and Application Of The Session-RPE Method For Quantifying Training Loads In Swimming. *Journal of Strength and Conditioning Research.* 2009;23(1):33-38.

66. Foster C. Monitoring training in athletes with reference to overtraining syndrome. *Med Sci Sports Exerc.* 1998;30:1164-1168.

67. Jurimae J, Maestu J, Purge P, Jurimae T. Changes in stress and recovery after heavy training in rowers. *J Sci Med Sport.* Sep 2004;7(3):335-339.

68. Johnson A. West Virginia University preseason basketball conditioning program. *National Strength and Conditioning Journal.* 1989;11(1):43-46.

69. Vermeil A. PROGRAM DESIGN: Training components for basketball. *Strength & Conditioning Journal.* 1988;10(6):64-67.

70. Kroll WA. Conditioning for Basketball. *Strength & Conditioning Journal.* 1983;5(2):24-26.

71. Santos E, Janeira, M. Effects Of Reduced Training And Detraining On Upper And Lower Body Explosive Strength In Adolescent Male Basketball Players. *Journal Of Strength and Conditioning.* 2009;23(6):1737-1744.

72. DeRenne C, Hetzler RK, Buxton BP, Ho KW. Effects of Training Frequency on Strength Maintenance in Pubescent Baseball Players. *The Journal of Strength & Conditioning Research.* 1996;10(1):8-14.

73. Groves B, Gayle, R. Physiological Changes in Male Basketball Players in Year-Round Strength Training. *Journal Of Strength and Conditioning.* 1993;7(1):30-33.

74. Shepard RJ, Shek, P.N. Potential impact of physical activity and sport on the immune system--a brief review. *Br J Sports Med.* 1994;28:247-255.

75. Nederhof E, Lemmink KA, Visscher C, Meeusen R, Mulder T. Psychomotor speed: possibly a new marker for overtraining syndrome. *Sports Med.* 2006;36(10):817-828.

76. Kreider R, Fry, A., O'Toole, M. Future Research Needs and Direction. In: Kreider R, Fry, A., O'Toole, M., ed. *Overtraining in Sport*. Champaign: Human Kinetics; 1998:373-384.

77. Kalda J, Jurimae,T.,Jurimae,J. Relationships Between Recovery-Stress State and Performance in Sprinters and Jumpers. *Perceptual and Motor Skills.* 2004;99:12-16.

78. Kinser A, Kimmel, B., Sands, W., Stone, M. Recovery Stress Questionnaire: Marker of Drop Jump Performance? *Journal of Strength and Conditioning Research*. Abstract2008.