

Monitoring NCAA Division II Female Runners With Noninvasive Measures for Overtraining Syndrome

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Graduation with Honors project (B.S.)

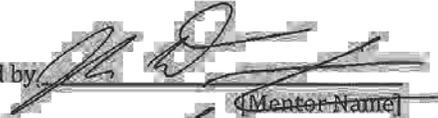
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**Monitoring NCAA Division II Female Runners
with Noninvasive Measures for Overtraining Syndrome**

by

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ABSTRACT

Objectives: Overtraining is directly linked to the imbalance in athletics between recovery and stress. Both overreaching and overtraining cause a variety of symptoms such as psychological, hormonal, physical, and physiological, yet many measures to test for overtraining syndrome are overly invasive like hormone testing. There has yet to be a definitive measure used to diagnose overtraining syndrome in contrast to nonfunctional overreaching. Diagnosing overreaching in order to prevent the progression into long-term overtraining is the ultimate goal as a sports medicine team. The present study aimed to test various non-invasive measures in monitoring female collegiate runners for overtraining syndrome in order to determine a successful and quick battery of measures that may be utilized in an athletics department.

Methods: 4 female collegiate cross country runners and 5 sprinters from Point Loma Nazarene University ($M_{\text{age}} = 20 \pm 1.32$ y) completed an online Stroop test, Recovery-Stress questionnaire for athletes, and resting heart rate palpations at the end of fall season and 4 weeks later at the beginning of spring season. The scores were examined with dependent t-tests between the likely high-stress post-season as compared to the pre-season, following 4 weeks of recovery. The p-values were adjusted to 0.0125 with Bonferroni correction to reduce chances of error. Cohen's *d* for effect size was also calculated to determine any measurable differences between the post-season and pre-season values.

Results: No significance ($p > 0.0125$) was found between any of the post-season and pre-season scores among the Stroop, resting heart rates, and recovery-stress questionnaire. Small effect sizes were found between the post-season and pre-season values for the recovery-stress questionnaire and resting heart rates and a medium sized effect between the Stroop scores.

Conclusions: A positive balance between stress and recovery was determined in the present study's sample of Point Loma female runners. The Stroop test, recovery-stress questionnaire for athletes, and measures of resting heart rates did not display any significant differences when taken in the post-season as compared to pre-season after weeks of recovery. The effect sizes displayed measurable differences between the post-season and pre-season values for each measure, implying that larger sample size may create even greater effects. More research is necessary to determine how successful this battery of non-invasive overtraining measures is at determining overtraining levels in athletes.

INTRODUCTION:

Achieving the correct balance between recovery and stress is the ultimate goal in a competitive athletics-training regimen, as the right balance may lead to performance gains and success in athletes^(12,14,23). The improvement of sport specific skills comes from the athlete overloading his or her body past comfortable limits, typically referred to as the individual's "tipping point"^(2,8,12,14,15). Once an athlete is pushed beyond this point, he or she may be considered overtrained or overreached^(2,8,12,14,15). This overload of training causes a decline in performance initially, which eventually leads to significant increases in performance^(1,15). This phenomenon, named functional overreaching, is considered positive^(1,2, 11,12,14, 21). When athletes do not achieve beneficial amounts of recovery while in this state, they develop nonfunctional overreaching and overtraining syndrome^(1,2, 11,12,14, 21). With nonfunctional overreaching and overtraining, athletes experience no performance gains, just significant decrements^(1,2, 11). The border between nonfunctional and functional overreaching is a thin line that is easily crossed. Although not all athletes end up with overtraining syndrome, their overreached states may cause

other problems such as respiratory infections and increased susceptibility to other illnesses from depressed immune function ^(9,11,14).

Preventing OTS (overtraining syndrome) and NFOR (non-functional overreaching) is a current issue in athletics due to the lack of definitive diagnoses for either or differential diagnoses between the two. There are immunological, hormonal, physiological, psychological, and physical markers that are useful in identifying OTS, but none of these are generally accepted ^(14, 15). Using a battery of various markers has demonstrated the most success in detecting overtraining syndrome due to the many factors that cause OTS ^(1, 11, 14).

Inhibition of overtraining syndrome would best be achieved through identifying athletes in the midst of overreached states with noninvasive measures, followed by implementation of correct periods of rest and recovery ⁽¹¹⁾. This is a task that must be taken on by the entire sports medicine team in order to avoid serious performance decrements in athletes ^(11,12,14).

Therefore the purpose of this study was to determine if a combination of physiological, psychological, and psychomotor tests may benefit sports medicine professionals in determining the need for recovery in their athletes. It was hypothesized that resting heart rate, the recovery-stress questionnaire for athletes, and the Stroop test may be used to detect overtraining syndrome in collegiate athletes.

THE TRAINING CONTINUUM: Figure 1 demonstrates the training continuum ⁽¹⁵⁾

As mentioned previously, the line between non-functional overreaching and overtraining is very thin. Overload of training causes overreaching initially, which eventually without sufficient recovery becomes overtraining syndrome ^(1,2, 11,12,14, 21). Overload is the process in which an individual's body is stressed from a higher volume and intensity of training, and he or she adapts to this higher performance level ^(12,15,23). Fatigue following training is a normal bodily

response, but this response is typically dissipated by an adequate period of rest between training sessions, eventually leading to a higher conditioning level of the athlete^(1, 15, 23). The overreaching phenomenon follows a planned suppression in performance because of an intensive short-term training increase, and this state will be followed by a rebound increase in potential with a slightly longer period of rest and regeneration^(1, 2, 12, 23). The final stage in this continuum is overtraining, in which an athlete reaches a severe chronic fatigue state^(1, 3, 11, 12, 15, 17). Overtraining results in a decrease in performance due to maladaptation to the exercise stimuli, an imbalance between exercise and recovery that exceeds a body's physiologic and psychological limits^(1, 2, 12, 15, 23).

Figure 1: Training Continuum of Overload, OR to OTS⁽¹⁵⁾



The major differentiation between the two states is the length of time that the athlete experiences symptoms. Table 1 displays the relationship between overreaching, overtraining, performance, and time.

Table 1: Possible Presentation of the different stages of training, OR, and OTS. (Adaptation from *Prevention, Diagnosis, and Treatment of the Overtraining Syndrome*)⁽¹⁴⁾.

Process	Training (overload)	Intensified Training		
		Functional OR	NFOR	OTS
Outcome	Acute Fatigue	Functional OR	NFOR	OTS
Recovery	Days	Days-Weeks	Weeks-Months	Months...
Performance	Increase	Temporary Decrease	Stagnation, Decrease	Decrease

Acute fatigue is accompanied by the need to recover for a few days, which is then followed by an increase in performance ^(2, 11, 12, 14). Similarly, functional overreaching takes a few days to weeks to recover and causes some performance decrements, but it eventually leads to an increase in potential ^(2, 11, 12, 14, 15). Non-functional overreaching and overtraining both cause only decreases in performance and no gains ^(2, 14, 15, 21, 23). The main difference between these two is NFOR can last for weeks to months, while overtraining syndrome typically lasts months ^(1, 14, 21 23).

The effect each diagnosis has on the body usually presents almost ambiguously.

The most common signs/symptoms for both states include: ^(1, 11, 14, 15, 21,23)

- Persistent fatigue, burned out feeling
- Decreased maximal performance
- Decrease training load tolerance
- Nagging and chronic injuries
- Sleep disturbances
- Persistent heavy, stiff, and sore muscles
- Decreased muscular strength
- Decreased mental concentration and restlessness
- Increased irritability
- Tachycardia, and sometimes bradycardia
- Loss of appetite and weight loss
- Anorexia
- Bowel movement changes
- Absence of menstruation
- Depression
- Emotional instability
- Recurrent infections

EPIDEMIOLOGY OF OTS

Overtraining syndrome has been observed in endurance athletes since the early 1920s, and the amount of research continues to grow to this date ^(3,12). Furthermore, endurance athletes usually are at the greatest risk of developing this condition ^(1,3,12,14). Epidemiology and exact statistics on the prevalence of overtraining have been difficult to define considering the lack of a definitive diagnosis of overtraining and differential diagnosis from non-functional overreaching ^(3,12,14). There is no overall trend established between genders of the likelihood to develop overtraining syndrome ^(2, 3).

The risk of developing NFOR/OTS increases as athletes move on to collegiate and professional athletics ⁽¹⁴⁾. In W.P. Morgan's surveys of elite distance runners, it was reported that 64% of females and 66% males had at least one episode of OTS over the course of their careers ^(12,16). A 33% rate of overtraining was revealed in non-elite runners ⁽¹⁴⁾. Overtraining is not limited to just runners, as a study also reported 91% of swimmers who had developed OTS during their 1st collegiate season were diagnosed again with OTS at least once more in their remaining 3 years; while only 34% of swimmers who did not develop OTS in their first year of collegiate swimming had it later ⁽¹⁴⁾. The greatest concern with these types of findings is the incidence of overtraining syndrome compounding over the course of an athlete's career and ruining performance potential.

LINK TO INFECTION

OTS and OR are difficult to differentiate between, yet without definitively diagnosing the exact issue at hand, both can cause immunosuppression in athletes ^(8, 9, 14, 24). Intense loads of training in athletes bring temporary immune system suppression, also known as the "open window," when athletes are more susceptible to infection for a short period of time ^(12,18,24). The

open window is extended with heavier bouts of training, especially in overtrained and overreached athletes, as the training exceeds the body's capacity to handle stress^(8, 9, 14, 24). In the athlete's attempt to reach the high performance required of them they may become excessively trained and exhibit respiratory infections as a symptom of the overtrained state^(1, 8, 14). Overload of training elevates stress hormones and alters immunity and defense against pathogens⁽¹⁴⁾. The changes in immunity directly involve decreases in the concentrations of secretory immunoglobulin-A in athletes, which is found in the inner linings of the nose and throat^(18,24). Natural killer cells can also become suppressed during this open window due elevated levels of stress hormones like cortisol⁽¹²⁾. The immunosuppression following heavy training leads athletes to become more susceptible to respiratory tract infections, which may limit their physical performance^(12, 14, 18, 20, 24).

Incidence of infection following competition and heavy training is high for all athletes, especially those of elite standing. Of the 10,568 athletes in the London 2012 Olympic Games, 7% contracted an illness during the games⁽⁶⁾. 758 illnesses were reported and 310 were affecting the respiratory system⁽⁶⁾. 46% of the illnesses were infectious, while 33% had no symptoms reported⁽⁶⁾. In a survey of Norwegian athletes for the 2002 and 2004 Olympic games, the average number of training days lost from infections was 15, and 1 missed competition per year due to illness⁽²⁰⁾. This last statistic is the key that pushes professionals to continue investigating heavy training, overreaching, and overtraining, as limiting the amount of missed practices and competitions is the ultimate goal to allow athletes to continually succeed. Catching overreaching or overtraining in the early stages can help prevent illness from arising in athletes and thus keep them competing to the best of their abilities⁽¹²⁾.

OVERTRAINING SYNDROME MEASURES:

There is a great extent of measures available to detect levels of OTS or OR, but many of the markers require invasive equipment and extensive amounts of resources. Noninvasive measures are most desirable for monitoring OTS levels, as they are quick and efficient to use everywhere. The collegiate athletics population has limited amounts of free time, as NCAA rules limit athletes to 4 hours per day and 20 hours per week of athletics activities. Noninvasive measures may be most beneficial to use in collegiate athletics settings as they respect the athlete's time and may easily be incorporated into athletic training clinics.

As there is no definitive measurement for diagnosing overtraining syndrome, there are only measures that can be used to assess the likelihood of an athlete entering into an overtrained state or having been in a nonfunctional-overreached state⁽¹⁴⁾. All other organic diseases that may cause underperformance must also be ruled out, such as anemia, asthma, nutritional deficiency, Epstein-Barr virus, diabetes, eating disorders, etc.^(11,12,14).

The potential OTS measures employed in this study are clarified below.

It is well understood that one of the major health benefits of exercise is improvement of cardiovascular fitness, especially lowering of resting heart rate^(7,15). With higher cardiovascular fitness, well trained athletes' bodies are more efficient in pumping blood to the extremities, as more blood is ejected per heart beat^(7,15). This leads to a decreased number of heartbeats needed per minute to get blood to the muscles^(7,15). In contrast, overtrained athletes present differently. A physiological measure often used in detecting OTS is monitoring resting heart rate^(1,8,12). Altered morning heart rate has been linked to show initial fatigue/overtraining and also infections in athletes due to the overstressed state OTS causes^(1,8,12). Monitoring heart rate is a

useful marker for OTS detection as it is very objective and can quickly and easily may be checked often.

An additional OTS measure utilized is psychological questionnaire. The POMS (profile of mood swings) is used by strength and conditioning professionals in monitoring athlete's recovery by assessing mood states; but this measure does not ask sport and training specific questions ^(1,3,14,15). The Recovery-Stress Questionnaire for athletes was created with the athlete in mind, as it includes general mental and physical stressor questions as well as questions that hone in on training stressors ^(1,3,10,14). The questionnaire is effective to identify individuals at risk of developing OTS, but it cannot be used as a definitive diagnosis for an overtrained individual ^(3,10,14).

Physiological tests have not revealed more success than psychological in determining levels of OTS, but a combination of the two may provide more accurate results ⁽¹⁾. Physiological mechanisms may create psychological responses in an athlete suffering from overtraining, which may mean physiological and psychological parameters together could be best in an overtraining assessment and prevention program ⁽¹⁾.

Psychomotor speed tests are an up and coming measure in assessing overtraining syndrome are. Overtrained athletes often report symptoms such as concentration problems, cognitive complaints and memory problems ^(1,12, 14, 17, 21). Central fatigue is likely to be an early (and possibly the most early) manifestation of overreaching ^(14, 22). Assessment through psychomotor speed tests is computerized, which facilitates the process as well as allows it to remain objective, inexpensive, and not manipulable ^(14, 17). These tests range from attention to reaction time tests in order to detect NFOR and hopefully prevent OTS. The specific psychomotor speed test utilized in this study was the Stroop test. The Stroop effect is a

phenomenon in which individuals take longer to name the color of words printed in a non-matching color, such as the word blue printed in red ink ⁽¹³⁾. Overtrained and overreached athletes typically present with significantly higher numbers of mistakes and slower reaction times in psychomotor speed tests such as the Stroop test, making it a viable option for monitoring OTS ^(5, 14, 17).

TERMINOLOGY:

Multiple acronyms are used in the place of the measures utilized in this study as well as the topics being researched. The figure below explains the acronyms.

Table 2: Terminology/Acronyms

Overtraining Syndrome	OTS
Overreaching	OR
Non-functional Overreaching	NFOR
Recovery-Stress Questionnaire	RESTQ
Resting Heart Rate	RHR

METHODS:

Participants

This study included a sample of 9 female student athletes from Point Loma Nazarene University. The participants were cross country/distance athletes and track/sprint athletes. These sports were chosen to analyze their levels of stress and recovery because of their

cardiovascular focus and effects on endurance. The athletes ranged in age from 18 to 22 years of age. 5 of the athletes were sprinters and 4 of the athletes were cross-country runners. 2 of those surveyed were new to the team and training program, one of which was a freshman. About half of the sample was in their second year on the team. All participants had participated in their sport since high school.

Materials

Email and in person instruction was used to inform the participants on the details and methods of the study. The consent to participate forms were given to participants in person as well as over email. Three measures were utilized to assess levels of stress in the athletes: resting heart rate, online Stroop test, and the RESTQ-Sport. The online Stroop test used was from cognitivefun.net and emailed to the participants. A copy of the Recovery-Stress Questionnaire for athletes was emailed to the participants as an online document.

Protocol Design

The athletes recruited to participate in this study completed the measures twice, once for “post” season scores and another time for “pre” season scores. Participants were recruited in person and followed up via email. All research protocols were sent out to participants at the end of their fall seasons, and they were instructed on when to specifically complete each measure for the study. The cross-country participants completed their post-season scores immediately following the end of their sport season in the fall. The sprinter participants completed their post-season scores following a competitive intrasquad fall season. It was assumed that the end of their athletic season would be when they should be in peak condition, which would be the time when the athletes have trained the hardest and may potentially be in an overreached or overtrained state. The measures were then repeated for pre-season values in the training week

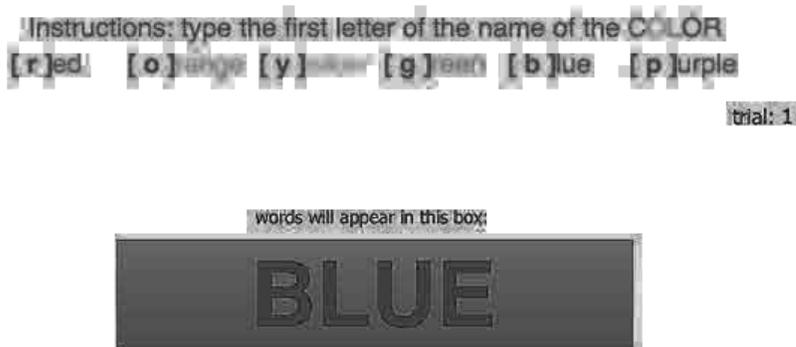
following 4 weeks rest. The athletes had workouts to complete in this rest period. Although, their training would not be as vigorous considering they were in between competition seasons, recovering from the heavy fall training, and training without team members alongside them.

Scores were collected after one week back of practice after the 4-week recovery period

Of the three measures required in the study, the participants were requested to count their resting heart rates upon waking for 3 days. The 3 days would fall within a typical training week (Monday thru Saturday). The participants would wake up and count resting heart rate while still sitting in bed. To facilitate the process for the participants, they counted their heart rates for 10 seconds and then multiplied the number by 6. These numbers were then sent to the researcher.

The online Stroop test was emailed out to the participants near the end of the same training week. As mentioned previously, the test was completed on cognitivefun.net, which includes variants of actual cognitive tests ⁽⁴⁾. The specific test used was color reading interference. A word would appear on the screen in which the participant then had to type the letter of the color that the word was presented in. After 20 presentations, the participants stopped the test and sent their responses via email to the researcher.

Figure 2: Example of a Stroop test presentation from computer screen



The Recovery-Stress Questionnaire for athletes was also completed near the end of a training week. There were 53 questions on the questionnaire that ranged from feelings of general well being, sleep, injuries, breaks at practice, and stress managed at practice. All questions were in regards to how the athlete was feeling for the past 3 days/nights. The answers possible for each question were on a Likert-type scale of 0-6 on how often they felt certain feelings of stress and recovery ⁽¹⁰⁾.

An example of a question from the questionnaire would be:

(In the past 3 days/nights) I recovered well physically

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

Measurements and Calculations

The three variables measured directly in this study were the Stroop reaction time, the resting heart rate values, and the RESTQ-Sport questionnaire scores. The 3 resting heart rates for each athlete were averaged for their post-season and pre-season measurements. All of the participant's post-season and pre-season heart rates were calculated into a mean post-season and pre-season heart rate for the sample.

The Stroop measurement scores were immediately calculated by the website that the test was completed on cognitivefun.net.

Figure 3: Example of results from the Stroop test

name	% correct	time (normal)	time (interfere)	when
<i>anonymous</i>	100.00	751.18 ms	987.07 ms	0 seconds ago

The “normal” time is the amount of milliseconds that it takes the participant to read the word, and the “interference” time is how long it takes for the participant to determine what the color of the word is, as the color and what the word actually says are incongruent^(13,19). The difference between the normal time and the interference time for each participant was then computed into a post-season difference and pre-season difference. The sample’s Stroop differences were then computed into an overall mean difference for post and pre-season.

The Recovery-stress questionnaire consists of 19 scales, 10 scales of stress and 9 scales of recovery. Scales 1-7 and 13-15 were in regards to the athlete’s stress levels, and scales 8-12 and 16-19 were their recovery levels. The stress and recovery score for each athlete was determined by taking the average of the stress scale answers and average of the recovery answers. The averages for all the athletes were then computed into an overall mean for stress and mean for recovery for both post and pre-season. The participant’s scores were also graphed on a hand-scoring sheet displaying their differences in the post-season versus pre-season measurements.

Statistical Analysis

The software IBM SPSS 24 was used to perform the statistical analysis of multiple paired dependent-T tests and descriptive statistics. Descriptive statistics were determined for the height, weight, and age of the participants. Within each measure of the Stroop test, RESTQ, and the resting heart rate values, four dependent-T tests were performed to compare the results between the athletes’ post-season and pre-season scores. Statistical significance was accepted as $P < 0.0125$. This alpha level was determined through a Bonferroni adjustment, which is necessary to correct the possibility of experimental error in performing multiple t-tests.

RESULTS

Table 3: Descriptive Statistics of the female collegiate athlete sample

	Minimum	Maximum	Mean	Std. Deviation
Height(cm)	152.40	172.72	163.97	7.74
Weight(kg)	46.27	62.14	55.94	4.96
Age	18	22	20	1.32

As depicted in table 3, there were 9 participants in the sample taken. The descriptive statistics display that the sample is a good representation of the population as there were participants who were seniors, a junior, sophomores, and freshmen. It is important that the span of the collegiate athlete ages were depicted in this study as all athletes are susceptible to becoming overtrained, specifically those on the younger end as they are new to the high intensity of collegiate level training.

Correlational analyses were run comparing the measures used in order to see if there is an ideal combination of the measures (RHR, Stroop, and RESTQ) to detect overtraining syndrome, but no significant correlations were found.

Table 4: Means \pm std. deviations, P-values, and effect size of measures used

Measure	Post-season mean+ std. dev.	Pre-season Mean+ std. dev.	P-value	Cohen's d (effect size)
RHR	60.48 \pm 8.04	60.04 \pm 8.40	0.55	0.21
Stroop	-89.79 \pm 357.05	-295.34 \pm 167	0.14	0.55

RESTQ Stress	6.36 ± 1.37	5.65 ± 1.67	0.31	0.36
RESTQ Recovery	10.26 ± 1.77	9.74 ± 2.54	0.46	0.26

*When the term “post” is used, it is referring to the scores taken first for statistical analysis. This is in regards to the timing of the athlete’s seasons, as the first score was taken “post” season, and the second score was taken “pre” season.

Table 4 reveals the lack of significance found overall within all 3 measures used to detect OTS. All p-values were well over the significance level of 0.0125. The effect sizes for RHR, Stress, and Recovery were all small, but the Stroop effect size was at a moderate level of 0.55. Although the p-values calculated showed no significance, the Cohn’s *d* for effect shows some promise. This value for the Stroop can be interpreted as the post-season and pre-season mean scores were 0.55 of a standard deviation different. 0.55 is a medium effect size, meaning it is an effect that is potentially observed with the naked eye.

Graph 1: Participant 1 RESTQ Profile 1

Key

Solid Black line = Post-season stress

Black - - - - = Pre-season stress

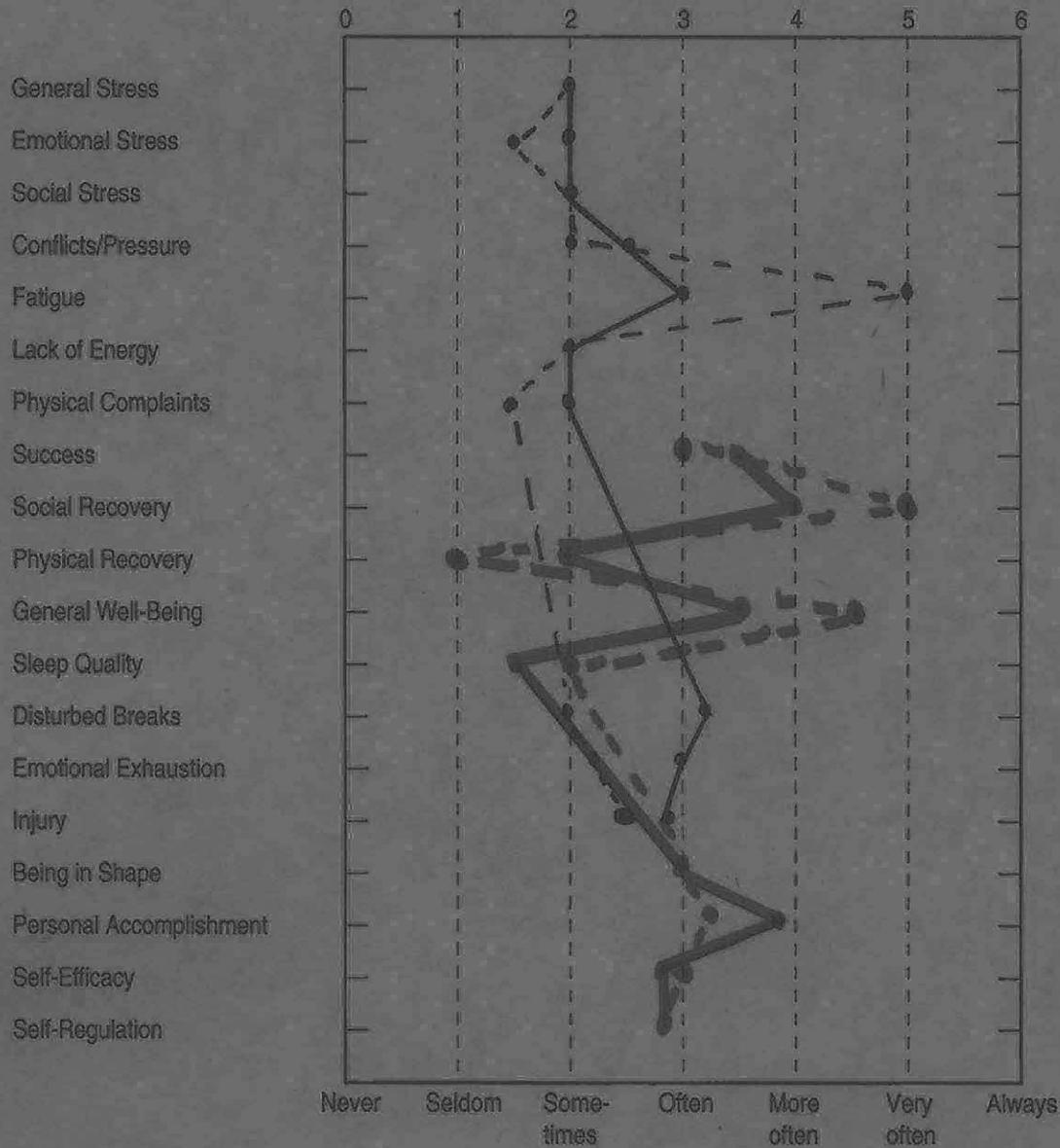
Solid Red line = Post-season recovery

Red - - - - = Pre-season recovery

Blank Hand Scoring Profile Sheet

RESTQ - 52 / 76 Sport
Profile:

Single Code / Group Code: 01



The remainder of the athlete profiles can be seen in the appendix. As depicted in the athlete RESTQ profiles, the stress and recovery scores for each athlete varied greatly. Every athlete is capable of taking a different level of stress on the body, which explains why every line graph varies so much from the next. There is no way of stating a clear trend from these graphs, as about half of the graphs show an increase in recovery scores and decrease in stress after the rest period, while the other graphs show a decrease in recovery scores and an increase in stress after the rest period, or a decrease in recovery and decrease in stress.

DISCUSSION

The main goal of this study was to determine a successful combination of noninvasive measures for detecting overtraining syndrome and overreaching. Overtraining syndrome is caused by a variety of factors adding up over time and overstressing the body of an athlete, making it difficult to determine which factors are in fact definitive diagnostics for this pathology^(3,12,14). The ideal regimen of measures to detect overtraining syndrome measure multiple factors and are taken several times in order to compare results to each other⁽¹⁴⁾. In the current study, 9 female NCAA DII track and field and cross-country athletes were monitored for physiological and psychological symptoms of overtraining syndrome through psychomotor speed test, psychological questionnaire, and resting heart rate values.

No statistically significant findings were presented in the athletes that were monitored through this study. As depicted in the athlete RESTQ line profiles, there was no specific trend for the athletes' recovery and stress between the post-season and pre-season. Some of the athletes decreased in stress and increased in recovery between post-season and pre-season, while others increased in stress and decreased in recovery. The second RESTQ scores were taken the week following the 4-week break. The athletes completed the RESTQ after the first week back of training. Potentially, this could have skewed the scores if the athletes had lost fitness over the break and stressed their bodies in the first week back to training.

This may be attributed to why some athletes showed decreases in their recovery and increases in their stress scores after having recovered for 3 weeks.

As depicted in table 4, there was no significant difference found between the post-season scores for each measure as compared to the pre-season measure taken. All p-values calculated were above the significance level set at 0.0125. Although no significance was found with the t-tests run, the Cohen's *d* for effect size showed an effect between all of the post-season and pre-season values. Due to the small sample size used, it is difficult to find statistically significant results. Yet, the small effect sizes (<0.5) seen with RHR and the RESTQ scores imply that there was a real effect and difference between the scores following the 4-week rest period. This effect is small enough though that it is only found through close study. The effects found indicate that with a greater sample size, the results may have shown statistical significance, as the effect was indeed measurable. Specifically, the effect size for Stroop being 0.55 with such a small sample is promising as this is a moderate effect that was measured between post-season Stroop and pre-season. Yet, the lack of significance found in the t-tests implies that there is a good balance between stress and recovery on the Point Loma women's cross country and track and field teams.

Overall, the results of this study displayed no statistical significance, which is a positive finding as the athletes sampled are not in an overtrained state.

Limitations & Future Research

There were various limitations in this study that could have been confounding factors in the extent of the results discovered. Utilization of heart rate monitors or wearable heart rate monitors may have been more accurate at counting the resting heart rates upon waking for each athlete. Yet, the counting of resting heart rates was a positive non-invasive method as it is less of a commitment for the participants. The palpation method is accessible anywhere, which facilitates applying this research to the daily life of athletes in order to monitor overtraining levels.

The RESTQ may have been a limiting factor in the study due to the subjectivity of the questions. An athlete's recovery and stress scores could have become skewed if she were feeling negative or tired on that specific day that the survey was completed. It is possible that just that specific day the athlete was feeling tired, and if she had taken the survey the next day, the scores could have been different. Additionally, the RESTQ called for the athletes to be training while completing it, as the description for the questions involved "in the last 3 days of training." The stress or recovery values may have been statistically different if they were taken immediately following the 4-week break from team training, as this could have shown higher values of recovery in the athletes. Assuring the athletes that their scores were confidential and that there was no right or wrong way to answer the survey questions decreased these limitations.

The main limitation with the Stroop test would be any outside stressors distorting the scores and reaction times. If the athlete took the test with multiple other things going on in the room, the athlete could have been unnecessarily distracted and scored lower than she was capable. This limit was taken into consideration by informing the participants of the attention the test requires of them prior to the first attempt at the test.

A larger sample size would be beneficial in the attempt at finding significant results within the athletics population. Greater sample sizes improve our confidence in estimation of results in regards to the entire population. Sample size was limited in this study as recruiting student athletes to participate in something outside of their sport was difficult. For further research, measures from the entirety of the cross-country and track and field teams would be beneficial to compare to these baseline data of just 9 of those athletes. A larger sample size of the athletes measured would be helpful in examining if these sports at Point Loma have a good balance between training and recovery. More sampling with these measures could also show more significant results such as pre-season (summer), mid fall season, end of

fall season, pre-season spring, mid spring season, and post season. Achieving this length of time for the current study was limited as participation in a study for that long of a period of time as a student athlete is not necessarily the most desirable. Further research could also be done in the whole Point Loma athletics department to compare within sports as well as in the athletic program as a whole. Adding onto this, overtraining levels measured in multiple college athletics programs could be compared, such as Point Loma to another collegiate institution in the area of similar size.

CONCLUSION

Overtraining syndrome is gaining more attention and clinical research as time progresses, but it still remains difficult to diagnose without a gold standard measure. Due to the impact OTS has on athletic performance and its causation of infection and missed practices, it is crucial that more research is done to find the safest and most efficient way to assess and to prevent overtraining syndrome. Point Loma Nazarene University does not have a specific measure used for detecting overtraining syndrome; It may be beneficial for them to use noninvasive measures such as the recovery-stress questionnaire, resting heart rates, and the Stroop test on the athletes throughout the year in order to monitor any incidence of nonfunctional overreaching leading into overtraining. All institutions for sports may benefit assessing the research and utilizing noninvasive measures for detecting and hopefully preventing overtraining syndrome in order to keep all athletes healthy and strong.

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Appendix

Graphs 02-09: RESTQ Profile of Recovery & Stress per athlete

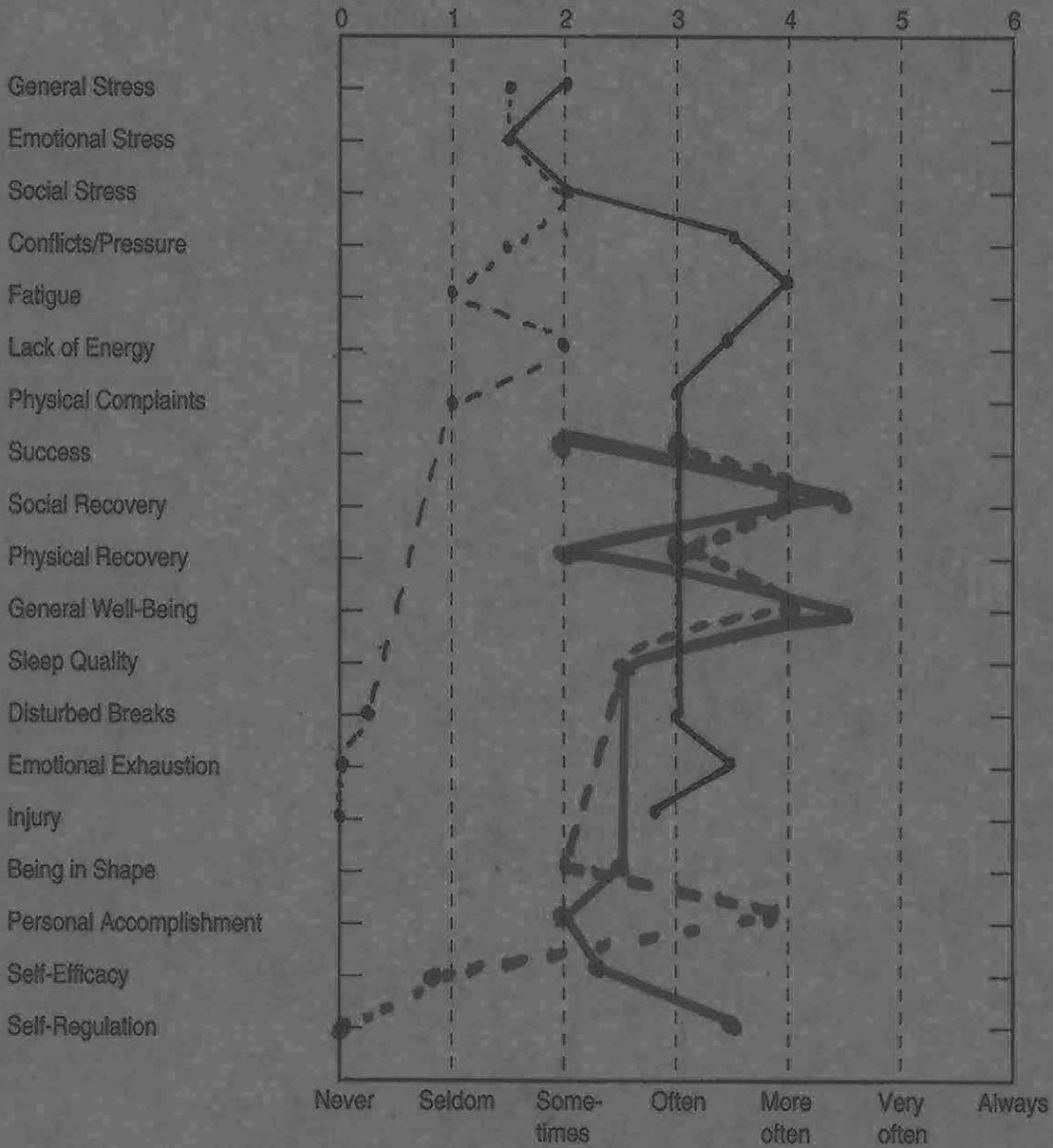
All graphs pictured are hand-scored profiles from the Recovery Stress Questionnaire for Athletes ⁽¹⁰⁾.

The profiles compare the athlete's answers for the stress or recovery questions in post-season vs their answers to the same questions 4 weeks later in pre-season. The solid lines signify the post-season values and the dotted lines are the pre-season values. Black lines are for the stress scores and red lines are for the recovery scores.

Blank Hand Scoring Profile Sheet

RESTQ - 52 / 76 Sport
Profile:

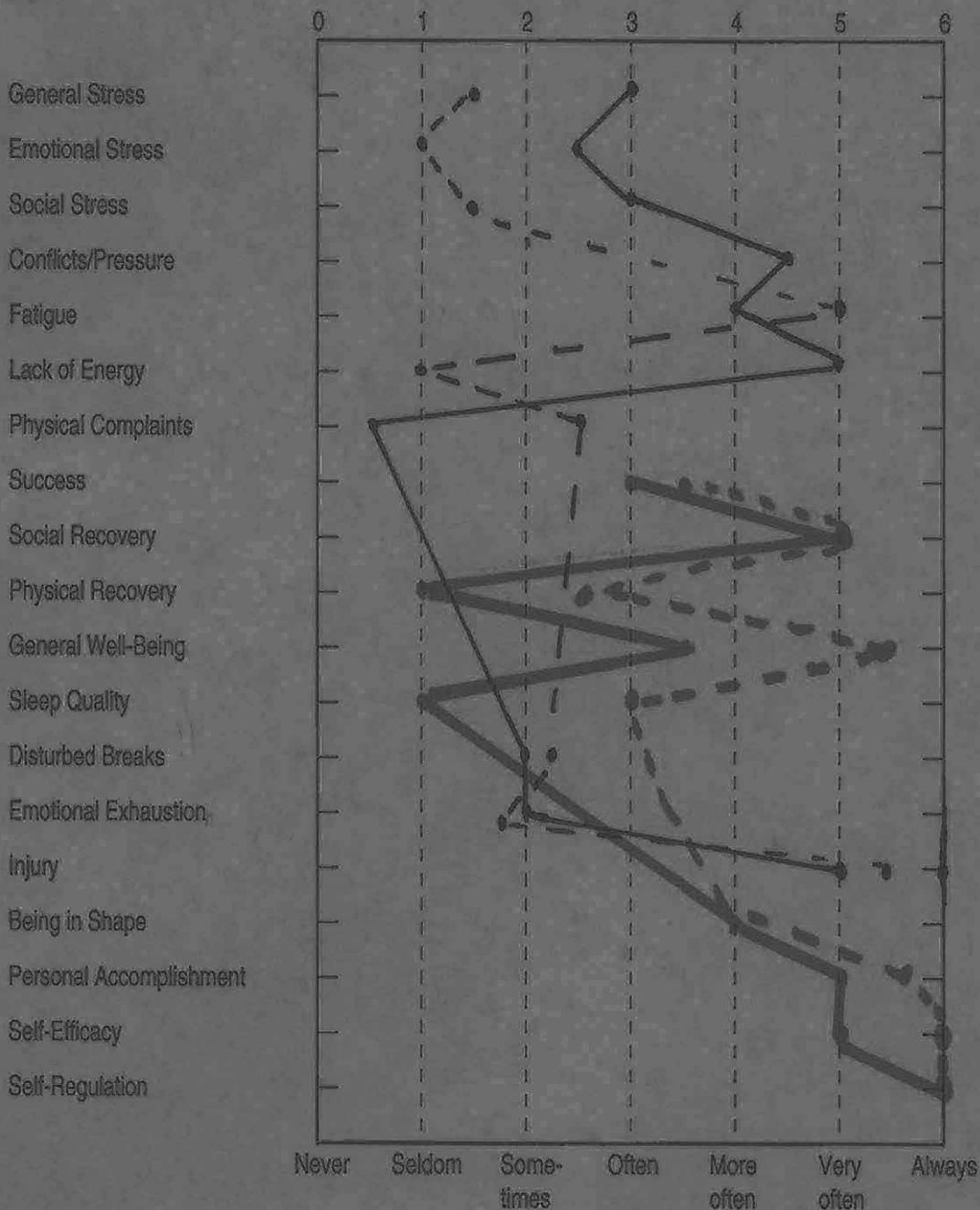
Single Code / Group Code: 02



Blank Hand Scoring Profile Sheet

RESTQ - 52 / 76 Sport
Profile:

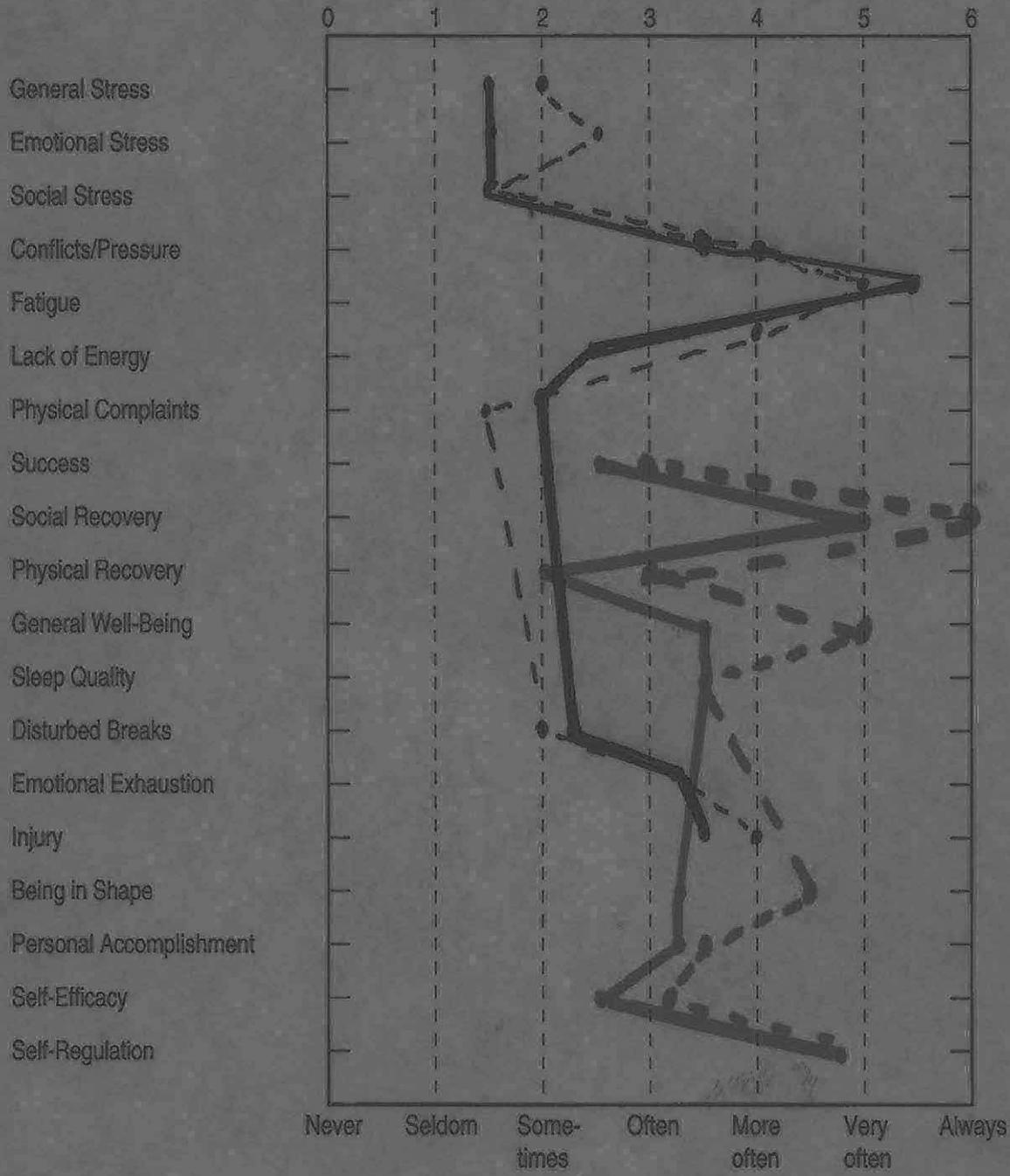
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Blank Hand Scoring Profile Sheet

RESTQ - 52 / 76 Sport
Profile:

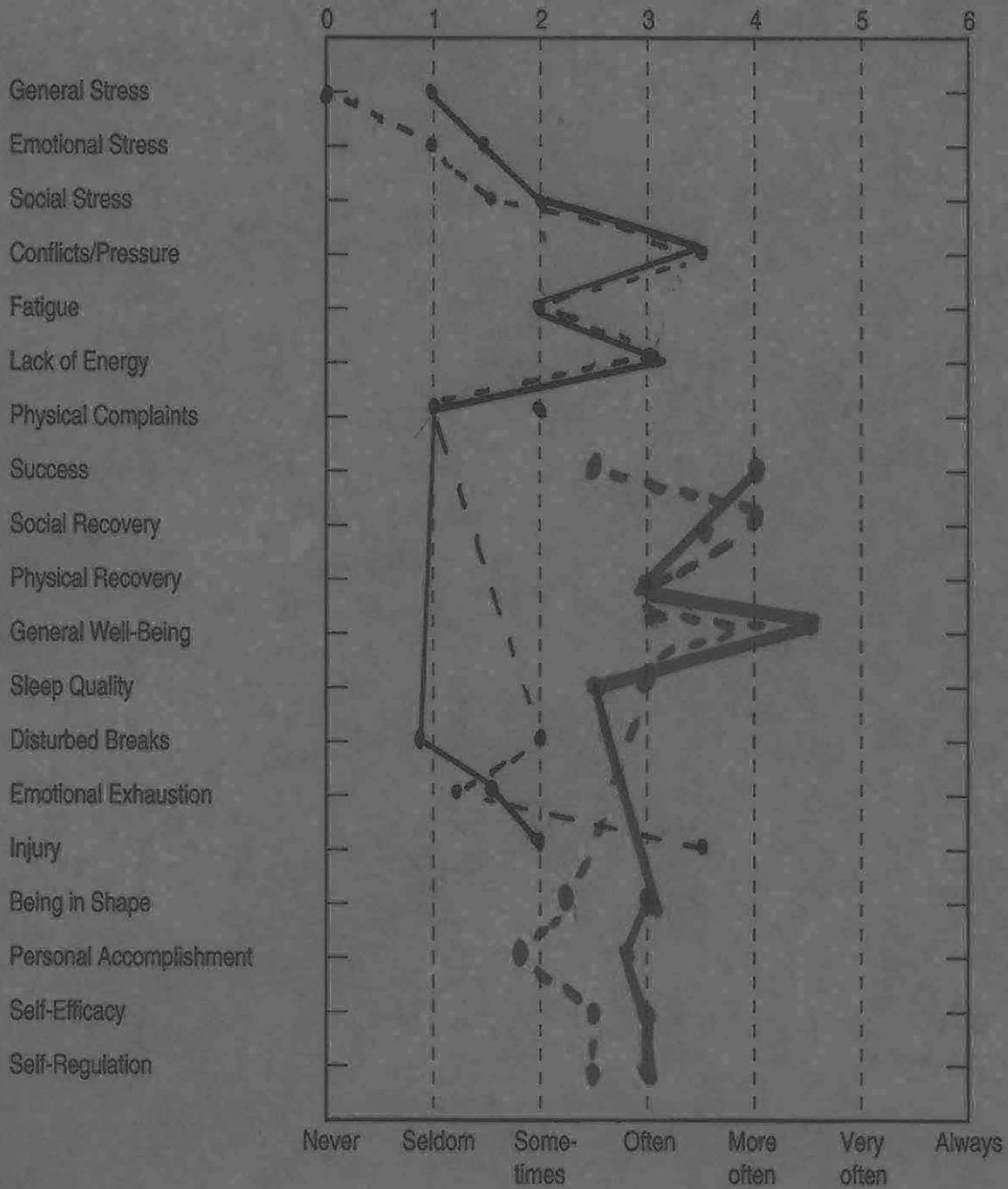
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Blank Hand Scoring Profile Sheet

RESTQ - 52 / 76 Sport
Profile:

Single Code / Group Code: 05

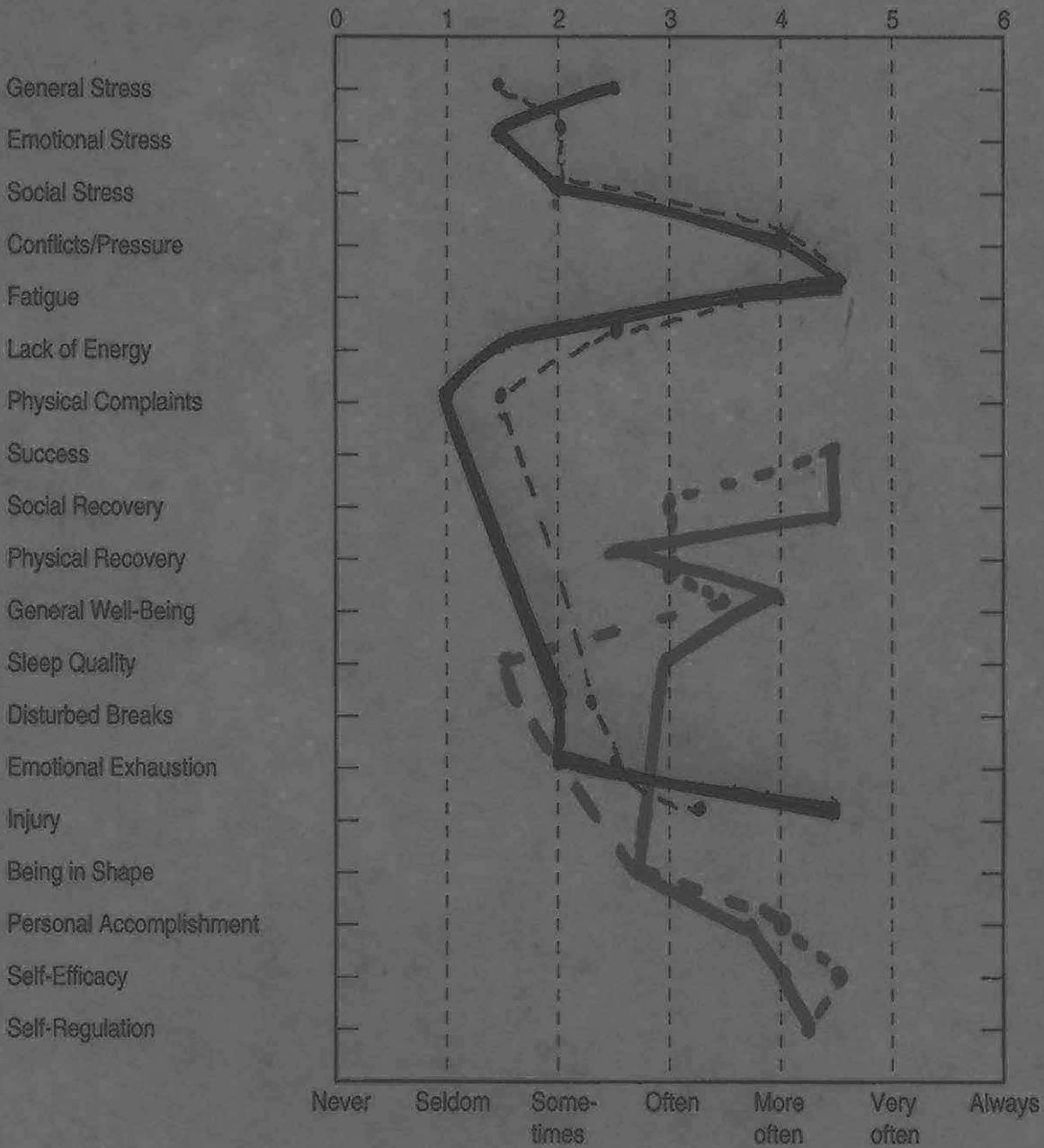


Blank Hand Scoring Profile Sheet

RESTQ - 52 / 76 Sport

Profile:

Single Code / Group Code: 06



Blank Hand Scoring Profile Sheet

RESTQ - 52 / 76 Sport
Profile:

Single Code / Group Code: 07

