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The Effects of a 4-Week Heart Rate Variability Biofeedback Intervention on Psychological and Performance Variables in Student-Athletes: A Pilot Study

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Purpose: To examine the effects of a 4-week biofeedback intervention on coherence, psychological, and performance variables in collegiate student-athletes. **Methods:** Thirteen student-athletes were randomly assigned to the intervention (one weekly biofeedback session for 4-weeks) or control group (no session). Data were collected at pre- and post-intervention using weekly averaged coherence scores, psychological measures for depression, arousal, stress, resiliency, and performance outcome measures. **Results:** A 3 (time) x 4 (week average) repeated measures ANOVA was independently conducted to examine difference between time and weekly coherence average for coherence scores. No significant differences were fount for "at rest, pre, or post-practice coherence scores. A 2 (treatment group) x (4 week) repeated measures ANOVAs were independently conducted to examine differences between treatment groups and week average performance, resilience, and recovery. Significant differences were found for performance by time (p=0.029). For the psychological variables, 2 (treatment group) x 2 (time) repeated measures ANOVAs were independently conducted to examine differences between treatment group and time for CESD, AD-ACL, CSSS, and the ASSQ sleep score and no significant differences were found. **Conclusions:** Overall biofeedback intervention did not improve coherence, psychological, or performance variables between the groups. While the biofeedback intervention did not show significant changes in this pilot study, there is potential for future research to address male participants and a change in timing during the season. **Key Words:** Mental Health, Performance, Intervention, Sports, Biofeedback

INTRODUCTION

Participation in college athletics has been documented to change the behavioral response of the individual through additional stress, increased episodes of anger, and symptoms of depression and anxiety due to sport performance.[1] Although sport has many positive effects, the mental health struggles of college student-athletes were recognized by the National Collegiate Athletic Association (NCAA) Sport Science Institute with a mission to improve access to quality mental healthcare and normalize mental health care seeking behavior.[2] The NCAA encourages prevention and wellness programs at all institutions and provides resources to help institutions implement best practice guidelines.[2] While the NCAA initiatives are promising, current prevention and intervention programs for student-athletes are psychoeducational and limited in nature. Intervention programs are not designed to reduce symptoms of depression, anxiety or stress, rather they are designed to inform mental health awareness and encourage student-athletes to seek help.[3,4] The gap in the programming provides ample opportunity to implement interventions designed to improve mental health symptoms in current, competing student-athletes.

In addition to maintaining mental health and wellness, collegiate student-athletes need to incorporate appropriate recovery mechanisms for optimal performance.[5] Recovery is defined as a multifaceted restorative process relative to time, which can be disrupted by internal or external factors such as stress or fatigue.[6] The internal and external factors dually affect student-athletes through a need for both physiological and psychological maintenance in their daily life and sport.[5,6] Adequate recovery can be achieved through the use of numerous interventions including sleep hygiene,[7] cognitive self-regulation,[8] and psychological relaxation techniques[5] which can be paired with biofeedback modalities such as heart rate variability (HRV).

Heart rate variability consists of changes and fluctuations in the time intervals between consecutive heartbeats.[9] The interaction of regulatory systems contribute to HRV recordings. More specifically, the autonomic, cardiovascular, and respiratory systems produce short-term HRV measurements.[10] The importance of HRV is demonstrated when the cardiovascular system effectively modulates vagal tone via the vagus nerve. For example, when an individual inhales, heart rate increases due to a withdrawal of vagus nerve inhibition and during exhalation, vagal inhibition is restored and thus slows the heart down. This process is largely responsible for generating HRV and helps maintain the dynamic autonomic balance within the body.[10] HRV has been used for parameters when designing training and recovery programs for athletes. In a comparison of sedentary subjects and recreationally active subjects, a distinct HRV profile was noted for active individuals including an overall increase in HRV and parasympathetic cardiac modulation.[11] Furthermore, in those with higher vagal tone, athletic conditioning is an important factor influencing autonomic control of the heart to influence performance and the regulation of emotional and mental health.[11,12]

Heart rate variability through biofeedback has primarily been used to improve concentration and performance.[8,13] Through biofeedback, individuals learn to recognize heart rate patterns as erratic and ineffective and in turn regulate their breathing to control the heart rate pattern.[11,14] Previous studies indicated that through HRV biofeedback interventions, student-athletes were able to lower anxiety, lower their heart rate, and improve their heart rate coherence.[8,15-17] One example of HRV biofeedback technology has been established through the HeartMath Institute (Heart Math Institute, Boulder CA). HeartMath has created self-regulation breathing techniques and numerous methods of obtaining heart rate biofeedback data including their systems EmWave and Inner Balance.[18] EmWave has been used to help student-athletes achieve their optimal training zone and improve overall performance; however, the EmWave system is a computer-based software, that does not allow for hands free, quick, and on the go biofeedback results.[8,16] The other method, Inner Balance, can be easily accessed through a smart phone mobile application and the heart rate monitor connects via Bluetooth technology. To date research is limited on student-athletes and their use of the HeartMath self-regulation techniques, technology, and more specifically using the Inner Balance method. The use of hands-free Bluetooth technology would allow student-athletes the opportunity to regulate their breathing and manage their stress and emotions when it is convenient for their schedules and without a computer. To the author's knowledge, Inner Balance has not been used in student-athletes to improve mental health status and performance outcomes.

The literature on biofeedback programs designed for mental health outcomes in combination with performance outcomes in student-athletes is limited and cross sectional in nature. [8,13,16] Therefore, the objective of the pilot study was to examine the effects of a four-week heart rate biofeedback intervention on coherence, psychological (i.e., depressive symptoms, level of activation, perceived stress, resilience), and performance variables in collegiate student-athletes. It is believed the outcomes of the study may be valuable to athletic trainers, coaches, and strength and conditioning professionals when providing mental wellness and performance enhancement strategies to student-athletes.

METHODS

Participants

Thirteen female student-athletes (age: 20 ± 1 years, height: 166.3 ± 8.7 cm, weight: 73.3 ± 19.0 kg) were recruited from local colleges and universities to participate. All student-athletes were currently participating in their respective sport and free of injury at the onset of the study. If a participant was injured during the study period, they were able to continue in the study. This study was approved by the University of South Carolina Institutional Review Board, and participants consented prior to participation.

Instruments

Demographics

The initial screening questionnaire including items relative to personal information (e.g., age, sex, injury status, etc.) to determine eligibility for the study and collect demographic factors including self-reported anthropometric measurements (e.g., height, weight).

Coherence

Coherence is the term to measure communication between the heart and brain and refers to the interactions between physiological and psychological processes for optimal functioning.[18] In HRV, distinct heart rate patterns characterize different emotional states. In individuals with high coherence, a smooth, sine wave like pattern is seen on the Inner Balance display screen and on the contrary, low coherence will have an erratic heart rate pattern. The Inner Balance mobile application uses a patented algorithm to determine heart coherence and HRV.[18] The coherence score was obtained from the earpiece heart rate sensor, graphed, and recorded in real time on the Inner Balance application.[18] The Inner Balance application provided a low, medium, or high coherence score reflecting the individual's ability to balance the autonomic system ranging from 0-16. Scores of 0.5 are considered to be beginner, 1.0 as good, 2.0 very good, and 3.0 and up is excellent. The coherence score was recorded daily with an "at rest" measure (no skill practice) and then measured pre- and post-team practice sessions. Daily coherence scores were averaged at the end of each week.

Psychological Variables

For the purposes of the study, the research team used four valid and reliable measures to assess psychological components of the participants, regardless of group allocation, during the study. The four measures were for depression, arousal, stress, and resiliency.

First, the Center for Epidemiologic Studies Depression Scale (CESD) was used as a self-report measure of depressive symptoms. The CESD is a 20 item tool that measured 8 different components including: depressed mood, feelings of guilt and worthlessness, psychomotor retardation, loss of appetite, and sleep disturbance.[19] Participants selected how often during the past week they have felt or behaved respective to certain items using a 4-point Likert scale (*1= rarely or none of the time to 4 = most or all of the time*). A participant would be considered at risk for depression if they scored >16 on the CESD. The internal consistency for the CESD α = 0.85 to 0.90, with a test-retest reliability of α = 0.45- 0.70.[19]

Next assessed was arousal, using the multi-dimensional Activation-Deactivation Adjective Check List (AD-ACL). The AD-ACL consists of 20 adjectives related to energy (general activation), tiredness (deactivation-sleep), tension (high activation), and calmness (general deactivation) which are the four subscales of the arousal states of energetic and tense arousal.[20] The instructions for the AD-ACL has the individual use the rating scale to describe their feelings at the moment, and to use their first reaction. The rating scale has four options to circle/mark. A selection of (vv) or double check means the individual definitely feels the mood or feeling at the moment, whereas a selection of (v) or single check means the individual slightly feels the mood or feeling at the moment. A selection of (?) or question mark means the word does not apply or the individual cannot decide if they feel that mood or feeling now. If the individual selects no, they are not feeling that mood or feeling. The AD-ACL is scored by summing the ten scores for the energy and tension dimensions. These two dimensions are the best indications of energetic and tense arousal, and a full use of all dimensions reduces the relationship strength between arousal and other behaviors. The test-retest reliability for the four subscales ranges from 0.79 – 0.93, and for the two specific subscales of energy 0.89 and tension 0.93.[20,21]

The College Student Stress Scale (CSSS), a screening instrument for students experiencing stress during the transition to college was used to assess stress. The purpose of the instrument is to identify those who believe the transition is highly stressful.[22] The CSSS includes 11 items that are answered with a 5-point Likert scale to assess how frequently they are distressed, anxious, or question their ability. The CSSS has good internal consistency and stability with an alpha for the total score of 0.87.[22]

Finally, resiliency was measured using the reliable Brief Resilience Scale (BRS). The instrument is used to assess the ability of an individual to bounce back from adversity using six statements measured on a 5-point Likert scale (1= strongly disagree to 5= strongly agree).[23] To score the BRS, add the responses on the six statements, with reverse scoring for items 2, 4, and 6. After summing the scores, divide the total by the total number of questions answered. Scores ranging from 1.00 to 2.99 indicate low resilience, 3.00-4.30 normal resilience, and 4.31 to 5.00 high resilience.[23]

Performance & Recovery

To assess performance and recovery, the participants completed three instruments including the Perceived Recovery Status Scale (PRSS), the Sport Performance Rating Scale (SPR), and the Athlete Sleep Screening Questionnaire (ASSQ). The PRSS was created to assess an individual's perceived recovery status on a scale of 0-10 similar in nature to the Rated Perceived Exertion Scale.[24] The scale ranges from 0 (very poorly recovered) to 10 (very well recovered). A decline in performance would be expected with scores from 0 to 3. With scores between a 4 and 7 a similar level of performance would be expected. With any scores of 8 to 10 an improved performance would be expected.[24]

Next, the SPR was used for participants to rate their perceived performance on a scale of 0 (worst performance) to 10 (best performance) for after each practice session. Prior studies used sport specific rubrics to assess performance, therefore, the SPR was created to allow for multiple teams to assess their performance. This numeric rating scale has been deemed reliable and used for pain studies and rating the intensity of pain.[25]

Finally, the ASSQ was used to detect sleep disturbances and daytime dysfunction in the student-athlete population. The ASSQ consists of 15 items to assess sleep quality, insomnia and chronotype with a timeframe of "over the recent past."[26] The sleep difficulty score from the ASSQ is used to classify the student-athletes into a level of sleep problems (none, mild, moderate, severe) based on their responses. The cut off scores for each classification include none: 0-4, mild: 5-7, moderate: 8-10, and severe: 11-17.[26] The ASSQ has an internal consistency of 0.74 and test-retest reliability of 0.86 for the athletic population.[26]

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Experimental Procedures

Baseline Measures and Group Allocation

The participants provided demographic and baseline information during the initial session to determine eligibility and informed consent was obtained. The baseline measures included all psychological measures (CESD, AD-ACL, CSSS, and BRS) and a performance & recovery measure (ASSQ). The participants were then randomly assigned into two experimental conditions: control and intervention. Participants in the control group did not receive the four-week HRV biofeedback intervention but were asked to complete the data collection for the main outcome measures. The participants randomly assigned to the intervention group received the four-week HRV biofeedback intervention.

Intervention

Participants in the intervention group were asked to attend four intervention sessions, which were held weekly for four weeks. Each session occurred in the athletic training facility at the local college and lasted 10 - 15 minutes. During each intervention session, the HeartMath Institute self-regulation techniques were taught, reviewed, and practiced with the participants by a licensed mental healthcare provider trained in the HeartMath techniques. The overall goal for self-regulation techniques was to help establish a new psychological baseline, resulting in sustainable perceptual and behavioral changes. During the first intervention session, participants learned the Heart-Focused Breathing Technique™ and the Quick Coherence Technique™. The following week, participants learned the Heart Lock-In Technique™, and the Coherent Communication Technique™ in addition to reviewing the previous week's content. The third week was the last week individuals learned new concepts and the techniques, the Freeze Frame Technique™ and Attitude Breathing Techniques™. The final week of the intervention reviewed all the techniques. Table 1 provides detailed information on each of the intervention techniques. Each week, student-athletes were asked to use the HeartMath Inner Balance™ mobile application to practice the techniques learned during the sessions. Prior to each practice the student-athlete had a "at rest" heart rate reading with the Inner Balance™ sensor, clipped onto their earlobe for two minutes and were asked to report their perceived recovery. After the "at rest" measure was obtained, the student-athlete was asked to practice the techniques learned for five minutes. The techniques were repeated after practice and participants were asked to report their perceived performance after each practice. For the duration of the four weeks, the participants were asked to practice the techniques and engage in the coherence training before and after practice. Figure 1 provides a detailed study procedure flow chart.

Technique	Focus of Technique
Heart-Focused Breathing	Reduce the impact of stress on your mind and body and reduce energy drain by going into a neutral state.
Quick Coherence	Builds on Heart Focused Breathing and allows individual to shift emotions to positive and productive ones.
Heart Lock-In	Builds on Quick Coherence and focuses on sustaining heartfelt positive emotions and coherence for longer periods of time.
Coherent Communication	Designed to improve connection and understanding between listener and speaker during communication.
Freeze Frame	Freeze frame is designed to help individuals slow down emotional reactions and make a positive shift to find new solutions to stressful or challenging problems.
Attitude Breathing	This technique focuses on emotional restructuring and refocusing by helping individuals identify undesired emotional states and identify a replacement attitude.

Table 1. HeatMath Self-Regulation Techniques

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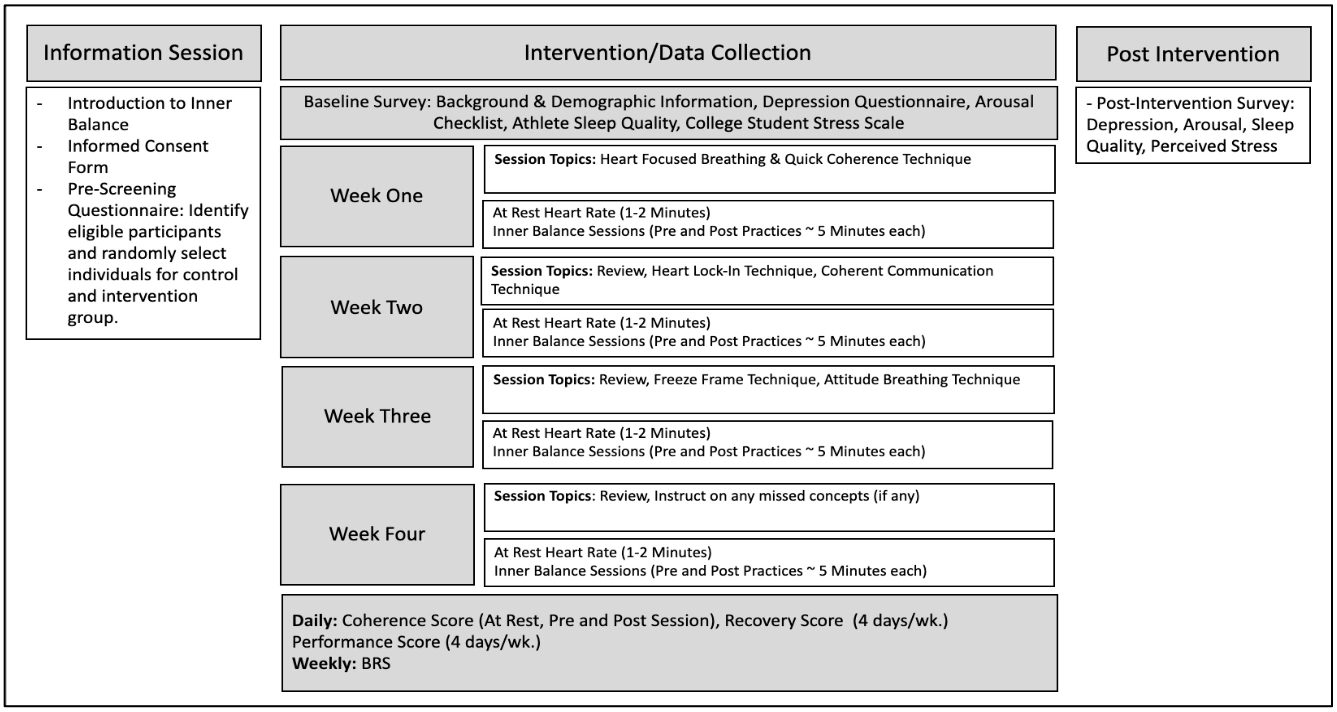

Figure 1. Detailed Outline of Procedures

Statistical Analysis

Quantitative Analysis

SPSS statistical software (Version 26; SPSS Inc. Armonk, NY) with an alpha set at P <.05 for all analyses was used. A priori power analysis was conducted using G*Power statistical software (version 3.1.9.2., Heinrich Heine University, Dusseldorf, Germany). Using a large effect size at .07, the power calculation indicated a sample size of 14 participants for each group was needed with estimated power being .90. However, a sample size of 14 participants (7 per group) is comparable to previously published studies examining heart rate biofeedback programs ranging from 14 to 20 participants per group.[8,13,16] Basic descriptive statistics were performed to examine the demographic information (e.g., height, weight, academic status, etc.). A 3 (Time: "at rest", pre-practice, post-practice) x 4 (Week average: week 1, week 2, week 3, week 4) repeated measures ANOVA was independently conducted to examine differences between time ("at rest", pre-practice, post-practice) and weekly coherence average (week 1, week 2, week 3, week 4) for coherence scores. A 2 (treatment group: intervention, control) x 4 (Week: week 1, week 2, week 3, week 4) repeated measures ANOVAs were independently conducted to examine differences between treatment group (intervention vs control) and week (week 1, week 2, week 3, week 4) for performance, resilience, and recovery. For the psychological variables, 2 (treatment group: intervention, control) X 2 (Time: pre-intervention, post-intervention) repeated measures ANOVAs were independently conducted to examine differences between treatment group (intervention vs control) and time (pre-intervention vs post-intervention) for CESD, AD-ACL, CSSS, and the ASSQ sleep score.

RESULTS

Demographics

Initially, 15 participants were assessed for eligibility for inclusion, and due to a current injury, one was removed from participation. Fourteen student-athletes were randomized into the intervention (n=6) and control (n=8) groups. One participant from the control group dropped out of the study after 1 week, therefore 13 participants were included in the final analysis (figure 2). All demographic data is presented in Table 2. The pre-test data was screened for naturally occurring differences between the intervention and control groups using independent t-tests to determine if onetime variables needed to be controlled as a covariate in subsequent analyses. Results indicated there were no significant differences (P<.05) precluding the need to control for time 1 data in subsequent 2x4 ANOVAs with repeated measures on the last factor. Given the sample size and required power, controlling for time 1 data was deemed inappropriate; covariate control is recommended in subsequent research.

	M	SD
Age	19.9	1.3
Height (cm)	166.3	8.7
Weight (kg)	73.3	19.0
	%	*n*
Academic Status (%)		
Freshman	30.8	4
Sophomore	15.4	2
Junior	30.8	4
Senior	23.1	3
Sport		
Lacrosse	69.2	9
Swimming	30.8	4
Ethnicity		
Caucasian	53.8	7
Black or African American	30.8	4
Biracial/ Two or More Races	23.1	2
Table 2. Demographic Information Including Academic Status, Sport, and Ethnicity (n=13)		

Table 2. Demographic information including academic status, sport and ethnicity (n=13)

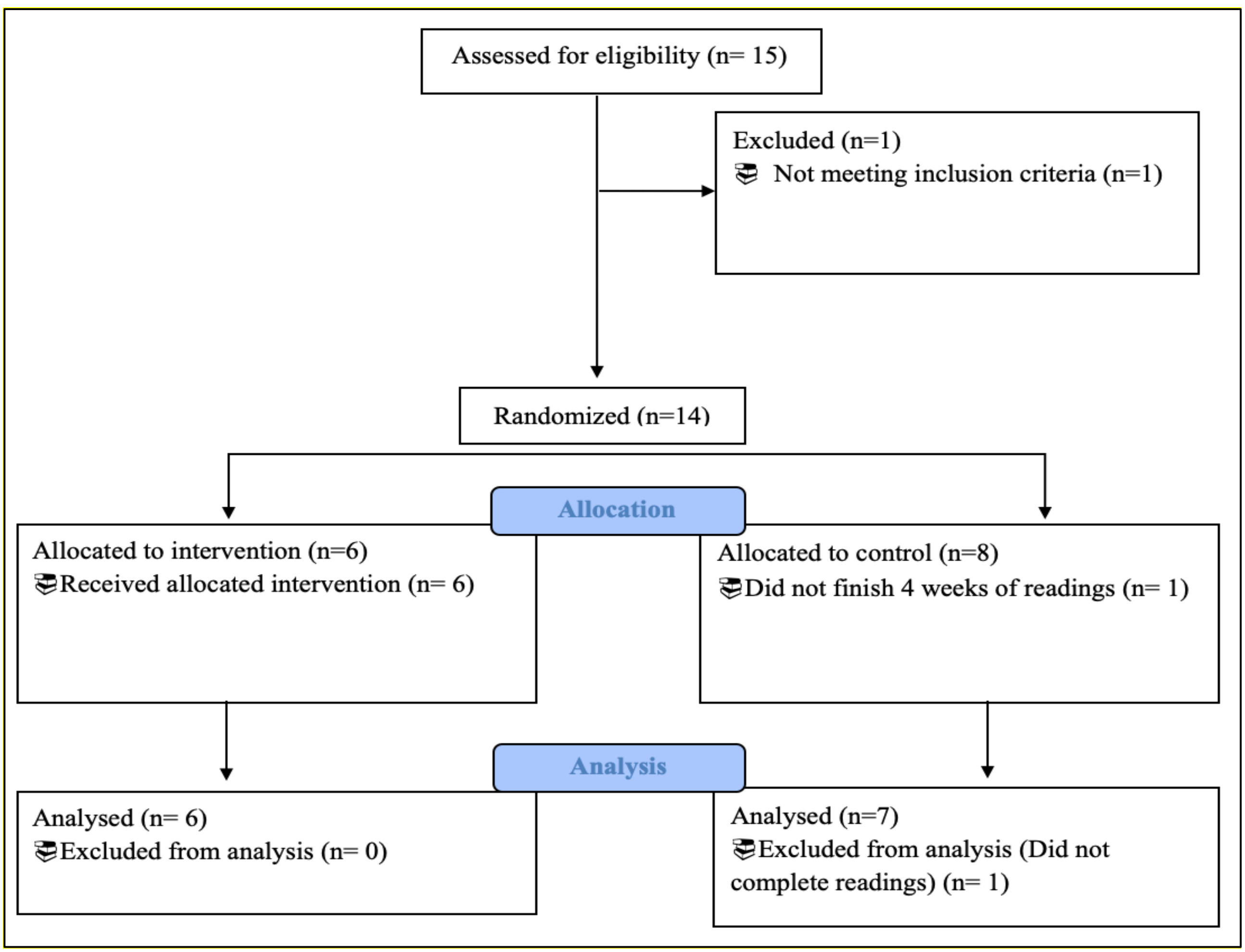

Figure 2. Summary of participant flow through the research protocol.

Coherence

A 3x4 repeated measures ANOVA with a Greenhouse-Geisser correction determined there were no significant interactions between coherence scores for "at rest", pre-practice, and post-practice ($F_{(1.025, 11.280)}$=4.463, P=.057, N^2 =.289), for coherence scores by group (intervention vs control) ($F_{(1.025, 11.280)}$=4.563, P=.055, N^2 =.293), for time ($F_{(1.129, 12.422)}$=1.004, P= .347) or for time by group ($F_{(1.129, 12.422)}$=1.039, P=.388, N^2 =.086). Additionally there were no significant interactions for coherence scores by time ($F_{(1.092, 12.422)}$=1.092, P=.377, N^2=.090) or for coherence scores by time and by group ($F_{(1.092, 12.422)}$=.948, P=.358, N^2=.079). The test between subjects indicates a significant main effect ($F_{(1,11)}$=108.43, P=.026, N^2=.377). Pairwise comparisons determined a significant difference between "at rest" and pre-practice ($F_{(1,11)}$=6.643, P=.040) and between "at rest" and post-practice ($F_{(1,11)}$=6.643, P= .00). There was not a significant difference between pre-practice and post-practice scores ($F_{(1,11)}$=6.643, P=.128). Pairwise comparisons also indicate significant differences between weeks 1 and 2 ($F_{(1,11)}$=6.643, P=.025) and between weeks 1 and 3 ($F_{(1,11)}$=6.643, P=.016).

Psychological Variables

There were no significant differences for CESD scores by time ($F_{(1,11)}$=.022, P=.884, N^2=.002) or scores by groups ($F_{(1,11)}$=.000, P=.991, N^2=.000), however there was a significant difference between groups ($F_{(1,11)}$ =5.890, P=.034, N^2 =.349) with means increasing from pre to post. For the AD-ACL energy dimension, no significant differences in means were indicated for time ($F_{(1,11)}$ =.243 P=.632) and an interaction ($F_{(1,11)}$=4.753, P=.052) was found, whereas in the AD-ACL tension dimension, there was no significant differences for time ($F_{(1,11)}$ =.313, P=.587) nor groups ($F_{(1,11)}$=.022, P=.886). When comparing the difference in mean for the energy and tension dimensions, no significant differences were found within subjects($F_{(1,11)}$=.510, P=.490) or subjects by groups ($F_{(1,11)}$=1.120, P=.313) and no between subject differences ($F_{(1,11)}$=5.847, P=.630) were found. When examining stress, no significant differences within subjects for stress scores ($F_{(1,11)}$ =.023, P=.883, N^2=.002) or stress scores by group ($F_{(1,11)}$=.204, P=.660, N^2=.018). Additionally, for stress between subjects, significant differences were found for groups ($F_{(1,11)}$ =5.597, P=.037, N^2 =.337). When examining the difference of weekly resilience scores, there were no significant differences found for the scores ($F_{(1,11)}$=.841, P=.379, N^2=.071) or for the score and group combination ($F_{(1,11)}$=1.649, P=.225, N^2=.130). There were no differences between groups for the weekly resiliency scores. All means and standard deviations are found in Table 3.

Performance and Recovery

No significant differences were found for weekly average recovery scores ($F_{(2.300, 25.301)}$=1.290, P=.296, N^2=.105) or recovery by group ($F_{(2.300, 25.301)}$=1.968, P=.156, N^2=.152). There were no significant between subject differences for group ($F_{(1,11)}$=1.023, P=.333, N^2=.085). As for weekly performance ratings, significant differences were found by time ($F_{(1.984, 21.824)}$=4.178, P=.029, N^2=.275), but not for performance ratings by group ($F_{(1.984, 29.028)}$=1.251, P=.306, N^2=.102). No significant between subject differences were found for group ($F_{(1,11)}$=.049, P=.829, N^2=.004). There were no significant differences found for sleep scores by time ($F_{(1,11)}$=.052, P=.823, N^2=.005), or by group ($F_{(1,11)}$=.052, P=.823, N^2=.005). When examining between subject differences, a significant difference was found ($F_{(1,11)}$=15.489, P=.002, N^2=.585). All means and standard deviations are found in Table 4.

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	Control (n =7)				Intervention (n=6)				
	Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention		ANOVA
	M	SD	M	SD	M	SD	M	SD	F (1,11)
CESD	10.43	5.94	10.71	4.35	19.67	12.03	20.00	7.64	.884
AD-ACL Energy	13.14	2.79	11.14	3.67	9.00	1.55	9.83	3.76	.632
AD-ACL Tension	8.00	2.08	8.57	2.64	9.50	5.24	9.83	4.02	.587
CSSS	25.29	7.91	24.29	4.96	35.17	11.92	35.67	8.91	.883
ASSQ	6.00	2.45	6.00	1.53	10.33	2.73	10.00	2.45	.823

**Significance at .05 level

*Center of Epidemiologic Studies Depression Scale - CESD
*Activation- Deactivation Adjective Check List- AD-ACL
* College Student Stress Scale- CSSS
*Athlete Sleep Screening Questionnaire - ASSQ

Table 3. Means and standard deviations for psychological variables

	Control (n=7)								
	Week 1		Week 2		Week 3		Week 4		ANOVA
	M	SD	M	SD	M	SD	M	SD	F (3,33)
Baseline Coherence	1.18	.27	1.47	.36	1.50	.44	1.50	.24	.055
Pre-Practice Coherence	1.46	.35	1.30	.37	1.50	.32	1.51	.33	
Post-Practice Coherence	1.63	.39	1.55	.21	1.55	.27	1.73	.54	
Recovery	5.76	1.57	6.18	1.45	5.61	1.41	4.76	1.27	.296
Performance	5.32	1.16	6.26	.75	5.64	.52	4.64	.93	.029**
Brief Resilience	3.44	.19	2.61	.35	3.56	.25	3.61	.35	.397
	Intervention (n=6)								
	Week 1		Week 2		Week 3		Week 4		
	M	SD	M	SD	M	SD	M	SD	
Baseline Coherence	1.67	.61	1.77	.48	1.31	.34	1.55	.56	
Pre-Practice Coherence	3.50	1.09	3.05	1.20	2.25	.95	5.74	8.57	
Post-Practice Coherence	2.98	.80	2.02	.98	1.78	.57	1.73	.54	
Recovery	5.16	.57	5.09	1.49	4.64	.50	5.25	1.07	
Performance	5.29	.64	5.71	1.53	5.33	1.04	5.21	.58	
Brief Resilience	3.50	.50	3.39	.67	3.44	.59	3.72	.38	

**Significance at .05 level

Table 4. Means and standard deviations for coherence and performance variables

DISCUSSION

Coherence

Increased order and harmony in psychological and physiological processes are defined as coherence, also more commonly known as an optimal state of function.[18] Through validated self-regulation techniques, individuals are able to experience mental clarity and improved function.[18] The purpose of the four week intervention was to introduce self-regulation techniques to the student-athletes and each week participants would practice these techniques during their normal routines. We hypothesized coherence scores would improve for the individuals practicing the self-regulation techniques each day. Contrary to our hypothesis, there were no differences between the control or intervention groups for "at rest", pre-practice, or post-practice coherence scores, however comparisons indicated differences between scores for "at rest" and pre-practice and for "at

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rest" and post-practice. While insignificant, the control group had consistently lower scores than the intervention group. The control group stayed within the coherence categories of beginner to good, while the intervention group ranged from very good to excellent through the four weeks. The lack of change in coherence scores also contradicts previous findings demonstrating changes not only in heart rate but also brain activity (i.e., Electroencephalography), when using self-regulation breathing techniques over the span of a 5-week period.[16,27] Changes and improvements in heart rate and brain activity demonstrate an increase in coherence and shift into more optimal state of functioning.[14] No change in the scores from the pilot study could be due to novice ability in learning the self-regulation techniques. It is possible that better understanding of the self-regulation techniques or application and remembering steps would help improve individual coherence scores.

Additionally, during the intervention time fame, post-practice coherence scores were obtained at the student-athletes' location of practice where they focused on their breathing techniques. While the environments were generally quiet, it is possible participants became distracted, unfocused, or were concerned about their performance that day. Prior research examining coherence conducted their sessions in a researcher's office or in a quiet environment at home, and not part of their normal everyday routines.[18,27] The student-athletes were encouraged to learn self-regulation techniques and practice throughout their day and by doing so, supported them to create a routine of practicing the learned techniques. The setting allowed the student-athletes to realistically practice self-regulation techniques as if they would do on their own.

Psychological Impact

Student-athletes experience signs and symptoms of mental illnesses (e.g., depression, stress) comparable to those of typical collegiate students.[28,29] There is a need for interventions to help reduce signs and symptoms and help student-athletes learn techniques to safely and effectively manage their mental health. With success in emWave and HeartMath self-regulation techniques being used to reduce anxiety in nursing students and stress in collegiate students,[30,31] it was hypothesized a similar intervention would benefit student-athletes and reduce reported signs and symptoms for depression, lower perceived stress, and increase resilience. The results revealed no significant differences between the control and intervention group for depression, stress, and resiliency scores. The intervention group had a large variance for depression scores which stayed relatively consistent through the four weeks of the intervention. No change in depression scores can possibly be attributed to pre-existing signs and symptoms of depression or poor sport performance through the same timeframe.

HeartMath describes improvement in energy as a shift in emotional stability in those utilizing self-regulation techniques.[18] The adjectives peppy, energetic, lively, full of pep, and activated are used to represent momentary states of arousal activation (AD-ACL).[20] The results identified individuals in both groups increasing their energy states, however the control group had a higher energy score. With a small increase in the energy dimension, it is possible a shift in emotional stability may have occurred in the intervention participants, however there is no certainty without changes in coherence scores. When examining the other spectrum of the arousal dimensions, the tension dimension remained consistent between the groups, and while insignificant the intervention group had higher scores of tension. Activation of arousal has not been previously studied in student-athletes with use of biofeedback and self-regulation techniques, however it may warrant further examination as a momentary arousal state and possibly demonstrate a shift in emotional stability and heart rhythm pattern.

Perceived stress was examined; while there were no significant changes across the four weeks, results indicate stress levels stayed consistent for both groups. Stress levels were similar to previous research on nursing students, demonstrating stress levels remained stable through five weeks with the use of biofeedback and self-regulation techniques.[31] It is possible consistent stress with both groups can illustrate all of the participants were experiencing stress during the timeframe of the intervention. Incoherent heart rhythm patterns are associated with emotions of stress, frustration, anger, and anxiety.[18] With continuous levels of stress, coherence scores would also remain unchanged.

The ability to adapt, maintain, or regain positive psychological health is thought to be resilience.[32] Resilience allows individuals to overcome and positively adapt to stressful situations and choose effective stress management techniques.[32] Results indicated resilience scores did not improve from the intervention and instead stayed consistent. Although insignificant, the intervention group had a slight increase in resilience scores.

Performance and Recovery

Performance is complex and can easily be affected by inadequate sleep or recovery.[6,7] Previous research has examined biofeedback and HRV within student-athletes to enhance performance.[17] While previous results indicated physiological changes in HRV, self-report measures were not clinically significant.[8] The included self-report measures for recovery, performance and sleep were similar. It was anticipated self-reported recovery would improve over time with use of self-regulation techniques and shifting into a coherent state after practices. Furthermore, student-athletes rated their performance over the four-week period. Previously an improvement in performance and focus for golfers, volleyball and basketball players, and long-distance runners was noted.[15]

Sleep is a vital requirement for improvements in recovery and performance.[7] Deficits in sleep quality may be detrimental to adequate recovery and sport performance.[6,7] Sleep quality did not change when examining the two time points or when examining the group and time comparisons. When examining sleep scores, the control group started with a lower sleep score than the intervention group. However, both groups fall into the mild to moderate sleep problem category. Both groups would benefit from sleep recommendations which were not included in this intervention.[26]

LIMITATIONS AND FUTURE RESEARCH

While the current study is one of few implementing a mental health intervention for student-athletes using self-regulation techniques to help manage mental health signs and symptoms, it is not without limitations. First, the use of self-report questionnaires for psychological constructs are widely used and reliable. While self-report data has been deemed reliable, it is unknown if student-athletes answered truthfully or if they answered according to what was expected as a student-athlete.

Second, this study was regarded as a pilot study due to the limited sample size, localized to one school and two sports. Prior sample size calculations revealed we needed 28 participants, with 14 in each group. However, spring sport seasons were canceled in March 2020 when this study was conducted due to COVID-19, restricting the continuation of the study at two other universities. It is possible the findings may have been different if the

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sample size was increased and if the study was not conducted during a global pandemic that may alter one's stress. Additionally, when examining pre-intervention scores for the intervention and control group, it was determined there were outliers for the CESD scores. The pre-intervention CESD scores ranged from 3 to 39, which provided a large standard deviation for the intervention group. Lastly, the intervention occurred in the middle of both seasons for swimming and lacrosse, which is not ideal for full attention and participation from the student-athletes. Conducting this study earlier in their off season or pre-season may be a better time for student-athletes to learn self-regulation techniques they can use for their season and managing their mental health.

Due to the scarcity of literature for student-athlete mental health interventions, there are notable future directions for research. This study is among previous research has examined HRV biofeedback with student-athletes, using HeartMath techniques specifically and includes areas for improvement.[13,16] First, a larger sample including males and various sports would provide powerful comparisons for gender, sport, and help determine if the intervention is effective in reducing psychological difficulties. Replication of this study would help determine the effectiveness of a four-week intervention for mental health improvement in student-athletes.

IMPLICATIONS FOR CLINICAL PRACTICE

With the current data, it can be concluded that a HRV intervention with student-athletes needs further research to determine if it is effective for improvement in the aspects of mental health and performance. While the results did not show statistical improvement in the intervention group, previous research is encouraging for implementation in sport. The ease of the self-regulation breathing techniques and use of the Inner Balance application are promising for athletic trainers, coaches, and strength and conditioning professionals to use for mental health and wellness and performance enhancement techniques.

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