A Plan to Measure the Changes in Performance, Physical Ability, and Psychological Stress and Recovery in Division III Men's and Women's Soccer Athletes

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Introduction

Having a protocol to monitor how athletes change over the course of a competitive season is an important tool for coaches to have. This protocol allows for coaches to make highly informed decisions, which ultimately improves the likelihood of team success. While having a system to measure changes in physical ability, performance, and psychological stress and recovery is important for coaches of all sports at all levels there is currently no such protocol specifically designed for NCAA® Division III soccer programs. This research attempts to develop such a protocol.

Movement Competency Screen

Understanding how well athletes move is an important piece of information for coaches and trainers. It grants insights into how players are developing physically and athletically, and this knowledge can help prevent or minimize the rate of injury in athletes.[11] Many places use assessments for movement competency in order to monitor the progression of rehabilitation programs.[6] Unfortunately the idea of moving well, that is to move in a biomechanically accurate and advantageous way, appears challenging to evaluate. However, there exists at least two methods of assessing how well an athlete moves, even for those less familiar with biomechanical principles. It is important to establish and understand the pros and cons of each method in order to determine which is the most appropriate to use.

The first is the Functional Movement Screen (FMS).[4,15,18] Employment of the FMS assesses such things as painful movement, asymmetries, and dysfunctions.[4] The presence of any of these three suggests an inability to move well. Furthermore, high scoring individuals are known to be at a lower risk of injury.[4] The FMS consists of seven distinct, gross motor

movements: overhead squat, hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability push up, and rotary stability.[15] Of the seven movements five of them are conducted twice, once per side of the body.[4]

There are a couple advantages to using the FMS over other methods. FMS is the most popular test for this type of evaluation, so there is an extensive body of research to compare results. FMS is also known to be reliable since it produces both inter- and intra-rater agreement.[15] Conversely, there are some disadvantages too. One is uncertainty over how well it is able to score younger athletes, especially youth athletes. For instance, in a 2018 study of youth soccer players in England researchers did not seem to find strong differences between players who were pre-pubescent, in puberty, or finished with puberty.[18] These results suggest that maturity status does not affect the scores of the FMS. In contrast a 2015 study, using a very similar population, found strong, statistically significant evidence that maturity level does influence the scores on the FMS.[15] Lastly, an investment in equipment and training is necessary in order to conduct the FMS, making it less accessible to athletic programs with smaller budgets.

The other method is the Movement Competency Screen (MCS). This instrument is very similar to the FMS, but it has a few key differences that make it more advantageous for use in certain studies or for specific teams/athletic programs. The MCS is composed of five, gross motor movements: body weight squat, a lunge and twist, a standard push-up, a bend and pull, and a single leg squat.[24] Of these movements two of them (lunge and twist and single leg squat) are conducted twice, once per side of the body. Fewer total movements mean this test can be done more quickly, which can be an advantage for smaller staffs. The MCS also does not require any special equipment since all of the movements are done using the participant's body weight. Not having to buy any additional equipment is particularly beneficial for programs with smaller

budgets. Another important advantage of the MCS over the FMS is the existence of clear directions for scoring.[24] This makes scoring easy and prevents the need for scorers to obtain explicit training. It would be logical to assume that not obtaining training would result in inconsistent scoring, but this has not been observed in MCS since the instructions are so explicit that both inter- and intra-rater scoring is consistent, just like it is for FMS.[24]

Based on this review, the MCS is used for this study. Nevertheless, since the FMS has been around longer and is still considered more popular there is considerably less research using the MCS so there is greater room to question the reliability of this examination tool. Short-term reliability has been established in several studies, but there have not been any long-term studies lasting over a year to assess reliability.[11,12,24] The lack of proven long-term reliability could potentially prove problematic if this protocol is adopted and the coaches desire to compare results between seasons, but if the coaches instead decide to only compare within a season this will not be an issue.

Stress and Recovery

Anyone who has spent time with athletes knows that at various points in the season the stress level of the team changes. This shift in stress has been specifically demonstrated in college athlete populations.[20] Stress is relatively high at the beginning of the season, right after the conclusion of training camp. The stress generally eases up over the early part of the season, unless the team is really underperforming. As the season progresses and playoffs come into focus the stress increases. If the team is lucky enough to make the playoffs stress levels climb as the team advances through each round. This general sense of perceived stress in the team is useful for coaches in determining if and when players need a break. Nevertheless, this is often very

subjective. Having an objective way to measure stress would allow for a more accurate assessment of the team and its players.

Previous studies have noted that periods of positive mental health profiles, such as at the beginning of the season, are often characterized by low levels of depression, tension, anger, confusion, and fatigue and high levels of vigor in the athletes.[20] As mental health profiles become more negative over the course of the season, the metrics that began the season at low levels increase, while vigor levels decrease. In addition to the already stated psychological variables, there is also cognition, perceptions of stress, and daytime sleepiness.[20] It is possible to use any of these variables, either individually or in combination, to quantitatively measure changes in stress levels over the course of a competitive season.

Monitoring and managing stress is important in order to keep the team healthy and performing well. Sustained periods of high stress and inadequate recovery can lead to decreases in sport specific performance and increases in injury and illness risk.[2,3] Previous studies have attempted to determine which components of stress and recovery are most clearly related to injury occurrence, but so far this remains unclear.[3]

Stress management consists of two inter-related parts. Stress has both physical and psychological components. A common way of monitoring physical stress is simply tracking how many hours are spent practicing/playing in games.[3] Another way in which to measure physical stress is Rate of Perceived Exertion.[3,13] While both of these tests are important, coaches generally are able to subjectively examine physical stress just by observing their teams. Additionally, there needs to be assessments for the psychological aspects of stress. The most ideal way to objectively measure this would be a test specifically designed for athletes. Such a test exists and is known as the RESTQ-Sport. This assessment tool has been used for a variety of sports,

including soccer (association football) and rugby union.[2,3,5,8,13,17] When used in combination with a metric that measures physical stress the RESTQ-Sport has been shown to indicate how perceived training load is dependent upon both physical and psychological factors.[13]

This assessment tool has been used in soccer players at various ages including high school aged, college aged, and adult, at various playing levels including the professional level, and for both men's and women's soccer.[2,3,13,17] This indicates that this assessment tool can be used in many different populations successfully. None of the published research articles used the same populations this project did, but since it has shown success in a wide variety of populations it is likely it will also work for this one.

In previously published research the RESTQ-Sport is able to identify when soccer players are overreaching up to two months before other metrics.[2] Overreaching exists near the middle of the continuum between supercompensation (high capacity to perform well) and overtraining syndrome.[2] Overtraining syndrome is characterized by a severe decrease in performance, and can take months to years to recover from, so it is essential that coaches and athletic training staffs are able to identify a player's progression towards overtraining to avoid it. Overreached athletes display an unfavorable overall recovery score on the RESTQ-Sport. When compared to a non-overreached control group the overreached athletes also had significantly different Emotional Stress, Physical Recovery, General Well-Being, Sleep Quality, Fatigue, and Being in Shape scores.[2] These previously determined results indicate that the RESTQ-Sport can be employed as a useful tool to monitor players' overall stress and recovery levels.

The stress and recovery profiles of collegiate athletes is likely different than other populations since they face several unique challenges. These athletes are unable to solely focus on the sport that they play, since they also must maintain certain academic requirements in order

to maintain their place on the team. Interestingly previous research has suggested that student athletes are actually healthier, with respect to mental health, than their non-athlete classmates.[20]

Physical Performance

The most important metric for coaches to monitor during a season is physical performance, since it is the one most clearly linked to team success. In the past physical performance has typically been measured using a set of specific workouts such as vertical jumps and sprints, or through the use of tests to measure the power or strength of a particular limb/body part (such as bench press).[1,10,16,21,22,23] Simple to administer, these tests can provide a lot of information to the coach. Previous research using these types of metrics have noted that physical performance decreases over the course of a season. In one such study NCAA® Division I soccer players were monitored during their 11-week season and starters experienced decreased sprint speeds, vertical jump heights, and peak isokinetic torque.[10] This decrease in performance over a season is of some concern since a high level of performance is necessary to maintain team success. It has been proposed that this decrease is a result of technical and tactical training taking higher priority during in-season practices, leading to a deemphasis of physical qualities being targeted for development.[23] The employment of a physical performance monitoring program allows for coaches to better inform their decisions with regards to what aspects of the sport need the most focus during practice.

These traditional metrics for monitoring physical performance are imperfect. For one they are difficult to do without devoting practice time specifically to collecting this data. While sprinting is a normal part of practice for most sports (especially soccer), practice is not the most conducive setting to tracking how fast each player is sprinting, at least not quantitatively.

Likewise, weightlifting regimens are common for most athletic teams, but usually this is done with relatively minimal oversight from the coaches so measuring the maximum weight that can be lifted for each player is time consuming and often not a priority. Dedicating practice time to conducting performance tests may seem reasonable, but the NCAA® has weekly practice limits that cannot be exceeded so devoting time to performance tests means less traditional practice can be done.

In order to combat the issue of limited practice time, as well as other reasons, such as a desire for more accurate and complete data, there has been a push to develop new ways to monitor physical performance in a less invasive manner. These techniques generally involve monitoring players using technology while they practice and/or compete and then evaluating the data at a later time. Examples of such systems include the VISTRACK (by Impire Corp.), LPM (Inmotio Object Tracking BV), and the Catapult Playertek.[1,7,14,19] One of the most popular of these systems is the Catapult Playertek, which consists of a GPS tracker worn in a vest that the player can wear during practices and games. This tracker pairs with a smartphone application to track various statistics such as top speed and total distance. The validity of this device has been confirmed since it has been able to detect differences between practices and games.[7]

Methods

Experimental Approach to the Problem

A small sample of subjects were used to test the efficacy of a protocol designed to assess how athletes are affected by a NCAA® Division III soccer season. The protocol monitored changes in physical ability, mental stress and recovery, and performance. Subjects were instructed to maintain their normal practice schedules and academic pursuits. All subjects

participated in the same three assessments of the study including a slightly modified RESTQ-52 Sport survey (originally designed by Michael Kellmann and K. Wolfgang Kallus), the Movement Competency Screen, and the wearing of a CATAPULT PLAYR Soccer GPS Tracker during team sanctioned practices.

Subjects

Three members of the Roanoke College Men's Soccer team were recruited for this study. Each had competed at the NCAA® Division III level for at least two years prior to the study. The only requirement for eligibility was being an active member of the Roanoke College Men's Soccer team. Subjects were informed of the study's purpose, procedures, and potential risks and benefits before consent was obtained using an informed consent document generated for this study and approved by Roanoke College. All subjects provided written informed consent prior to commencing the study, which was approved by the Roanoke College Institutional Review Board (Study Number 21006).

Procedures

RESTQ-52 Sport

In order to measure changes in stress and recovery subjects were administered a slightly modified version of the RESTQ-52 Sport. Designed by Kellmann and Kallus, this questionnaire measures an athlete's current stress and recovery levels.[9] In addition to the standard 52 questions the RESTQ-52 Sport typically includes a warmup question at the beginning of the questionnaire. This question has been removed in the questionnaire used in this study and instead two demographic questions are presented at the beginning of the survey. The first question asks the

respondent to identify their position group in soccer (e.g., mid-field). The second question asks them what their academic class is (freshman, sophomore, junior, or senior). The purpose of these two questions is to provide the coaches with the ability to see if specific segments of their team are more stressed/less recovered than the others.

The 52 questions of the RESTQ-52 Sport are divided into 19 categories and two primary groups: Stress-Associated and Recovery-Oriented. The division of categories into the two groups is shown in Table 1. Each category contains either two or four questions. The average score of each question in each category is taken and then used to evaluate stress and recovery levels. High average scores in the Stress-Associated categories reflect high stress levels, while high average scores in the Recovery-Oriented categories reflect high levels of recovery.

Table 1. Division of RESTQ-52 Sport Question Categories into Stress-Associated or Recovery-Oriented Groups

Stress-Associated	**Recovery-Oriented**
General Stress	Success
Emotional Stress	Social Recovery
Social Stress	Physical Recovery
Conflicts/Pressure	General Well-Being
Fatigue	Sleep Quality
Lack of Energy	Fitness/Being in Shape
Physical Complaints	Burnout/Personal Accomplishment
Disturbed Breaks	Self-Efficacy
Burnout/Emotional Exhaustion	Self-Regulation
Fitness/Injury	

The questionnaire used in this study was administered digitally using Qualtrics®. The first two questions were multiple choice. The final 52 questions used a Likert-type scale with values ranging from 0 (Never) to 6 (Always). Subjects were asked to take the survey on a bi-weekly basis, three times in total during the study.

Movement Competency Screen

Changes in physical ability were assessed using the Movement Competency Screen (MCS). The MCS is a test that consists of five movements and it evaluates the subject's proficiency in each. A description of each movement is presented in Table 2.

Each movement is scored on a scale of 1 to 3. A score of 1 indicates that the subject has minimal proficiency in that specific movement, while a score of 2 indicates moderate proficiency, and a score of 3 indicates full proficiency. Several of these movements are unilateral in nature, testing only the proficiency of one side of the body at a time. Movements that are unilateral were done for both sides and scores for both sides individually were determined. The lower of the two was then determined to be the overall score for that movement.

Table 2. Description of Movements that Comprise the Movement Competency Screen

Movement	Description
Body Weight Squat	Place fingertips on the side of your head. Hold elbows even with your ears. Squat down as low and as quickly as comfortably possible. Return to starting position.
Lunge-and-Twist	Cross arms with hands on opposite shoulders. Have your elbows pointing forwards. Lunge forward, and once in the lunge position rotate towards the forward knee. Rotate back to center. Return to starting position. Repeat with other knee forward this time.
Bend-and-Pull	Stretch arms above your head. Bend forward, allowing your arms to drop as you bend. Arms should now be pointing forward from your chest and towards the ground. Pull arms towards yourself as you would do during a bar bell row. Return to starting position.
Push-Up	Standard push up movement.
Single Leg Squat	Place fingertips on the side of your head. Hold elbows even with your ears. Lift one leg off of the ground and hold behind you. Squat down as low and as quickly as comfortably

	possible. Return to starting position. Repeat, but lift your other leg off the ground this time.

Figure 1. Body Weight Squat start (left) and end (right) positions.

Figure 2. Lunge-and-Twist starting position (left) and lunge position (right).

Figure 3. Bend-and-Pull starting position (left), bend position (center), and pull position (right).

Figure 4. Push-Up starting position.

Figure 5. Single Leg Squat start (left) and end (right) position.

Subjects were asked to complete the MCS twice, once at the beginning of the study and once at the end. Each time subjects completed the MCS they were video recorded to allow for scoring at a later time and place. Scoring was done by two individuals to ensure inter-rater reliability. The two scorers reviewed the video separately and then met to discuss what scores they believed were most accurate based upon the screening criteria (Appendix A). Scorers used a common scoring rubric, which is included in Appendix B, to rate the subjects' performances.

CATAPULT PLAYR Soccer GPS Tracker

In order to measure performance changes all subjects were given a CATAPULT PLAYR Soccer GPS Tracker to wear while participating in team sanctioned practices. These devices are able to measure top speed, distance traveled, sprint distance, load, and intensity of workout. The device pairs with a smartphone app so the data collected can be viewed. Subjects were instructed to take screenshots of their performance summaries after each practice, and at least once a week

submitted these screenshots. The data was recorded in a weekly summary for each subject in Excel. This summary included the fastest top speed of the week, the total distance traveled, and total sprint distance. At the end of study these weekly summaries were compared to one another to see if there were changes in any of the measures over the course of the study.

Statistical Analyses

Statistical analyses were done using Microsoft Excel. The following built-in functions were used: AVERAGE, STDEV, SQRT, ABS, and T.DIST.2T. These functions were used to calculate one-sample, two-tailed t-tests comparing the baseline (Survey Attempt 1) RESTQ-Sport results to the results from Survey Attempt 3, with the baseline serving as the null hypothesis. An alpha level of $p \leq 0.05$ was used for these statistical analyses, while a sample size of $n=3$ was used for all calculations. No conclusions were drawn from these analyses since the sample sizes were too small. This analysis served as an exercise to demonstrate how the data would be used in a full-scale implementation of this protocol.

Results

RestQ-52 Sport

Upon comparison between the first and third survey attempts it was determined that there were no statistical differences between any of the sub scores that correlated to the 19 categories that compose the RESTQ-52 Sport, except for Injury. At the time of the first attempt the mean Injury score was 3.58, but at the time of the third attempt the mean score had dropped to 0.50 (Figure 6). The remaining sub score data is presented in Appendices C, D, and E.

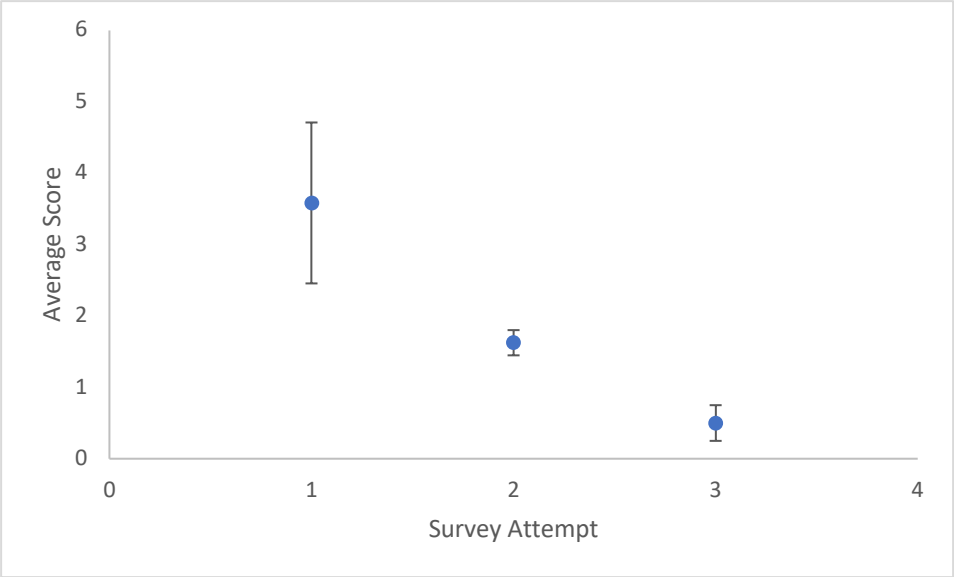

Figure 6. The mean Injury sub scores from the three attempts of the RESTQ-52 Sport.

When the sub scores were averaged together to produce the overall Stress and Recovery scores again there was no evidence that the scores from the first survey attempts were statistically different than the scores obtained from the third attempts. With regards to the Overall Stress Score it was 2.08 at the time of the first attempt and 1.49 at the time of the third attempt (Figure 7). With regards to the Overall Recovery Score, it was 4.35 at the time of the first attempt and 4.22 at the time of the third attempt (Figure 8).

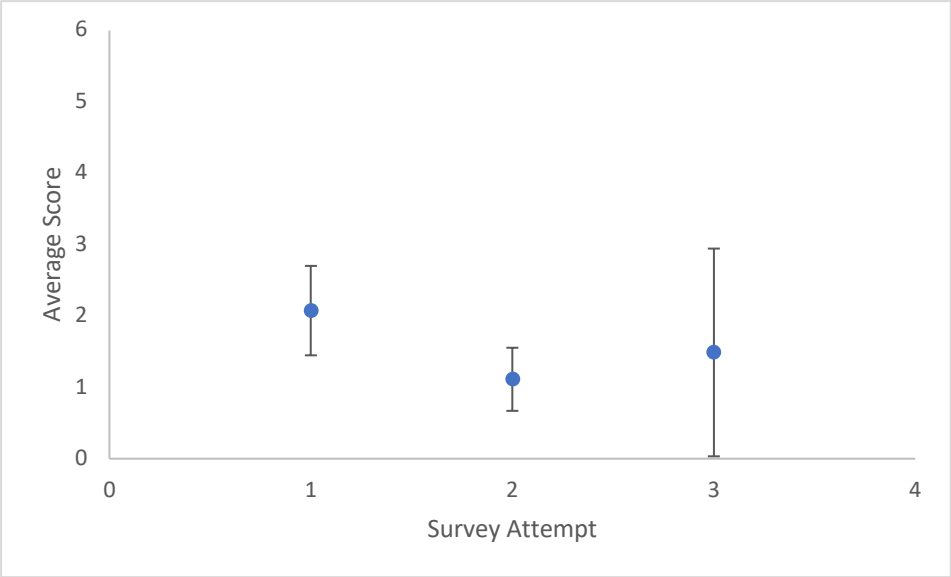

Figure 7. The mean Overall Stress Score results from the three attempts of the RESTQ-52 Sport.

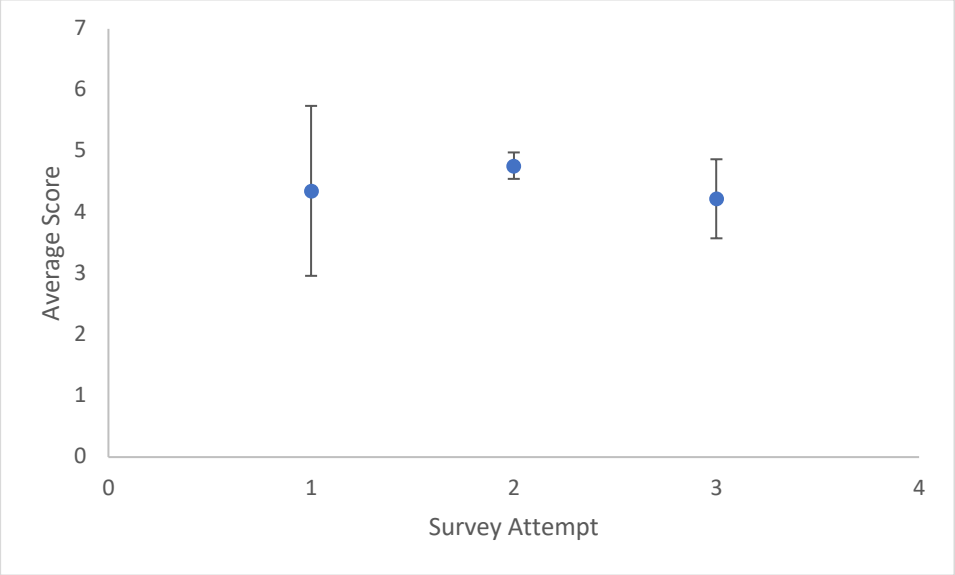

Figure 8. The mean Overall Recovery Score results from the three attempts of the RESTQ-52 Sport.

Movement Competency Screen

Each participant completed the Movement Competency Screen (MCS) twice, with the two attempts taking place approximately three apart from one another. The results of the MCS

trials are displayed below (Table 3 and Table 4). A blank cell in one of the below tables indicates that the subject failed to complete the proper movement, so no score was given for it.

Table 3. Movement Competency Screen Results from the First Round of Testing

	Two Leg Squat		Lunge & Twist		Push-Up		Bend & Pull		Single Leg Squat	
Subject	**Scorer 1**	**Scorer 2**	**Scorer 1**	**Scorer 2**	**Scorer 1**	**Scorer 2**	**Scorer 1**	**Scorer 2**	**Scorer 1**	**Scorer 2**
1	3	3	2	2	3	3	3	3	1	1
2	2	2	1	2	3	3	3	3	2	2
3	2	2	1	1	3	3	2	3	1	1

Table 4. Movement Competency Screen Results from the Second Round of Testing

	Two Leg Squat		Lunge & Twist		Push-Up		Bend & Pull		Single Leg Squat	
Subject	**Scorer 1**	**Scorer 2**	**Scorer 1**	**Scorer 2**	**Scorer 1**	**Scorer 2**	**Scorer 1**	**Scorer 2**	**Scorer 1**	**Scorer 2**
1	3	3	3	3	3	3	3	3	2	2
2	2	2	3	3	3	3	3	3	2	2
3	2	2			3	3	2	2	1	1

CATAPULT PLAYR Soccer GPS Tracker

All three participants recorded at least 6 practices/scrimmages (range 6-12) over a four-week period. The data for the player who completed 12 sessions is displayed below in Table 5. The data for the other two players is included in Appendix F.

Table 5. Sample CATAPULT PLAYR Soccer GPS Tracker Data from Subject 3

Week	Number of Recorded Sessions	Fastest Top Speed (m/s)	Total Distance (km)	Total Sprint Distance (m)
1	3	8.09	16.63	1469
2	4	7.84	18.13	1060
3	3	8.40	20.28	1242
4	2	8.33	8.49	363.3

The fastest top speed for any player was 8.40 m/s, which was recorded by Subject 3. The player who had the highest average top speed was also Subject 3. The longest total distance run

in a single session (11.51 km) was recorded by Subject 2. That player also had the highest average for total distance per session (5.39 km) With regards to total sprint distance Subject 3 recorded a distance of 690 m during one of his sessions, which was the longest by far. He also had the highest per session average (344.53 m).

Discussion

The primary goal of this study was to explore the efficacy of measuring changes in performance, physical ability, and psychological stress and recovery in a population of male and female NCAA® Division III soccer players over the course of a season. Results indicate the three assessment tools are easy to administer, non-invasive, and provide useful information to players and coaches that would not otherwise be available during a traditional season. Findings were consistent with previous literature which suggests these tools are appropriate for using with athletes. To our knowledge this is the first time all three were employed simultaneously in a population of soccer players.

Preliminary Athlete Discoveries

While the data collected for this project was primarily designed to be descriptive and serve as a proof of concept, several interesting observations were noted. The most important was the ability for the RESTQ-52 Sport to detect recovery from injury. At the time of the first survey attempt Subject 1 was dealing with a shoulder injury. The presence of this injury lead to an average Injury subsection score for all participants of 3.58. By the third survey attempt the injury was fully healed and the average score for that subsection dropped to 0.50, which was

statistically significant. This helps demonstrate that even in a small sample the RESTQ-52 Sport can provide usable feedback.

Additionally, it was interesting to see that the overall stress and overall recovery scores were very similar between survey attempts 1 and 3, but survey attempt 2 produced results that were more noticeably (at least visually) different. The athletes seemed a little less stressed at the time of survey attempt 2 than at attempts 1 or 3. Their recovery scores were higher at survey attempt 2 than at the other attempts. The cause of this could be indicative of the academic situation at the times of the attempts. The first survey attempt was the week after midterm exams at Roanoke College. The third attempt was right before final exams at Roanoke College. The second attempt was taken between these two periods, during a portion of the semester that is relatively less academically intensive. It is logical to postulate that periods of increased academic intensity and stress would impact the stress and recovery levels of collegiate athletes, and this would likely impact the scores on the RESTQ-52 Sport.

Another interesting observation was how low the single leg squat scores were during the MCS compared to how high the push-up scores were. During both rounds of MCS testing all three participants received 3s for their push-up score (the highest possible score), while two of the three participants scored 1s on their single leg squats during the first round, with the other only scoring a 2. The second round showed some improvement with only one participant getting a 1 and the others receiving 2s. This observation was surprising since it had been anticipated that the single leg squat scores would be higher since leg strength is such an important factor in soccer. From these observations two potential conclusions can be drawn. The first is that the upper body training regimen employed by the Roanoke College Men's soccer team is more than adequate. The second is that additional lower body unilateral training is needed.

It would be interesting to investigate how these MCS score results compare to the injury histories of the players. Based on the score results it seems safe to assume that all three participants have suffered more lower body injuries than upper body injuries. These injuries were not necessarily major injuries like ACL or rotator cuff tears but could have included any sort of injury such as contusions and muscle pulls.

The last observation concerns the CATAPULT PLAYR Soccer GPS Tracker data. Going into this research the hypothesis was that Subject 3 would have the highest average distance traveled per training session since he is a midfielder, and that position requires more running than a forward or defender. Surprisingly, he ended up coming in second place, with Subject 2, a forward, coming in first.

Additionally, it was hypothesized that Subject 2 would have the highest top speed. As a forward his position highly values speed since it allows him to get past defenders more easily. Subject 3 was anticipated to have the second highest top speed, with a small difference between him and Subject 2. Subject 3 had the highest top speed which was not too surprising, because midfielders run a lot and speed is important, but it was assumed that endurance would be valued over speed for midfielders.

Finally, Subject 3 was expected to have the highest average sprint distance. This hypothesis was built on the knowledge that midfielders spend a significant portion of games sprinting from offense to defense (and vice versa). The data collected for this project supported this hypothesis.

Changes to the Original Protocol

While the implementation of all three assessments was successful, improvements to the original protocol could be made. First includes overhauling how the RESTQ-52 Sport was administered. It was believed at the beginning of the project that using the Qualtrics® system would be ideal since it is a professional program, and Roanoke College has a subscription to it. Unfortunately, this system was determined to be impractical for a large-scale implementation of this protocol since the program would not be the most coach-friendly option since it can be rather time-consuming. It is necessary for additional research to be done to develop a system that allows the data collected by the RESTQ-52 Sport surveys to be quickly processed. Other programs to investigate include Google Forms and SurveyMonkey. At Roanoke College it is likely the Stat Crew could be used to help develop such a system.

Other changes to the original protocol include giving clearer instructions to the participants when they are completing the MCS. While the athletes were typically able to complete the intended movements properly it became clear when reviewing the video footage that clearer instructions would have likely led to higher scores overall. One such clarification that should have been made is in regards to squat depth (for both single and two legged squats). The MCS Screening Criteria (found in Appendix A) specify that the depth of for both types of squats should be "Top of thighs appear parallel with floor." Several of the participants achieved deeper depths than this, which isn't inherently problematic, but often when they did so other aspects of their movement deteriorated, especially balance. If they had only gone to the desired depth it is likely that their balance would have been better, leading to a higher score for that movement.

One final change that should be made to the original protocol is the creation of a "Week 0" for the CATAPULT PLAYR Soccer GPS Tracker data collection. This Week 0 will give the

participants time to properly set up their GPS trackers and ensure they know how to record sessions. The first week of data collection during this research was difficult since several of the subjects had difficulty setting up their devices. While not essential, having a period of time where participants familiarize themselves with the device ultimately leads to a more successful system.

Conclusions

Proof of concept and the primary hypotheses of this research project were supported. While the exact mechanism of the original protocol was modified to comply with COVID-19 social distancing mandates, it is clear these three assessment tools would allow for coaches to monitor changes in performance, physical ability, and psychological stress and recovery in NCAA® Division III soccer players. This research also led to several interesting observations that, if expanded and refined, could be used by the players and coaches to further improve their development in the sport of soccer. Future research should be done to see if these same protocols could be used for other team sports at the NCAA® Division III level, such as basketball, lacrosse, field hockey, and volleyball. Research into if this protocol can be used at other competition levels (such as NCAA® Divisions I and II, professional sports, and youth sports) would also be appropriate.

Practical Applications

Upon the conclusion of this research the below stated protocol should be implemented by the Roanoke College Men's and Womens soccer teams, as well as by other NCAA® Division III

soccer programs. The protocol outlined below includes all of the recommended changes mentioned above.

RestQ-52 Sport

Prior to the start of training camp, a coach (or another staff member) should put together a survey including all of the questions and choices outlined below.

- Question 1: What position group are you on the (*insert school name here*)'s soccer team?
    - Answer choices
        - Forwards (includes Strikers, Center Forwards, etc.)
        - Midfielders (includes Center Midfielder, Attacking Midfielder, Defensive Midfielder, etc.)
        - Defenders/Goalkeepers (Center-backs, Sweepers, Full-backs, Wing-backs, etc.)
- Question 2: What is your academic class?
    - Answer choices
        - Freshman
        - Sophomore
        - Junior
        - Senior
- Questions 3-54: The 52 questions that compose the RESTQ-52 Sport (excluding the initial sample question).[9]
    - Answer choices
        - 0 (Never)

- 1 (Seldom)
- 2 (Sometimes)
- 3 (Often)
- 4 (More Often)
- 5 (Very Often)
- 6 (Always)

This survey should be created on a program such as Google Forms. Every two weeks during training camp and the season (including playoffs) players should be sent this survey electronically and informed to fill it out within the next 24 hours. The survey should also be sent out one additional time, at least two weeks after the conclusion of the season.

Movement Competency Screen

During the first week of training camp all players should undergo a Movement Competency Screen (MCS) using the screening criteria established in Appendix A. This should be administered by one or more of the coaches. Prior to the MCS being administered all participants (both subjects and administrators) should familiarize themselves with the screening criteria and the description of the movements provided in Table 2. Subjects should be given a chance to ask questions about the movements if the instructions are unclear. Once all participants are familiar with what they are doing the administrator(s) should video record each subject as they do the MCS. Each movement should be done three times (once facing the administrator, once with their left shoulder towards the administrator, and once with their right shoulder towards the administrator). Once all players have undergone the MCS at least two coaches

should meet with one another to review the video recordings and score the players using the score sheet provided in Appendix B.

Following this initial session, the MCS should be repeated every 3 weeks. To make additional sessions less time consuming for the coaches, players should be assigned a partner to do the MCS with. As one partner does the MCS the other will record them. These videos will then be sent into the coaches for scoring.

CATAPULT PLAYR Soccer GPS Tracker

Teams should purchase a minimum of 11 trackers (one for each starter), but additional trackers (enough for all players) should be purchased if the budget allows. Trackers should then be assigned to players at the beginning of training camp. Players will then download the accompanying smartphone application and pair the device to their smartphone. At least one coach should also download the application, since they can then create a "squad" that their players can join. Data collected by players in the squad will be viewable by all members of the squad, allowing for coaches to make intra-player and inter-player comparisons. Players who are assigned a tracker should wear the device during every team sanctioned game and practice. During the first week the players have the tracker they should be sure to familiarize themselves with how it works and ensure that it will collect the proper data.

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Appendix A: Screening Criteria for the Movement Competency Screen

This screening criteria was adapted from a previously published paper.[11]

Body Region/Capacity	Two Leg Squat	Lunge & Twist	Push-Up	Bend & Pull	Single Leg Squat
Head	Held in a neutral position, appears centrally aligned.				
Shoulders	Held down and away from ears. Elbows appear in line with ears.	Held down and away from ears. Rotation appears to occur through thoracic spine.	Held down and away from ears. Scapulae movement balanced and rhythmic and not excessively abducted during arm extension.	Held down and away from ears. Scapulae movement balanced and rhythmic. During arm flexion scapulae are retracted and are not excessively abducted during arm extension.	Held down and away from ears. Elbows appear in line with ears.
Lumbar	Held in neutral curve position.	Held in neutral curve position. Rotation and/or lateral flexion does not occur during trunk twisting.	Held in neutral curve position.	Held in neutral curve position throughout trunk flexion.	Held in neutral curve position.
Hips	Horizontally aligned and mobile. Move back and down during flexion.	Mobile and stable to prohibit elevation and depression during rotation.	Held in line with the body during arm flexion and extension.	Facilitate trunk flexion.	Mobile to facilitate flexion and stable to minimize weight shift to over stance leg.
Knees	Aligned with hips and feet during flexion.	Aligned with hips and feet during flexion and do not move laterally	Extended.	Extended.	Aligned with hips and feet during flexion.

		during rotation.			
Ankles	Mobility allows adequate dorsiflexion during knee and hip flexion.		NR.	NR.	Mobility allows adequate dorsiflexion during knee and hip flexion.
Feet	Stable with heels grounded during lower limb flexion.	Heel of lead leg in contact with the floor, trail foot flexed and balanced on forefoot.	Feet straight, heels not falling in or out.	Pointing straight.	Stable with heels grounded during lower limb flexion.
Balance	Evenly distributed.	Maintained on each leg.	NR.	Maintained.	Maintained on each leg.
Depth	Top of thighs appear parallel with floor.	Lead thigh parallel with the floor.	Chest touches floor.	75-90 degrees of trunk flexion achieved.	Top of thigh appears parallel with floor.

Appendix B: Score Sheet for the Movement Competency Screen

This score sheet was adapted from a previously published paper.[11]

Movement	Primary Regions	Secondary Regions	Load Level	Comments
Two Leg Squat	Shoulders Lumbar Hips Ankles/Feet	Head Knees Depth Balance	1 2 3	
Lunge & Twist (The Lunge)	Balance Lumbar Hips Ankles/Feet	Head Knees Depth	1 2 3	
Lunge & Twist (The Twist)	Shoulders Lumbar Hips Ankles/Feet	Head Knees Depth Balance	1 2 3	
Push-Up	Head Shoulders Lumbar Depth	Hips Knees Ankles/Feet Balance	1 2 3	
Bend & Pull (The Bend)	Shoulders Lumbar Hips Depth	Head Knees Ankles/Feet Balance	1 2 3	
Bend & Pull (The Pull)	Shoulders Lumbar Hips Depth	Head Knees Ankles/Feet Balance	1 2 3	
Single Leg Squat	Depth Lumbar Hips Ankles/Feet	Head Shoulders Knees Balance	1 2 3	

Scoring Instructions

Load Level	Scoring Rationale	Considerations
1 (Assisted)	2 or more primary regions circled*	Pay close attention to the primary regions for each movement task. The primary regions will have the most meaningful impact on movement competency. To score unilateral movements the load level should reflect the poorest side.
2 (Bodyweight)	1 primary region and 2 or more secondary regions circled	
3 (External Load)	No primary and only 1 secondary region circled	

*The circling of a primary or secondary region indicates a deviation in that region from the ideal as stated on the Screening Criteria document found in Appendix A.

Appendix C: Summary of Statistical Analyses for RESTQ-52 Sport Data

	General Stress	Emotional Stress	Social Stress	Conflicts/ Pressures	Fatigue	Lack of Energy	Physical Complaints
Mean for Survey Attempt 3	0.33	1.50	1.00	2.67	2.67	2.67	0.83
Mean for Survey Attempt 1	1.17	2.50	2.00	2.83	2.00	2.83	2.33
t-Statistic	2.5	1.31	3.46	0.10	0.39	0.10	3.40
p-Value	0.13	0.32	0.07	0.93	0.73	0.93	0.08
Significant?	No	No	No	No	No	No	No
	Success	**Social Recovery**	**Physical Recovery**	**General Well-Being**	**Sleep Quality**	**Disturbed Breaks**	**Emotional Exhaustion**
Mean for Survey Attempt 3	3.33	4.83	3.33	5.17	3.83	1.58	1.14
Mean for Survey Attempt 1	3.50	5.67	3.67	4.83	5.17	0.08	1.42
t-Statistic	0.25	0.90	0.28	0.55	2.22	1.03	0.35
p-Value	0.83	0.46	0.81	0.63	0.16	0.41	0.76
Significant?	No	No	No	No	No	No	No
	Injury	**Being in Shape**	**Personal Accomplishment**	**Self-Efficacy**	**Self-Regulation**	**Overall Stress Score**	**Overall Recovery Score**
Mean for Survey Attempt 3	0.50	4.17	4.50	5.17	3.67	1.49	4.22
Mean for Survey Attempt 1	3.58	3.83	4.25	4.17	4.08	2.08	4.35
t-Statistic	21.36	0.76	0.50	1.97	1.15	0.70	0.35
p-Value	0.00	0.53	0.67	0.19	0.37	0.56	0.76
Significant?	Yes	No	No	No	No	No	No

Appendix D: RESTQ-52 Sport Survey Data

Please note that any blanks in the tables found below indicate that the question was not answered

Survey Attempt 1

Respondent 1

Player Position – Defender

Player Academic Class – Senior

RESTQ-52 Sport Question Number	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Response	5	1	2	3	1	1	5	2	2	3	1	1	1
RESTQ-52 Sport Question Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Response	3	0	4	0	1	1	4	0	2	2	1	6	0
RESTQ-52 Sport Question Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Response	1	2	2	1	1	3	0	0	3	1	5	1	5
RESTQ-52 Sport Question Number	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Response	2	0	0	2	1	4	3	0	5	4	2	5	5

Respondent 2

Player Position – Midfield

Player Academic Class – Senior

RESTQ-52 Sport Question Number	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

Response	6	1	1	5	3	3	6	0	5	5	5	0	2
RESTQ-52 Sport Question Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Response	5	2	5	3	0	1	4	1	6	0	3	6	0
RESTQ-52 Sport Question Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Response	5	4	0	5	6	3	1	5	2	5	6	0	5
RESTQ-52 Sport Question Number	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Response	5	0	4	0	5	4	5	0	0	1	3	0	5

Respondent 3

Player Position – Forward

Player Academic Class – Junior

RESTQ-52 Sport Question Number	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Response	6	5	6	6	5	6	6	2	1	5	4	5	2
RESTQ-52 Sport Question Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Response	6	0	6	1	0	6	5	5	0	6	3	4	0
RESTQ-52 Sport Question Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Response	6	6	2	6	6	3	0	6	4	6	6	0	2
RESTQ-52 Sport Question Number	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Response	6	0	4	0	6	6	6	0	1	6	5	5	6

Survey Attempt 2

Respondent 1

Player Position – Defender

Player Academic Class – Senior

RESTQ-52 Sport Question Number	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Response	6	0	2		5	2	5	0	1	4	0	1	0
RESTQ-52 Sport Question Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Response	5	1	6	1	1	1	5	0	1	2	0	2	0
RESTQ-52 Sport Question Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Response	5	5	0	3	4	2	0	6	4	5	4	0	1
RESTQ-52 Sport Question Number	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Response	5	0	3	0	6	4	6	0	1	3	5	0	6

Respondent 2

Player Position – Forward

Player Academic Class – Junior

RESTQ-52 Sport Question Number	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Response	6	2	5	6	1	2	6	3	2	6	3	3	1
RESTQ-52 Sport Question Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Response	5	0	6	2	1	1	2	1	1	3	2	3	0

RESTQ-52 Sport Question Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Response	4	5	0	5	4	2	0	4	6	6	5	0	1
RESTQ-52 Sport Question Number	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Response	5	0	4	0	6	5	5	0	1	5	5	2	3

Survey Attempt 3

Respondent 1

Player Position – Defender

Player Academic Class – Senior

RESTQ-52 Sport Question Number	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Response	6	0	5	5	2	1	5	0	1	4	0	1	0
RESTQ-52 Sport Question Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Response	5	0	6	0	1	0	5	0	1	4	1	1	0
RESTQ-52 Sport Question Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Response	6	5	0	5	3	0	0	5	4	5	6	0	0
RESTQ-52 Sport Question Number	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Response	5	0	1	0	5	5	5	0	1	2	5	0	6

Respondent 2

Player Position – Midfield

Player Academic Class – Senior

RESTQ-52 Sport Question Number	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Response	5	2	2	4	6	6	1	0	6	4	3	2	2
RESTQ-52 Sport Question Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Response	0	0	4	6	0	2	0	0	6	0	6	1	6
RESTQ-52 Sport Question Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Response	6	4	0	6	2	0	1	6	4	4	6	5	0
RESTQ-52 Sport Question Number	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Response	6	6	6		3	4	6	5	2	3	3	3	6

Respondent 3

Player Position – Forward

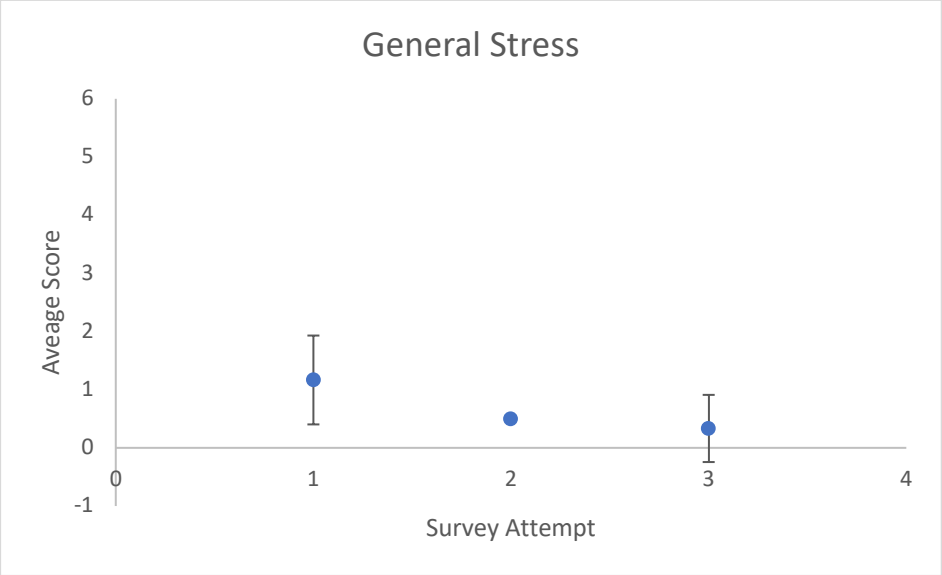
Player Academic Class – Junior

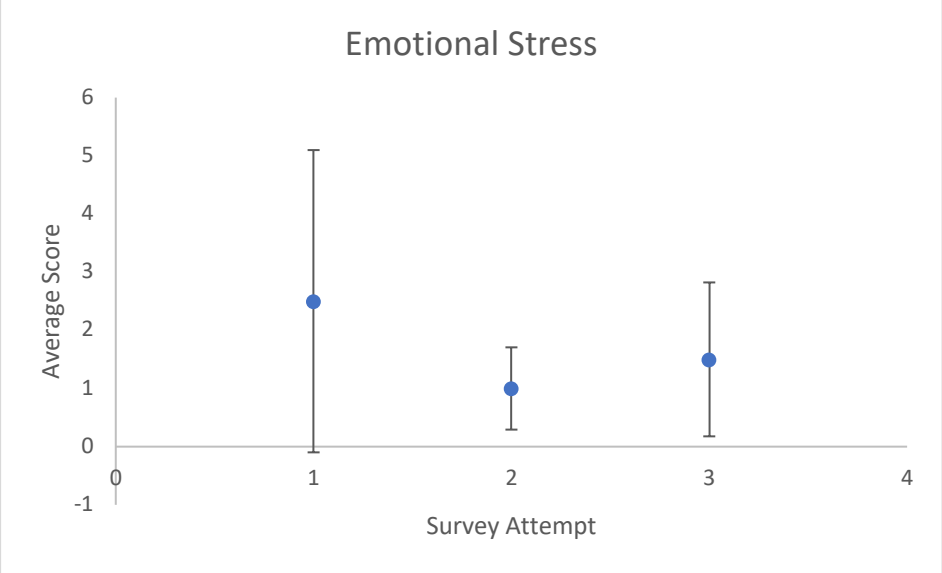
RESTQ-52 Sport Question Number	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Response	6	2	4	6	1	2		1	1	6	1	2	0
RESTQ-52 Sport Question Number	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Response	2	0	6	2	1	3	4	1	0	2	0	1	0
RESTQ-52 Sport Question Number	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Response	5	5	0	3	3	0	1	3	3	4	5	0	0

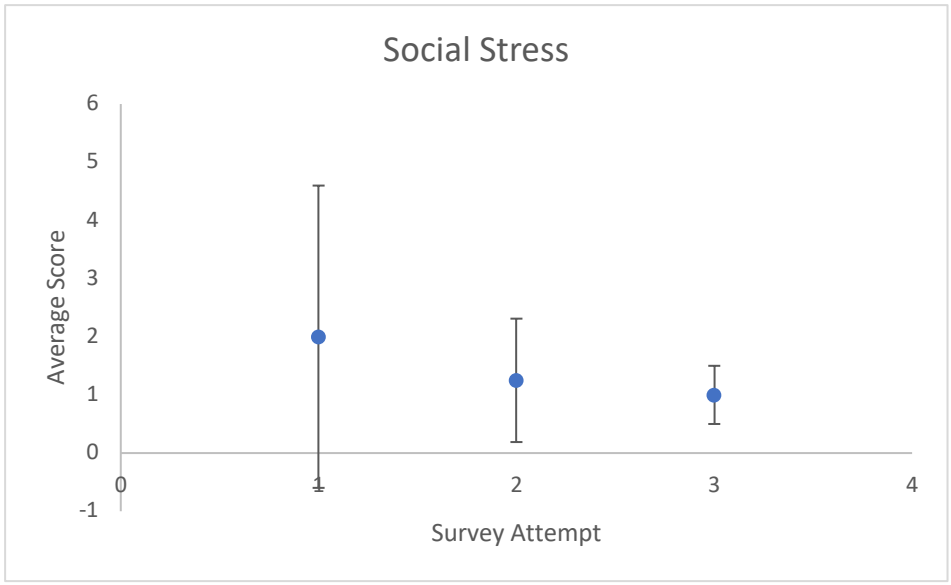
RESTQ-52 Sport Question Number	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
Response	4	0	3	0	4	5	5	0	0	4	3	3	3

Appendix E: Graphical Summary of RESTQ-52 Sport Data

All graphs pertaining to RESTQ-52 Sport summary data not reported in the main body of the report is presented below.



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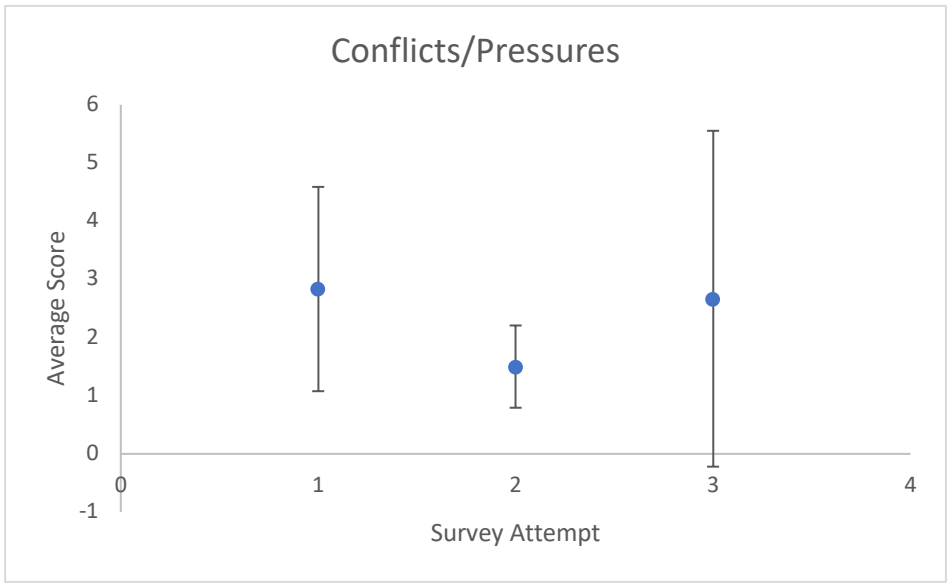
5
4
3
2
1
0
-1
0
1
2
3
4
Survey Attempt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Average Score
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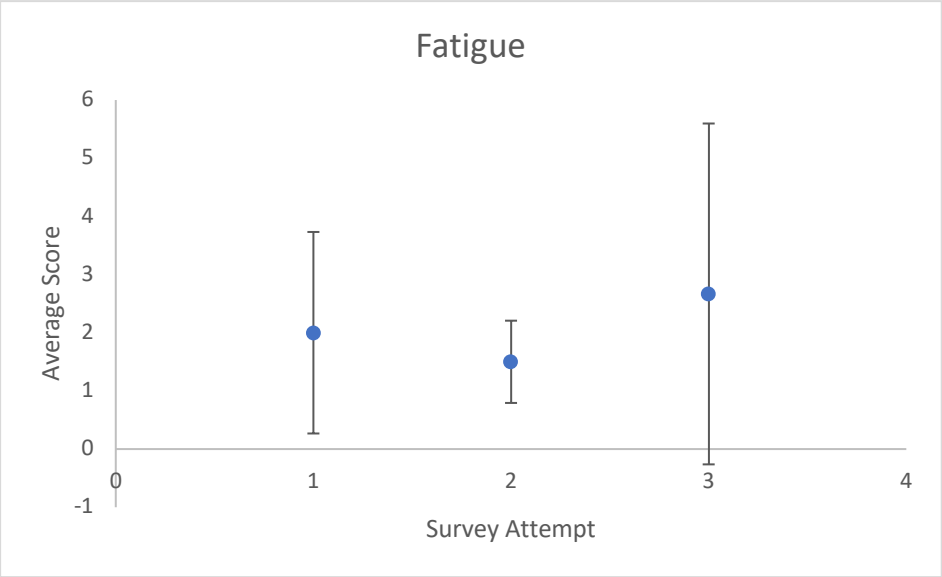
1
0
-1
0
1
2
3
4
Survey Attempt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Average Score
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4
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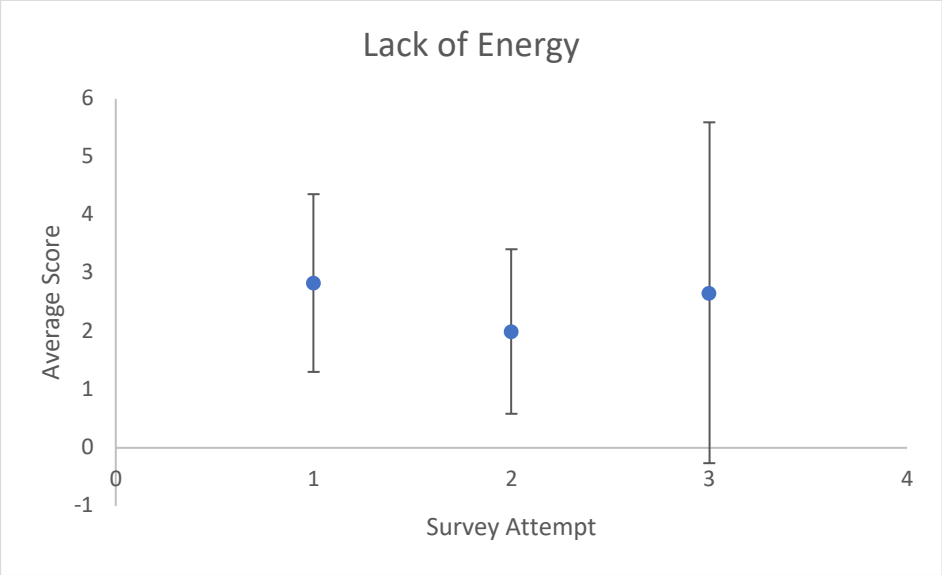
2
1
0
-1
0
1
2
3
4
Survey Attempt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Average Score
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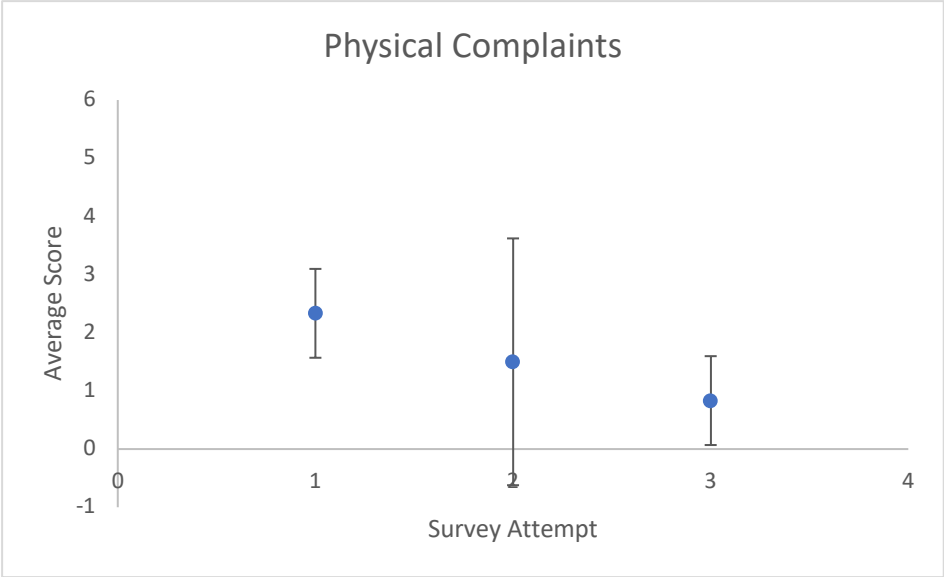
1
0
-1
0
1
2
3
4
Survey Attempt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Average Score
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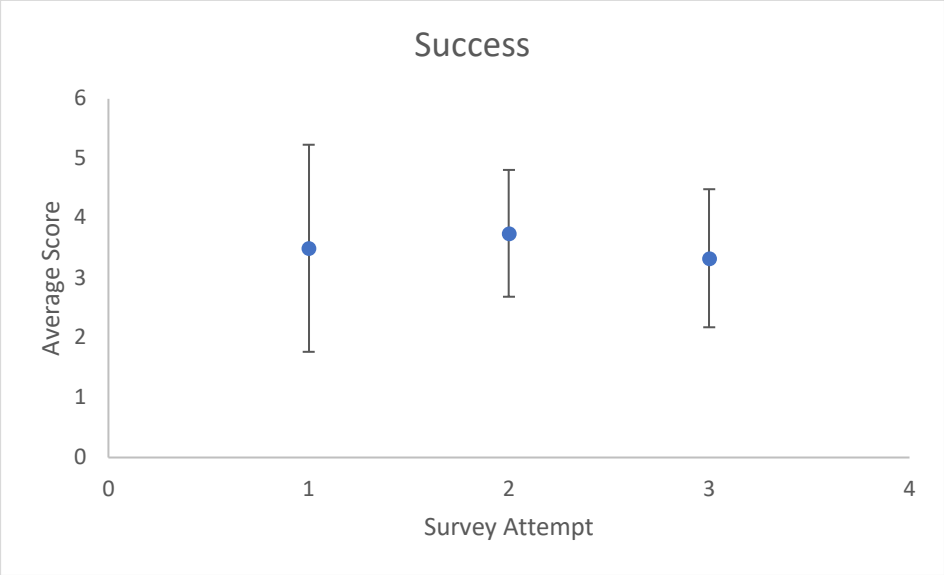
1
0
-1
0
1
2
3
4
Survey Attempt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2
3
4
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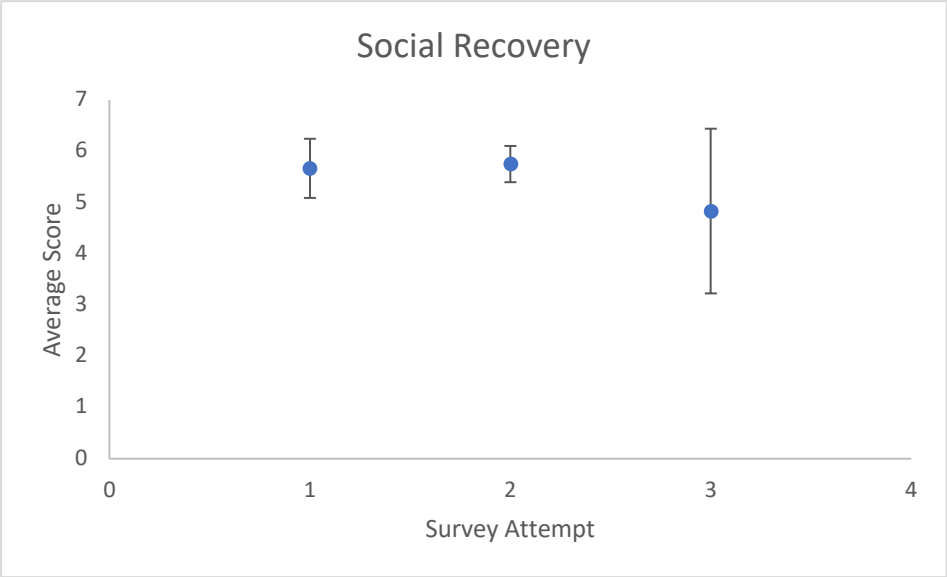
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Average Score
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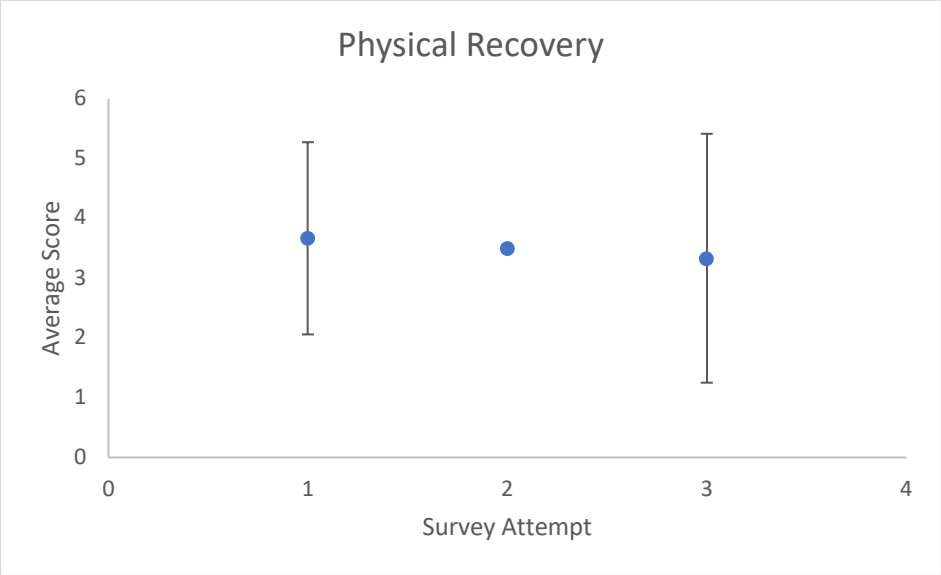
1
2
3
4
Survey Attempt


Physical Recovery
Average Score
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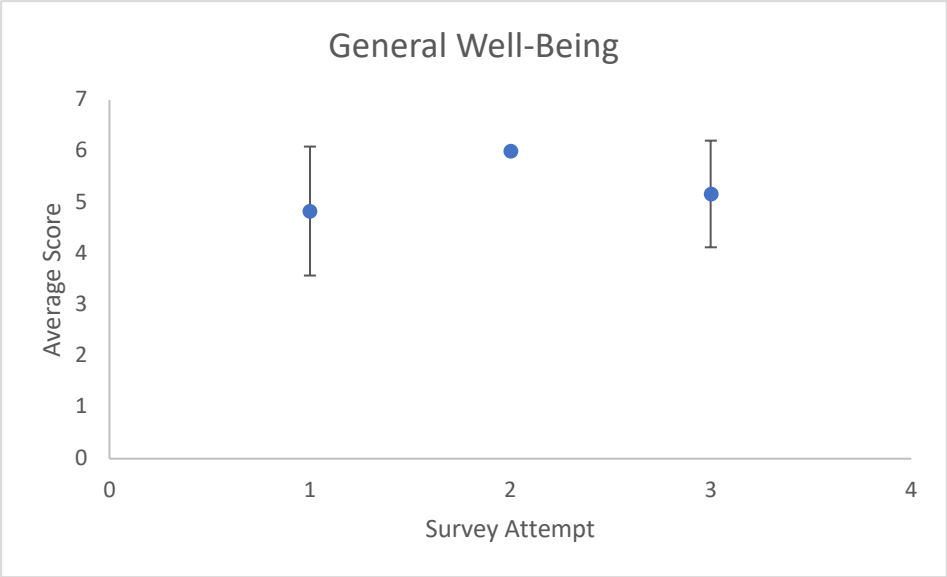
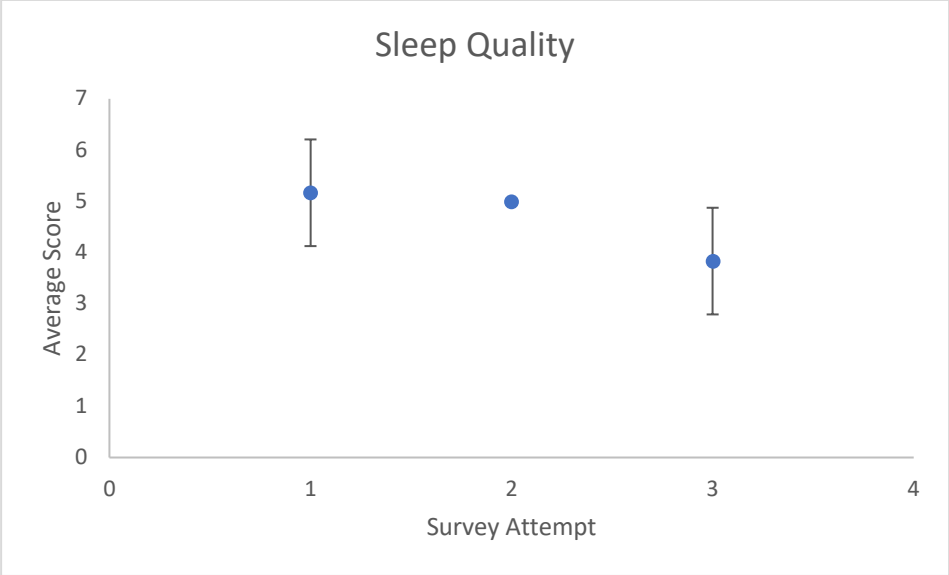
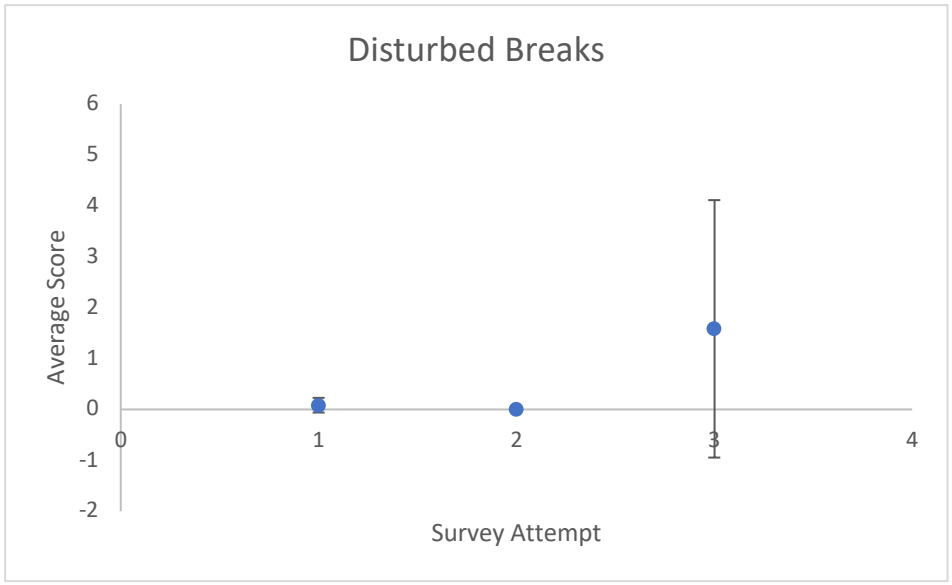
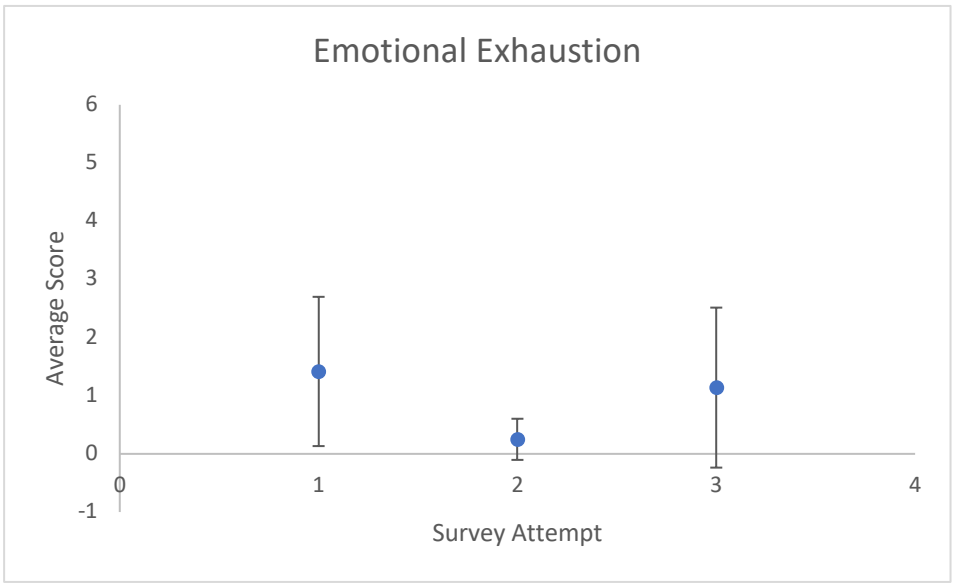
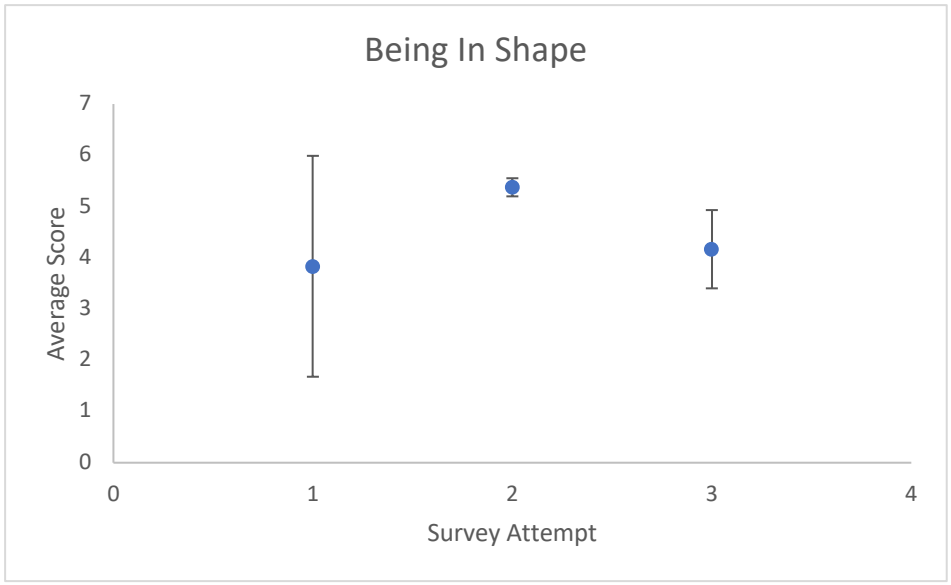
1
2
3
4
Survey Attempt

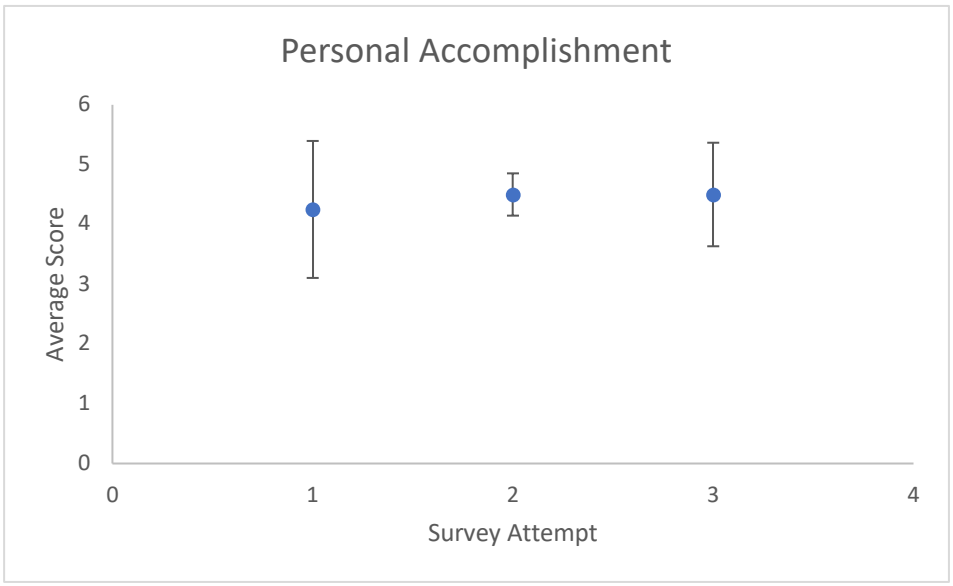

General Well-Being
Average Score
7
6
5
4
3
2
1
0
0
1
2
3
4
Survey Attempt

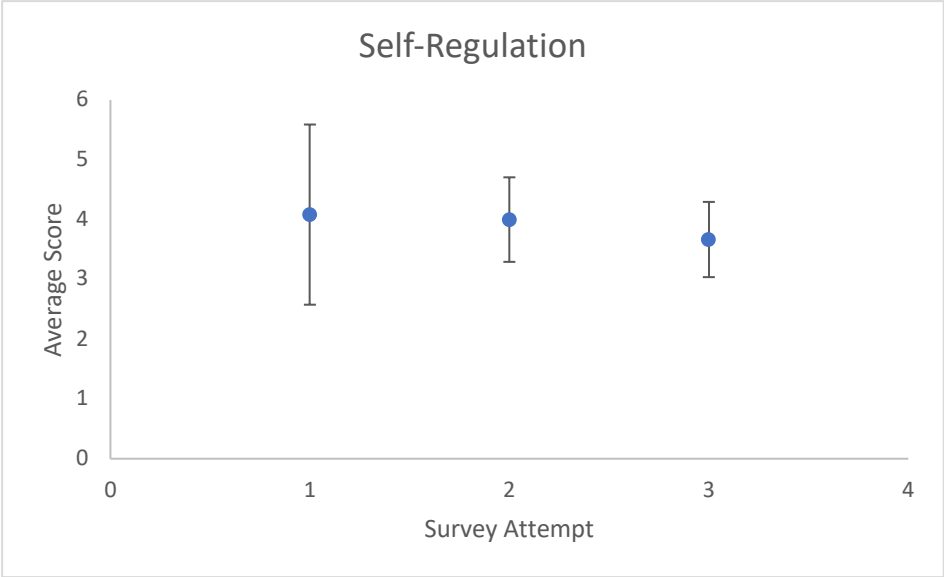

Sleep Quality
Average Score
7
6
5
4
3
2
1
0
0
1
2
3
4
Survey Attempt

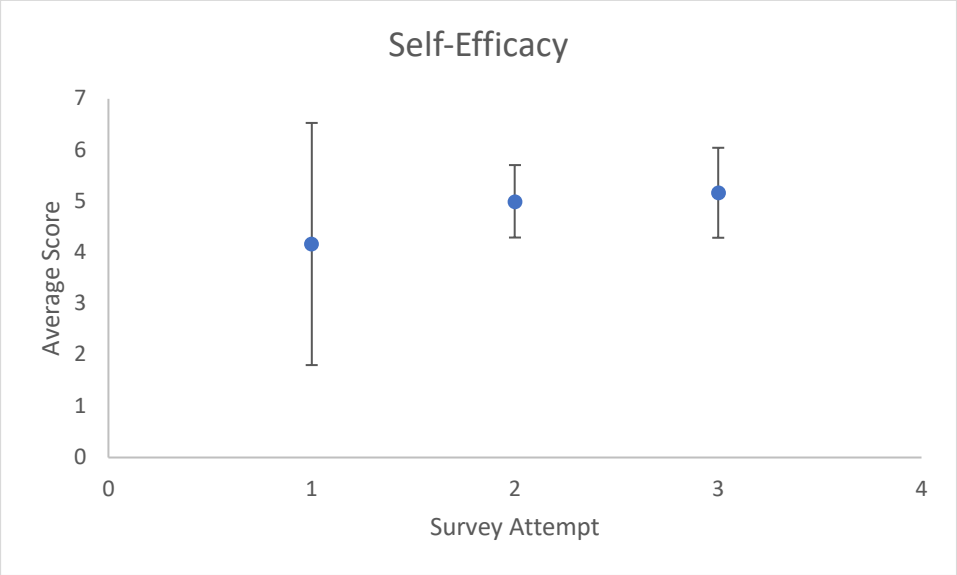

Disturbed Breaks
Average Score
6
5
4
3
2
1
0
-1
-2
0
1
2
3
4
Survey Attempt


Emotional Exhaustion
Average Score
6
5
4
3
2
1
0
-1
0
1
2
3
4
Survey Attempt


Being In Shape
Average Score
7
6
5
4
3
2
1
0
0
1
2
3
4
Survey Attempt


Personal Accomplishment
Average Score
6
5
4
3
2
1
0
0
1
2
3
4
Survey Attempt


Self-Regulation
Average Score
6
5
4
3
2
1
0
0
1
2
3
4
Survey Attempt


Self-Efficacy
Average Score
7
6
5
4
3
2
1
0
0
1
2
3
4
Survey Attempt

Appendix F: Summary of CATAPULT PLAYR Soccer GPS Tracker Data

Summary of CATAPULT PLAYR Soccer GPS Tracker of Data for All Subjects							
Subject	**Total Number of Sessions**	**Fastest Top Speed (m/s)**	**Average Top Speed (m/s)**	**Longest Distance in a Session (km)**	**Average Distance per Session (km)**	**Longest Sprint Distance in a Session (km)**	**Average Sprint Distance per Session (m)**
1	6	7.70	6.35	8.69	4.61	468	153.67
2	8	7.80	6.60	11.51	5.39	562	187.75
3	12	8.40	7.56	9.25	5.29	690	344.53

CATAPULT PLAYR Soccer GPS Tracker Data from Subject 1				
Week	**Number of Recorded Sessions**	**Fastest Top Speed (m/s)**	**Total Distance (km)**	**Total Sprint Distance (m)**
1	0	N/A	N/A	N/A
2	2	6.10	5.73	86
3	3	7.20	13.22	368
4	1	7.70	8.69	468

CATAPULT PLAYR Soccer GPS Tracker Data from Subject 2				
Week	**Number of Recorded Sessions**	**Fastest Top Speed (m/s)**	**Total Distance (km)**	**Total Sprint Distance (m)**
1	1	6.40	3.54	167
2	2	6.90	9.47	331
3	3	7.30	20.69	821
4	2	7.80	9.44	183