THE EFFECTS OF HEART RHYTHM VARIABILITY BIOFEEDBACK WITH EMOTIONAL REGULATION ON THE ATHLETIC PERFORMANCE OF WOMEN COLLEGIATE VOLLEYBALL PLAYERS

by

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A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

Capella University

May 2008

Abstract

The purpose of this research was to investigate the effects of heart rhythm variability (HRV) biofeedback training with emotional regulation on the athletic performance of women collegiate volleyball players. The participant's ability to self-regulate and her perception of the intervention were also examined. Individual biofeedback training using the emWave® PC (1.0) was provided to 13 student-athletes during six weekly sessions. A portable biofeedback device known as the emWave® PSR was available for independent self-regulation rehearsal. The research was a quasi-experimental, repeated-measure, mixed-methodology, within-subject design. The quantitative results supported the hypothesis that the team and its 13 participants self-regulated at will. The results did not support the hypothesis that the intervention improved performance. One possibility for this finding was the presence of a statistical and performance ceiling effect. The qualitative results revealed a positive perception of the intervention relating to the participants' roles as students, athletes, and team members. Numerous themes emerged from the interviews reflecting the benefits of the intervention. (a) Learning about biofeedback and self-regulation while visualizing the heart rhythm on the computer screen. (b) Improving self-awareness and increasing self-control. (c) Reducing the effects of physical and mental stress relating to academic and athletic rigors. (d) Experiencing enhanced physical and mental states improving academic and athletic performance.
(e) Improving team composure and camaraderie. Although further research is warranted, the results of this innovative intervention demonstrate the potential to enhance academic and athletic performance in collegiate sport.

Dedication

This research is lovingly dedicated to my family…

My husband, Jim

my daughters, Rebecca and Lianna

and my son, Jacob

Thank you for your tangible acts of love and encouragement these past five years

…for editing numerous papers,

…for celebrating the completion of another class by coloring in the pyramid square,

…for doing homework with me at the kitchen table.

To God be the glory!

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Acknowledgments

Thank you to my mentor and chair, Dr Gordon Williamson, for your continual guidance and support during my doctoral journey. Your instruction inspired me as a learner and a professor. To Dr. Donna Eckstein and Dr. David Chapman, thank you for assistance on my dissertation committee. I respect your knowledge and experience. I also admire the contributions you have made to the field of psychology and aspire to do the same.

Thank you to my family and friends for walking with me during my five years of coursework and colloquium. Your support was priceless! To my longtime friend and colleague, Dr. Susan Hebel ("Auntie Susie"), thanks for your many words and prayers of support. You were my faithful encourager! To my colleagues, Dr. Joseph Mintah and Dr. Malia Lawrence, thanks for imparting your statistical expertise. To Chris Keife, thanks for believing in the intervention and allowing me to work with your team.

Thank you to Dr. Rollin McCraty, Dr. Tani Shaffer, Jeff Goelitz and Tom Beckman at the HeartMath Institute® for your assistance through numerous phone calls and e-mails. I also appreciate access to the emWave® PSRs.

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CHAPTER 1: INTRODUCTION

Introduction to the Problem

Biofeedback is used to assist one in developing awareness of internal physiological processes that are not consciously controlled (Zaichkowsky & Fuchs, 1988). Through a variety of feedback modalities, such as heart rhythm variability (HRV), muscle contraction (EMG), and temperature, clients observe the relationship of their current psychological state and physiological response. In biofeedback training, the clinician assists the client in identifying incoherent, or unhealthy biological responses, and implements adaptive practices such as paced breathing, positive self-talk, and emotional regulation (De Witt, 1980; McCraty, Atkinson & Tomasino, 2001). The goal of biofeedback training is to develop strategies to gain voluntary control, or self-regulation of biological responses, and to transfer this ability to everyday situations without any instrumentation (Blumenstein, Bar Eli, & Tenenbaum, 1997).

Biofeedback training conducted with athletes has demonstrated a variety of results including the enhancement of self-control (Miller, 1994), the prevention and treatment of overtraining and athletic injuries, the reduction of competition anxiety (Sime, 2003), and the encouragement of perceived control (Kavussanu, Crews & Gill, 1998). As a mental skills training technique, an improvement in performance is the result of many biofeedback treatment interventions (De Witt, 1980; Galloway & Lane, 2005; Davis & Sime, 2005). When a direct relationship between biofeedback and performance is not noted, an increase in perceived control has been expressed by athletes which ultimately may impact performance (Kavussanu et al., 1998).

Background of the Study

Biofeedback modalities, session protocols, and self-regulation tools are current sources of debate with biofeedback use in sport. According to Sime (2003), there is minimal information regarding specific biofeedback protocols used with various athletic venues, thus making treatment protocols diverse and difficult to replicate. Gould and Udry (1994) noted an arbitrary number of biofeedback sessions are often implemented in sport, and the process of self-regulation is not discussed or identified with each client. Petruzzelo, Landers, and Salazar (1991) described EMG and alpha brain-wave biofeedback as the primary methods used in sport, yet their effects on performance are the least impressive. Additionally, since biofeedback is often part of a larger intervention program or a multi-modal biofeedback intervention is used, it is difficult to ascertain its true effect on performance.

Furthermore, there is debate among researchers regarding the ideal self regulation tool. Traditional biofeedback research focused primarily on the the communication between the brain, the body's organs and nervous system (Berger, Pargman, & Weinberg, 2002). Psychophysiological balance, also referred to as coherence, is achieved with such mind-body techniques as positive self-talk (Thiese & Huddleston, 1999), respiratory control, (Gevirtz & Schwartz, 2003), and relaxation training (Weinberg & Gould, 2007). However, current research reveals a direct communication between the heart to the brain. Extended periods of psychophysiological balance and the ability to transfer this skill into activites of daily living is achieved via the emotional state of the heart and its communication to the brain (McCraty et al., 2001). Emotional self-regulation is enhanced through thoughts and experiences of appreciation, care or compassion (McCraty & Tomasino, 2004).

Formally, heart rhythm variability (HRV) has been analyzed by means of time or frequency domain, referred to as spectral analysis. An updated approach to HRV is the monitoring and analysis of heart rhythm waveform. HRV dynamics are sensitive to changes in one's physiological and emotional state as positive and negative emotions are distinguished by smooth or erratic heart rhythm patterns, respectively (McCraty & Tomasino, 2004). Research with heart rhythm variability and the focus of emotional self-regulation has demonstrated promising results in the clinic, workplace and educational setting. HRV is also recommended in sport to maximize emotional stability, focus, concentration, and physical coordination (McCraty & Tomasino), but has not been officially investigated with this population.

Statement of the Problem

Previously, heart rhythm variability using emotional regulation was not implemented in sport to measure its effect on performance. Furthermore, there were three specific problems of biofeedback use in sport addressed in literature. Biofeedback protocols for specific sports did not exist (Sime, 2003) and the amount of sessions was arbitrary (Gould & Uldry, 1994). Second, the most popular biofeedback modalities used in sport, muscle contraction and alpha biofeedback, revealed the least impressive results. Third, many biofeedback studies in sport incorporated multiple biofeedback devices and self-regulation processes which made it difficult to determine the true effect of the biofeedback intervention on performance (Petruzzelo et al., 1991). Therefore, the research problem was to investigate the effects of biofeedback training with emotional regulation on collegiate volleyball athletic performance, psychophysiological coherence, and perception using a scripted protocol and a single-modal HRV biofeedback device.

Purposes of the Study

The purpose of this research was to implement, in athletics, heart rhythm biofeedback training encompassing positive emotions as a component of self-regulation training. A quasi-experimental, repeated-measures treatment outcome study was proposed to demonstrate the efficacy of heart rhythm variability biofeedback, including emotional self-regulation strategies, on the effect of volleyball performance. The biofeedback modality designated for this study was single-modal, encompassing heart rhythm variability. Heart rhythm variability biofeedback was used to analyze the waveform of the heartbeat, as the heart is sensitive to changes in physiological and emotional states, demonstrated through smooth or erratic heart rhythm patterns. Six weekly sessions, following a scripted protocol, were used for each participant to teach the process of self-regulation with the use of feedback (Appendix A). The clients were also encouraged and reminded to rehearse the self-regulation skills independently with and without the use of a portable biofeedback device known as the emWave® PSR. The ultimate goal was the ability to transfer the self-regulation skills into daily student-athlete activities without the use of instrumentation.

Research Questions and Hypotheses

A mixed-methodology approach was used to investigate the effects of heart rhythm variability biofeedback encompassing physical and emotional self-regulation strategies on the effects of volleyball athletic performance. Respectively, research questions 1 and 2 focused on athletic performance and on the process of self-regulation, and were analyzed quantitatively. Research questions 3 through 5 focused on the participants' perception of the biofeedback and were investigated qualitatively.

Research question 1: Does athletic performance improve with the incorporation of heart rhythm biofeedback training for women collegiate volleyball players over a six-week period as measured by the individual rating of four volleyball skills?

Hypothesis: Athletic performance will improve with the incorporation of heart rhythm biofeedback training for women collegiate volleyball players over a six-week period as measured by the rating of four volleyball skills.

Research question 2: Do the volleyball players' heart rhythm variability (HRV) coherence scores improve during the six-week biofeedback treatment as measured by individual accumulated coherence scores provided by the biofeedback output?

> Research question 2a: Do the participants' HRV coherence scores, gathered at the beginning of each session without the use of self-regulation, improve each week during the biofeedback treatment, reflecting autonomic nervous system homeostasis and a positive physiological shift?

Hypothesis: The HRV coherence scores gathered at the beginning of each session without the use of self-regulation will improve each week, reflecting autonomic nervous system homeostasis and a positive physiological shift.

Research question 2b: Do the participants' HRV coherence scores, gathered at the end of each session during independent self-regulation, improve each week during the biofeedback treatment, reflecting the ability to self-regulate?

Hypothesis: The HRV coherence scores gathered at the end of each session during independent self-regulation will improve each week during the biofeedback treatment, reflecting the ability to self-regulate.

Research question 3: What are the participants' perceptions and experiences in regard to the six-week biofeedback treatment?

Research question 4: What are the participants' perceptions and experiences of the six-week biofeedback treatment relating to athletic performance?

Research question 5: What are the participants' perceived benefits from using the biofeedback treatment?

Nature of the Study

A repeated-measure, mixed-methodology, within-subject design was incorporated with 14 female, collegiate, volleyball players measuring performance, psychophysiological stability via coherence scores, and perception. The quantitative analysis measured the effects of the biofeedback training on performance, the participants' ability to achieve psychophysiological stability, and their ability to self-regulate via feedback training. The qualitative analysis explored the participants' perception of the biofeedback treatment experience, including the benefits and detriments.

A mixed methodology approach is supported by Anderson, Miles, Mahoney, and Robinson (2002) who stated, “by collecting both qualitative and quantitative data, the evaluation can provide a holistic picture of the intervention that can be used to document effectiveness and provide rich information that can be used to facilitate intervention improvement” (p. 439). Former biofeedback interventions focused primarily on respiration control as the predominant self-regulation tool, whereas this study included emotional regulation as a means to achieve psychophysiological balance and potentially enhance athletic performance. According to Casebeer and Verhoef (1997), qualitative studies can be initially implemented to explore unchartered territory which then provides data for instruments to be developed in subsequent quantitative work. Furthermore, qualitative techniques interpret and explain quantitative data and enables more information and experiences to be gathered and evaluated.

Significance of the Study

This study extends the existing knowledge of biofeedback use in sport by investigating the inclusion of positive emotions as a component of self-regulation training which previously had not been researched in athletics. It included a six-session scripted protocol using heart rhythm biofeedback training (Appendix A). Furthermore, a portable biofeedback device, known as the emWave PSR was administered to each participant for independent self-regulation practice between sessions.

The intended audience for this study includes sport psychology practitioners, coaches and sports medicine personnel. The results of this study will provide these sport personnel with the tools to potentially enhance athletic performance for their athletes. The biofeedback software and equipment is relatively inexpensive and designed for the layperson, thus making it feasible for this audience to implement. It also encourages subsequent research to be conducted with other athletic teams to identify its effect on components relating to performance.

Definitions of Terms

Performance

Four skills were individually rated and defined the performance measure. Closed skills in athletics refer to movements that occur in predictable or unchanging situations, whereas open skills are skills conducted during uncertain or changing situations (Collet, Roure, Delhomme, Dittmar, Rada, & Vernet-Maury, 1999). In volleyball, the closed skill is serving, whereas the open skills included in this measure were passing off the serve (serve-receive), digging (defensive skill), and hitting. A 5-point Likert-scale was implemented during each game by the assistant coaches to evaluate each player's performance according to the skills she performed (Appendix B). Raw and mean scores were analyzed for each skill performed in the game. The data was compiled as a team and analyzed individually.

Physiological Coherence Score

The coherence score originated from the photophlethysmograph, a fingertip or earpiece heartbeat sensor, which graphed the participant's heart rhythm onto the computer screen. The heart rhythm biofeedback provided a low, medium, and high coherence score reflecting the participant's ability to self-regulate and balance the autonomic nervous system (ANS). One can assume that higher coherence scores reflect greater self-regulation ability and balance of the ANS (Culbert, Martin & McCraty, 2004). The coherence score gathered at the beginning of each session was considered the baseline score that reflected physiological changes or shifts in ANS homeostasis. The independent coherence scores reflected the participant's ability to master self-regulation during the treatment session.

Perception

As the client learns how to self-regulate and gain control over biological responses, perceived control may develop (Kavussanu et al., 1998). “Our perceptions of what we can control in our lives, and in ourselves broadly influence the way we think, feel and act” (London & Schwartz, 1984, p. 266). Perception, in this proposed research, was considered the participants' understanding of the biofeedback treatment as it related to her experiences with the process of self-regulation and its athletic and non-athletic benefits. Perception was investigated using three open-ended interview questions during the sixth and final biofeedback treatment session.

Assumptions and Limitations

It was assumed that the volleyball participants would attend six, thirty-minute heart rhythm biofeedback sessions to learn and rehearse self-regulation with this researcher. Furthermore, each participant was requested to independently rehearse the self-regulation steps throughout the week, with and without a portable biofeedback device known as the emWave PSR. Although these assumptions could be considered potential limitations, the following precautions were utilized. First, an appointment card was provided for each session and the participant was contacted the day before her session as a reminder. Second, a one-page journal was dispensed to each participant during the weekly biofeedback sessions (Appendix C). The purpose of the journal was to remind the participant to practice the self-regulation technique, to record the practices, and to become sensitive to her feelings before and after she practiced. The journals were collected and reviewed during each weekly biofeedback session, but the data was not used in this study.

A limitation of the study was the difficulty to demonstrate a direct relationship between biofeedback and athletic performance (Petruzzelo et al., 1991). However, most research conducted with volleyball athletes evaluated only the closed skill of serving as the performance measure (Lidor & Mayan, 2005; Kitsantas, Mason, & Zimmerman, 2002). This research proposed to evaluate three other open skills using a 5-point Likert-scale. Therefore, each player was evaluated according to her position and the skills she performed during each game. This approach increased the potential of identifying a relationship between the biofeedback intervention and performance. Furthermore, since perception is an important component of biofeedback training (Kavussanu et al, 1998), the treatment benefits in athletic and non-athletic areas were explored.

Organization of the Remainder of the Study

Chapter 2 discusses the relevant literature associated with biofeedback use in sport including self-regulation theories and strategies. Chapter 3 describes the research methodology suggested for this study, its design, sample population, specific procedures and protocol, and data analyses. Chapter 4 presents and examines the quantitative and qualitative data, and chapter 5 concludes with a discussion of the data, its application, and recommendations for future research.

CHAPTER 2: LITERATURE REVIEW

Psychophysiology and Biofeedback

Psychophysiology is defined as the "inference of psychological processes, emotional states, and performance outcomes from examining physiological measures" (Anshel, 2003, p. 14). Psychophysiological processes are measured with various biofeedback modalities. Muscle contraction and relaxation is measured by electromyography (EMG). Temperature change is assessed via fingertip thermometers. Skin resistance influenced by sweat is evaluated by electrodermal assessments (EDR). Cardiovascular activity is measured via heart rate, heart rhythm, and blood pressure. Respiration is analyzed by the depth and rate of breathing, and brain wave activity is measured by electroencephalography (EEG) (Arena & Schwartz, 2003).

According to Sime (2003), the most common biofeedback modalities used in sport are heart rate variability, respiration, temperature, EMG, EDR, and EEG. These biofeedback modalities reveal the subtle and dramatic changes in the autonomic nervous system (ANS). The ANS, comprised of the sympathetic and parasympathetic branches, controls the cardiovascular, digestive and respiratory functions. Salivation, perspiration, pupil regulation, urination, and erection are also controlled by the ANS. In general, the sympathetic branches of the ANS are responsible for fight or flight actions, whereas the parasympathetic nervous system focuses on actions of rest and digestion. The two branches are functionally antagonistic to each other and account for a balanced, homeostatic ANS (Schwartz & Olson, 2003).

In biofeedback training, the clinician assists the athlete in developing strategies to gain voluntary control over biological responses that are not normally, consciously controlled. This is referred to as self-regulation (Blumenstein et al., 1997). During this self-regulation process, the athlete learns to regulate various physiological states with instrumentation and then proceeds without the use of feedback devices. Eventually, the athlete transfers the knowledge acquired through biofeedback training into other arenas of life (Blumenstein et al.; Weinberg & Gould, 2007). Ultimately, the client is trained to perceive unhealthy biological responses during daily activities and is able to substitute healthier responses in such events (DeWitt, 1980).

Although athletes engaged in psychophysiological training through biofeedback report diverse psychological and emotional experiences, an ideal athletic performance state is the culmination of all descriptions. Contributors to ideal performance states include the following: an absence of fear, freedom of movement and thought without overanalyzing performance, focus on the activity and not on outside interruptions, control over voluntary and involuntary movement, and a perception that time slows down (Hatfield & Hillman, 2001). Additional personal measures include a reduction in cognitive anxiety, an increase in self-confidence (Ryska, 1998) and perceived control (Petruzzelo et al., 1991), and the enhancement of self-control (Miller, 1994).

Theories and Models

Hanin's Zone of Optimal Functioning (ZOF) depicts the interaction of emotional states and optimal performance. This theory considers differences in arousal levels and emotions and their influence on ideal performance states. Some athletes thrive on higher levels of arousal for optimal performance, whereas others find this state to be counter-productive to performance (Zaichkowsky & Baltzell, 2001). Addressing the influence of emotions that pertain to athletes will assist them in identifying their zone of optimal performance. This occurs during biofeedback as the individuals visualize their psychophysiological response to emotions and implement self-regulation strategies to control the effects of dysfunctional emotions (Sime, 2003).

Self-regulation describes the progression as one negotiates from current states towards a future goal or intention. It is a “complex, time-dependent, multilevel process that may be approached from different theoretic vantage points” (Crews, Lochbaum, & Karoly, 2001, p. 568).

There are two mechanisms of self-regulation appropriate to biofeedback. First, awareness-based and metacognitive factors involve the use of a self-monitoring system, self-observation, and a task (Crews et al., 2001). The athlete is the participant who monitors psychophysiological changes via the biofeedback device. The task, or outcome measure, is relevant to a predetermined cognitive-affective response, such as anxiety reduction or automatic movement. The potential advantage of self-regulation-regulation is performance enhancement.

Motivation and emotional competencies and dispositions are the second mechanism of self-regulation (Crews et al., 2001). This mechanism posits the inclusion of intrinsic and extrinsic motives for successful self-regulation. It also involves the important aspect of emotional recognition and regulation. Traditional biofeedback research focused primarily on the communication between the brain and the heart. However, current research reveals a direct communication between the heart to the brain via the emotions (McCraty et al., 2001). Although research demonstrates the ability to achieve psychophysiological balance between the heart and mind via respiratory control, extended periods of heart-brain coherence is achieved via the emotional state of the heart (McCraty et al.). Emotional self-regulation is enhanced through thoughts and feelings of appreciation, care or compassion to sustain psychophysiological balance (McCraty & Tomasino, 2004). This balance promotes healthy perceptions and beliefs, and physical well-being (Salovey, Rothman, Detweiler & Steward, 20001).

Blumenstein et al. (1997) developed a five-step model to psychological training with biofeedback. First, the psychophysiological equipment and protocol is introduced to the athlete. Initial sessions include guided instruction in self-regulation as the athlete learns how to consciously control psychophysiological responses. Independent self-regulation exercises are also included between biofeedback sessions. The second step involves identification of the athlete's most sensitive biofeedback response related to muscle tension, skin response, EEG, heart rate, and breathing frequency. Imagery is practiced with “soft eyes” (p. 444) where the eyes are partially opened so the athlete can visualize the feedback on the biofeedback screen. Auditory feedback can also be provided in biofeedback training sessions. Simulation training is the third step as the athlete mentally practices in a natural environment while video scenes from competitive situations are offered. Step four involves the transformation of practice into actual training settings. Portable biofeedback devices can be helpful for the athlete to regulate arousal states in competitive environments. Realization, the final step, is the transfer of guided learning and independent rehearsal into competition. Blumenstein et al. stated: “the ultimate goal of mental preparation in sport is to teach the athlete to independently monitor his or her arousal state as required” (p. 449). The authors emphasized the modification of these five steps as needed, depending upon the sport and population.

Biofeedback and Sport

A review of literature revealed the utilization of biofeedback in the following athletic venues: football (DeWitt, 1980), rifle shooting (Daniels & Landers, 1981), handball (Costa, Bonaccorsi, & Scrimali, 1984), archery (Landers, Han, Salazar, Petruzello, Kubitz, & Gannon, 1992), running (Blumenstein, Bar-Eli, & Tenebaum, 1995), basketball (De Witt; Kavaussanu et al., 1998), baseball (Davis & Sime, 2005), and tennis (Galloway & Lane, 2005).

Galloway and Lane (2005) implemented Blumenstein et al.'s (1997) five-step biofeedback protocol with five tennis players. A multi-modal approach was implemented through EMG, EEG, and GSR measuring successful serves. Results following the 15-session study demonstrated improvement in serves for all participants with post-intervention effects demonstrating the same or improved success in serves.

In another biofeedback study, 18 handball athletes completed the Minnesota Multiphasic Personality Inventory (MMPI) and State-Trait Anxiety Inventory (STAI). Out of the 18 athletes, 10 participants with normal anxiety profiles were chosen to participate. Five participants were assigned to either a treatment or control group. Seven sessions of biofeedback using a handheld audio stress reducer and a home-use device were implemented with the treatment group. The STAI was readministered at the completion of the study. The compiled treatment scores demonstrated lower anxiety in the treatment group compared to the control. Performance measures were not included (Costa et al., 1984). According to Davis and Sime (2005), biofeedback training is advantageous in reducing anxiety in athletes. However, increasing self-confidence should be the primary focus of biofeedback training as this ultimately enhances performance.

Davis and Sime (2005) incorporated a multi-modal approach with an injured baseball athlete to improve his confidence, and to reduce anxiety and batting errors. Diaphragmatic breathing, cognitive exercises, imagery, and EEG biofeedback were implemented. The athlete watched a video display of a pitcher delivering a ball to the plate. The athlete was instructed to swing and hit the imaginary baseball while focusing on the feel of the bat. EEG biofeedback was gathered to measure the athlete's level of concentration and alertness during the exercise. Throughout the baseball season, the injured athlete reported increased confidence and his hitting and fielding percentages also improved. Upon the completion of the year, his biofeedback training sessions were terminated. His statistics the following year returned to below pretreatment levels.

Heart rate feedback is popular in sports such as archery and rifle shooting, which require intense focus and accuracy. Performance improvements relate to the timing of the skill with the heartbeat and reducing the heart rate. In a study with eight Olympic and collegiate rifle shooters, half of the group received constant cardiac auditory feedback through earphones while shooting and the other half received only presession instructions. Those in the biofeedback group learned to fire in between their heart beats, and improved 51% compared to the control group's increase of only 2% (Daniels & Landers, 1981). Landers et al. (1992) conducted another study with archers. Heart rate variability training was implemented for 12 weeks resulting in a 62% improvement in shooting accuracy. In addition, the participant's heart rates decelerated substantially just prior to shooting (91.5 to 85.1 beats/min).

DeWitt (1980) conducted two studies involving six university football players and twelve basketball players. In the first study with football players, EMG biofeedback was implemented for 12, one-hour sessions to identify muscle bracing, implement relaxation training with myographic feedback, and incorporate cognitive training. Results demonstrated a decrease in muscle tension according to EMG readings, and an increase in game performance according to coaches' ratings. In the second study with basketball players, 11, one-hour sessions were incorporated similar to those in the first study. Again, muscle tension reduced according to EMG readings, and game performances improved according to the managers' ratings.

Kavussanu et al. (1998) designed a study with 36 basketball players to determine if single versus multi-modal biofeedback measures were superior in measuring free throw percentages, perceived control and self-efficacy. 12 participants were assigned either to a single biofeedback group using EMG, to a multimodal group using EEG, EMG, and HR biofeedback, or to a control group. Results did not support a single or multi-modal biofeedback approach, nor did biofeedback enhance perceived control or self-efficacy. Furthermore, all groups improved in free throw percentages over a period, thus the relationship between biofeedback intervention and performance was not supported.

Blumenstein et al. (1995) also utilized a multi-modal approach and assigned 39 college students to one of five treatment groups. The athletic measure was the 100-meter run. Physiological measures were gathered with EMG, heart rate, and GSR. Results demonstrated that biofeedback, imagery, and music improved 100 meter run scores and physiological measures. However, one must practice discernment in the interpretation of these results. The incorporation of a multi-modal approach in these studies exemplifies the concern that the true effect of biofeedback on athletic performance cannot be purely identified (Petruzzelo et al., 1991), and the results should be interpreted with caution.

Issues and Debate

In 1985, Sandweiss and Wolf suggested that athletes have great potential to benefit from biofeedback training. However almost 20 years later, Leonards (2003) observed that research in sport psychophysiology is still very limited. Additionally, specific biofeedback protocols used with different sports are deficient (Sime, 2003), and many studies use an arbitrary amount of biofeedback sessions rather than a criterion score to verify the achievement of self-regulation (Gould & Udry, 1994). According to Blumenstein et al. (1997), it is difficult to design and develop specific protocols since the responses to biofeedback training are related to personality and situational variables. Petruzzelo et al. (1991) include that EMG and alpha biofeedback are the primary methods used in sport, yet their effects on performance are the least impressive. Furthermore, since biofeedback is often part of a larger or a multi-modal biofeedback intervention, it is difficult to measure its true effect on performance.

There is debate regarding pychophysiological techniques and performance enhancement because it is difficult to ascertain their true relationship. Do psychophysiological techniques truly result in improved athletic performance, or are the cognitive-affective responses merely a byproduct of the intervention program? Kavussanu et al. (1998) posit that the process of one gaining control over autonomic responses results in an increased perception, rather than a true physiological response, which may enhance performance. Furthermore, one must not assume that a self-regulatory process has occurred based on the completion of a predetermined goal. Crews et al. (2001) also emphasized that failure to reach a predetermined goal is not a failure. “Outcome and process are preserved as separate and distinct” (p. 566).

EmWave PC and the Quick Coherence Technique

The HeartMath Institute developed a heart rhythm variability (HRV) biofeedback system known as the emWave PC (Institute of HeartMath, 2008). Formerly, HRV was analyzed by means of time or frequency domain referred to as spectral analysis. An updated approached to HRV monitoring and feedback is through the analysis of HRV waveform. HRV dynamics are sensitive to changes in one's physiological and emotional state as positive and negative emotions are distinguished by smooth or erratic heart rhythm patterns, respectively (McCraty & Tomasino, 2004). Constant heart beat variations with rhythmical patterns are desirable because they demonstrate a healthy heart and balanced autonomic nervous system (ANS) (Gevirtz & Lehrer, 2003). Therefore, the goal of biofeedback training with the emWave PC is to instruct the client to recognize faulty and healthy heart rhythm patterns on the screen. Through a self-regulation process referred to as the Quick Coherence Technique® (QCT), the individual learns to initiate a smooth heart rhythm with variability, ultimately creating psychophysiological coherence and a balanced ANS (Culbert et al., 2004).

Coherence

The achievement of psychophysiological coherence is the goal of heart rhythm variability training. Coherence is the term to measure the communication efficiency between the heart and mind. It also refers to the interactions between physiological, emotional, and cognitive functions (McCraty, Atkinson, Tomasino, & Bradley, 2006). Coherence, also referred to as entrainment, is the result of two different oscillators, such as the heart and the brain, aligning their movement or frequency with each other (Mahi, 1998). High coherence is displayed on the computer screen as consistent and smooth heart rhythm patterns with variability, whereas low coherence is displayed as erratic heart rhythms. In sport, high coherence relates to the experience of flow or playing in the zone as automatic movement initiates efficient performance (Cooper, 1998).

Quick Coherence Technique

Although research demonstrates the ability to achieve coherence or entrainment between the heart and mind via respiratory control, extended periods of heart-brain coherence is achieved via the emotional state of the heart (McCraty et al., 2001). The HeartMath Institute developed the Quick Coherence Technique (QCT) which consists of the following three steps. First, the individual focuses attention around the area of the heart. Second, the individual visualizes breathing through the heart while consciously inhaling and exhaling at a slow and gentle rate of five to six seconds. Third, the individual continues to slowly breathe through the heart, and consciously experiences a positive feeling of appreciation, care, or compassion to initiate and sustain psychophysiological coherence (Culbert et al., 2004). The results of psychophysiological coherence include synchronization between the sympathetic and parasympathetic nervous systems, a shift in ANS balance towards increased parasympathetic activity, and increased heart-brain synchronization as heart rhythms align with the brain's alpha rhythms (McCraty & Tomasino, 2004).

Emotional Regulation

According to Friedrickson (2001), “an emotion begins with an individual's assessment of the personal meaning of some antecedent event” (p. 218). Emotional memory, relating to positive and negative life events, responses and attitudes, is stored in the amygdala portion of the brain. The amygdala compares incoming sensory information with previously stored emotional memory and decides how to respond based on that comparison. However, it often makes inappropriate responses about current stimuli based on past experiences (Johnson, 2003). The result is altered perceptions and inappropriate emotional reactions and thought processes (McCraty & Childre, 2003). The amygdala also receives information from the heart. Even if the heart rhythm patterns are chronically disordered and incoherent, the amygdala identifies them as familiar. Thus, the individual will feel comfortable with internal incoherence, which may eventually affect learning, creativity, and emotional balance. However, the QCT engages the emotions in an attempt to restructure and restore healthy emotional memory patterns and coherent heart rhythms (McCraty & Childre). Ultimately, positive emotions improve psychological resiliency (Friedrickson), performance, and overall well being (McCraty et al., 2006).

Flow States

Flow is often used to describe conditions leading to optimal performance in athletics (Sime, 2003). The concept or experience of flow is explained with various terminology and phrasing including the following: deep concentration, highly efficient performance, emotional buoyancy, a heightened sense of mastery, a lack of self-consciousness, and self-transcendence (Cooper, 1998). It is also referred to as being in the zone (Cooper), experiencing peak moments (Berger et al., 2002), and being unaware of the passage of time (Csikszentmihalyi, 1990). According to McCraty and Childre (2003), flow states rely on the integration of the heart and the mind. Experiencing positive emotions, such as feelings of love, gratitude and appreciation correlate with the experience of flow. Positive emotions necessary for optimal physiological functioning and flow states are monitored through heart rhythm variability.

Research Conducted with the emWave PC in Sport

The emWave PC is recommended in sport as the athlete learns to achieve coherence which maximizes emotional stability, focus, concentration, and physical coordination. The result is enhanced performance, and the ability to play in sync or in the zone (McCraty & Tomasino, 2004*)*. The implementation of the emWave PC and handheld device known as the emWave PSR is receiving predominant research and discussion in the sport of golf. The European Ryder Cup captain, Ian Woosnam, reported the HeartMath biofeedback system improved his sleep, reduced competitive anxiety, and improved personal performance (Professional Golf Association, 2006).

These benefits have the potential to transfer into other athletic venues as well. The biofeedback training prepares the athlete for activities that require concentration and motor coordination. In addition, it assists in controlling competitive anxiety, both before and during activity, which is necessary for stress management and quality performance (Rozman & Rosch, 2004). It trains the athlete to transform feelings of stress and worry into productive energy. The instant feedback is beneficial to stabilize emotions and balance the autonomic nervous system (ANS), which ultimately promotes peak performance. Furthermore, confidence is enhanced as the athlete learns to create a calm, yet dynamic internal state at will (McCraty et al., 2006).

CHAPTER 3: METHODS

Restatement of the Purpose

The purpose of this study was to implement a six-week heart rhythm biofeedback training protocol encompassing positive emotions as a self-regulation technique with 14 female collegiate volleyball players. The effects of this treatment intervention were investigated on volleyball performance, psychophysiological stability via coherence scores, and perception.

Research Design

A quasi-experimental, repeated-measure, within-subject research design was incorporated using a mixed-methodology approach. Each consenting participant met with this researcher/clinician once a week for approximately 30 minutes of heart rhythm biofeedback training, using positive emotional focusing as a component of self-regulation. The participants were also encouraged and reminded to independently rehearse the self-regulation techniques throughout the week using a portable biofeedback device known as the emWave PSR. The goal of the intervention was to assist the participant in using the self-regulation techniques at will without the use of biofeedback instrumentation during daily student-athlete activities. This treatment intervention aligns with Blumenstein et al.'s (1997) five-step approach to psychological training with biofeedback. Research questions 1 and 2, relating to performance and psychophysiological stability, were investigated quantitatively using one sample and paired sample *t* tests and a repeated-measure *ANOVA*. Research questions 3 through

5 concentrated on the participants' perception of the biofeedback treatment and were explored qualitatively using three open-ended interview questions during the sixth and final biofeedback session.

Target Population

Research with heart rhythm variability and the emphasis of emotional focus as a component of self-regulation has not been investigated officially in sport. However, golfers are the first group of athletes who have expressed benefits from using this psychophysiological treatment method (Diaz, 2007), but their reports are a by-product of media interviews and not rigorous research.

The target population of participants was recruited from a Christian university located in southern California. The athletic program, governed by the NAIA, is renown for its athletic excellence, as it has received the prestigious Sears Cup Athletic Award for overall success in men and women's athletics the past three years. The women's volleyball team was recruited with 14 players participating in the study. The age group of the participants ranged from 18-23, representing freshman, sophomore, junior, and senior student-athletes. Although the research questions were addressed using this population, findings cannot be generalized to other athletic teams as the process of self-regulation and the ability to transfer the skills into activities of daily living is unique among individuals (Blumenstein et al., 1997).

Selection of Participants

The head coach of the women's volleyball team consented for his volleyball players to participate in this research. All of the volleyball players were requested, but not coerced, to participate in this study during the second half of their competitive 2007 season. It was emphasized that athletic participation was not jeopardized if they refused to participate or withdrew during the study. Furthermore, all volleyball participants were included regardless of prior biofeedback treatments or psychological skills training.

Exclusion criteria were presented to the volleyball players before they volunteered as participants. The researcher/clinician explained that the participant would be ineligible for the biofeedback intervention/study if any of the criteria applied. However, they were not requested to identify the excluding condition. The following criterion have been established by HeartMath Institute, the originator of the biofeedback treatment protocol with number five being included by this researcher as a potential confounder to the study:

1. I have an acute, severe, or unstable medical illness.
2. I have significant psychiatric disorders such a schizophrenia, mania, major depression, paranoia, severe obsessive-compulsive disorder, or posttraumatic stress disorder.
3. I have a seizure disorder.
4. I have heart irregularities such as atrial fibrillation, flutter, or premature atrial contractions.
5. I am currently receiving treatment from a clinical psychologist for volleyball performance issues.

The amount of participants is potentially small for this study (n=14) and while it would be intriguing to recruit other athletic teams, it would not be possible for one biofeedback clinician/researcher to meet with numerous participants each week for six sessions. Since this heart rhythm biofeedback intervention was not previously addressed in sport, it is realistic to initiate the study using this population. Furthermore, there were ample data points for the researcher to implement a paired sample *t* test, to compare the effects of the treatment intervention from the first half of conference play to the second half.

Variables

The investigated constructs in this research included volleyball performance, psychophysiological regulation, and perception. The independent variable was the heart rhythm biofeedback intervention that was implemented for all consenting participants over a six week period. The biofeedback intervention was defined as HeartMath's heart rhythm variability biofeedback with the incorporation of positive emotional focus as a component of self-regulation. HeartMath's guidelines and protocol as developed by Culbert et al. (2004) were included in this study.

The dependent variables were performance, psychophysiological coherence, and perception. Volleyball performance was defined as the individual rating of four volleyball skills performed in each game by each player. These skills included the following: serving, hitting (spiking), passing, and digging. Passing is considered a serve-receive skill as the player attempts to pass the ball to the setter from the opponent's serve. Digging is the attempt to pass the ball to the setter after the opponent hits (spikes). The evaluation reflects the position and ability of the player, the amount of playing time, and the frequency in which the player handles the ball. Raw and mean scores were utilized for each skill the player conducted during each game using a 5-point Likert-scale. Team and individual analysis were conducted by comparing eight conference games before the intervention (pretest), to the same eight conference games during and after the intervention (posttest). This provided a cause and effect relationship between the biofeedback treatment and volleyball performance.

Psychophysiological changes were determined by low, medium, and high coherence scores provided by the heart rhythm biofeedback software as the fingertip or earpiece photophlethysmograph charted the participant's heart rhythm. Higher coherence scores reflected psychophysiological control and balance, which is the goal of self-regulation training. The coherence scores constantly changed and were one of the three visual feedback components available to the participant. The other two visuals were the client's heart rhythm waveform and an accumulated coherence score graph. Coherence scores were saved at two specific times during each biofeedback treatment session. The first five-minute data gathering occurred at the initiation of each session. This data provided a baseline psychophysiological coherence score, reflecting shifts in autonomic nervous system balance without the use of self-regulation. A second five-minute data gathering occurred at the completion of the session while the participant was practicing self-regulation with feedback. This data provided an independent rehearsal coherence score demonstrating the ability to self-regulate. The process of self-regulation was reflected in higher coherence scores throughout the biofeedback treatment intervention at both the baseline and independent rehearsal data points.

Perception was considered the participant's personal understanding of the biofeedback treatment as it related to her experiences with the intervention including the guided and independent self-regulation rehearsal. It also included the benefits, detriments, or impartiality of the intervention relating to athletic and non-athletic areas. Perception was explored qualitatively and revealed the subtle and dramatic perspective the participants had concerning the biofeedback treatment.

Measures

For the performance measure, a rubric was used to evaluate four volleyball skills using a 5-point Likert-scale (Appendix B). The evaluation ranged from 1 to 5, which characterized an error to a perfectly performed skill, respectively. This evaluation was implemented by the assistant coaches during 12 preseason games, and statistics were administered on this data to ascertain reliability since this measure was not previously used in research. Using SPSS software (14.0), Chronback's alpha reliability and validity statistics were executed. The psychometric results are included in chapter four. This performance rubric is superior to the performance measures typically used in volleyball research. Four proficiencies, including open and closed skills, reflected performance in this study, whereas in literature the closed skill of serving is often the only skill representing overall volleyball performance (Gebbet, Boris, Anderson, Cotton, Savoic & Nicholson, 2006; Kitanas et al, 2002; Lidor & Mayan, 2005).

For the coherence variable, no inventory or measure was used as the data was provided by the biofeedback unit. The emWave PC (1.0), developed by the Institute of HeartMath was the heart rhythm variability biofeedback software used in this study. A repeated-measure *ANOVA* was implemented to explain changes in coherence from each session and to compare the data across the six sessions for each individual.

For the perception variable, codes were developed and assigned to the interview data to categorize the responses for each participant. Codes from the initial participant data were grouped into themes as relationships were noted. This is referred to as pattern coding (Breakwell, Hammon & Fife-Schaw, 2000). Individual case studies were implemented to investigate relationships between the quantitative and qualitative data (Vernacchia, 1998).

Procedures

This researcher/clinician was invited by the volleyball coach to present the study to his women's volleyball team. First, an explanation of the biofeedback study using heart rhythm variability and emotional self-regulation were discussed via a power point presentation. Second, the biofeedback device was demonstrated on the coach so the players could visualize his heart rhythm on the PC screen. Subsequently, the coach was excused from the room. Third, a list of the exclusion criterion previously mentioned and a three-page consent form were administered to all 14 volleyball players. The researcher proceeded to read both forms with the potential participants. At the completion, the participants were given the opportunity to ask any questions. After all questions and concerns were addressed, the players met individually with the researcher to avoid any peer pressure. If the player desired to participate, she was requested to sign the consent form and a copy of the form was available to her at her first biofeedback session. If any of the exclusion criteria applied to her, the participant simply stated that she was not able to participate without having to identify the reason. If she chose not to participate, the cause for her decision was not inquired.

Once the participants were identified and the consent forms signed, an appointment was made with each individual for her first biofeedback session. Ideally, weekly biofeedback sessions would be administered over the duration of six weeks. However, considering the busy schedules of student-athletes, the protocol allowed for six biofeedback sessions within a seven-week period. The scripted protocol is provided in Appendix A, however an abridged version is presented in this section. This protocol follows the guidelines established by the Institute of HeartMath and was custom designed for the student-athlete using the guidelines suggested by Culbert et al. (2004) and Blumenstein et al. (1997).

Session One

Using an identical script, the researcher taught each participant about biofeedback, heart rhythm variability, and their influence on the autonomic nervous system. The researcher explained how the fingertip or earpiece sensor (photophlethysmograph) detects the heartbeat and displays it on the computer screen, just as it did for the coach during the initial presentation. The photophlethysmograph was attached to the participant, and the biofeedback software was launched using the researcher's Toshiba Pentium PC (2002) and Microsoft Windows XP system. Five minutes of baseline data was collected to identify the participant's psychophysiological state. The client was requested to refrain from moving or talking during this time. There are four levels of difficulty designed for this biofeedback software, and a level two difficulty was used throughout the duration of this study. The data was collected and saved on the computers hard drive according to the random code assigned to the participant (Participant (P) #, S1: BD). After this data collection, psychophysiological coherence was explained and the baseline data reviewed with the volleyball player. A three-step Quick Coherence Technique (QCT) developed by the HeartMath Institute was described which includes “heart focus,” “heart breathing,” and “heart feeling.” The participant was encouraged to practice the QCT with her heart rhythm projected on the computer screen as feedback. Five minutes of independent rehearsal data was gathered and saved using the participants assigned code (P#, S1: IR). This was the second data set for session one.

This first session was completed by reviewing the data from the independent rehearsal, and identifying changes in psychophysiological balance. A practice diary and tracking system was provided which also explained the QCT (Appendix C). The participant was requested to write in the journal each day to record her feelings before and after she independently rehearsed the QCT. She was asked to return the completed journal at her second biofeedback session. Finally, a handheld biofeedback device known as the emWave PSR was provided to the participant. Instructions for its use and a demonstration ensued. At the completion of this first session, the second biofeedback session was scheduled at the participant's convenience. This first session lasted 40 minutes with subsequent sessions requiring 30 minutes.

Session Two

The researcher began by collecting and reviewing the self-regulation diary for the week. The researcher also answered the participant's questions. The biofeedback unit was attached to the participant using the fingertip photophlethysmograph, and the software was launched. While the participant was sitting quietly, five minutes of baseline data was collected and labeled (P#, S2: BD). Following this data collection, the data sets from week one were reviewed as well as the previous week's script about biofeedback, heart rate variability, psychophysiological coherence and the Quick Coherence Technique (QCT). The participant was encouraged to practice the self-regulation technique using the feedback by breathing with her heart rhythm. After two minutes, she was encouraged to practice self-regulation using the feedback including the engagement of emotion. It was emphasized that engaging positive emotions sustains healthy coherence better than focusing on breathing alone. Five minutes of independent practice followed, and the data was saved (P#, S2:IP). The participant was taught the “link up” signal that consisted of interlocking the thumb and index fingers into two conjoined rings. She was encouraged to use this sign during practices and games to prompt all members to initiate the QCT to promote team coherence. The session ended when the researcher provided a new practice diary for the upcoming week, discussed practice strategies, and verified the next session's date and time.

Session Three

The researcher began by collecting and reviewing the self-regulation diary for the week. The participant's questions were addressed. Five minutes of baseline data was gathered and saved (P#, S3: BD). The data from sessions one and two was reviewed with the participant, and progress or regression was noted. The participant was asked to explain the QCT to the researcher to demonstrate understanding. Five minutes of independent practice was provided, and the data was saved (P#, S3:IP). A three-minute visual biofeedback exercise known as the “garden game” was initiated. The participant was informed that as coherence increased, the screen would change from black and white to color. The QCT was reviewed and the participant was encouraged to use this self-regulation technique. In addition, background noise replicating the sounds of a volleyball game was played as a means for the participant to learn how to self-regulate during games. The background noise volume was consistent throughout the study. The researcher ended the session by reviewing the data from the past week demonstrating progress or areas of challenge. The participant was also reminded to use the “link-up” signal during practices and games to encourage all members to simultaneously self-regulate and to promote team coherence. A new practice journal for the upcoming week was provided and an appointment for the fourth session was made.

Session Four

The researcher collected the journal and the participant's questions were answered. Five minutes of baseline data was collected and recorded (P#, S4: BD). The participant was asked if she was using the QCT spontaneously throughout the day. The data from session one through three was reviewed with the participant with progress or challenges noted. Five minutes of independent practice ensued and the data was saved (P#, S4: IP). A five-minute biofeedback game known as the “rainbow game” was introduced this session. As the participant's coherence score increased, the feedback displayed coins being placed in a pot of gold; as the coherence score decreased, the money vanished from the pot. The background noise from a volleyball game was played during this time of self-regulation practice. The participant was reminded to use the “link-up” signal during practices and games to encourage all members to self-regulate using the

QCT and to promote team coherence. The researcher provided a new practice journal and emphasized the importance of self-regulation practice in all aspects of life. The fifth session's date and time were verified.

Session Five

The researcher collected and reviewed the practice diary. Five minutes of baseline data was collected and saved (P#, S5: BD). The data from sessions one through four was analyzed with the player to demonstrate and discuss progress. Five minutes of independent self-regulation practice with feedback followed and was saved (P#, S4: IP). A ten-minute biofeedback game referred to as the “balloon game” was initiated as the sounds of the volleyball game were played. As the coherence score increased or decreased, the hot air balloon soared higher or lower, respectively. The researcher reminded the participant that next week's session would include a three-question, audiotaped interview. The researcher also reminded the participant to use the “link-up” signal during practices and games to promote team coherence via the QCT. The participant was provided a new practice diary for the upcoming week and was encouraged to practice self-regulation in all aspects of life. The final session's date and time was verified.

Session Six

The researcher collected and reviewed the practice diary. Five minutes of baseline data was collected and saved (P#, S6: BD). Data from sessions one through five was reviewed to demonstrate and discuss progress. Self-regulation maintenance and future practice of the QCT was emphasized to prolong the benefits of the biofeedback training. Five minutes of independent practice was initiated and the data was stored (P#, S6: IP).

The session and study was concluded with a three-question interview conducted by the researcher. The questions were provided for the participant to read and the interview was audio recorded. At the completion of the interview, the researcher thanked the participant for her time and effort. The participant kept the emWave PSR device as remuneration for her involvement in the study.

Research Questions/Hypotheses

Research question 1: Does athletic performance improve with the incorporation of heart rhythm biofeedback training for women collegiate volleyball players over a six-week period as measured by the individual rating of four volleyball skills?

Null hypothesis (H_O): There is no improvement in athletic performance with the incorporation of heart rhythm variability biofeedback training for women collegiate volleyball players over a six-week period as measured by the individual rating of four volleyball skills.

Alternate hypothesis (H_1): Athletic performance improves as measured by the rating of four volleyball skills with the incorporation of heart rhythm variability biofeedback training for women collegiate volleyball players.

Research question 2: Do the volleyball players' heart rhythm variability (HRV) coherence scores improve during the six-week biofeedback treatment as measured by individual accumulated coherence scores provided by the biofeedback output?

Research question 2a: Do the participants' HRV coherence scores, gathered at the beginning of each session without the use of self-regulation, improve each week during the biofeedback treatment, reflecting autonomic nervous system homeostasis and a positive physiological shift?

Null hypothesis (H_O): The HRV coherence scores, gathered at the beginning of each session without the use of self-regulation, do not improve each week during the biofeedback treatment, and do not reflect autonomic nervous system homeostasis and a positive physiological shift.

Alternate hypothesis (H_1): The HRV coherence scores, gathered at the beginning of each session without the use of self-regulation improves each week reflecting ANS homeostasis and a positive physiological shift.

Research question 2b: Do the participants' HRV coherence scores, gathered at the end of each session during independent self-regulation, improve each week during the biofeedback treatment, reflecting the ability to self-regulate?

Null hypothesis (H_O): The HRV coherence scores, gathered at the end of each session and during independent self-regulation, do not improve each week during the biofeedback treatment and do not reflect the ability to self-regulate.

Alternate hypothesis (H_1): The HRV coherence scores, gathered at the end of each session and during independent self-regulation improve each week reflecting the ability to self-regulate.

Research question 3: What are the participants' perceptions and experiences in regard to the six-week biofeedback treatment?

Research question 4: What are the participants' perceptions and experiences of the six-week biofeedback treatment experience relating to athletic performance?

Research question 5: What are the participants' perceived benefits from using the biofeedback treatment?

Data Collection

Two assistant volleyball coaches evaluated their volleyball players' performance during each game using the skill rubric. Each coach evaluated the same two skills through the season. Upon the completion of each game, the results were given to the researcher who copied the data, but substituted each player’s name with her participant code. Codes were randomly assigned to each participant before the first biofeedback session after the participant signed the consent form. The physiological measure provided by the biofeedback coherence scores at baseline, and after independent self-regulation rehearsal, was also labeled using the participant's assigned code.

At the end of the sixth and final biofeedback session, the audiotaped interview was administered to each participant, individually. The tape was labeled with the participant's code. The three semi-structured interview questions were as follows:

1. What was your experience attending the six biofeedback sessions and independently practicing the self-regulation techniques?

2. Did you experience any benefits from the biofeedback intervention?

3. Did you experience any negative aspects to the biofeedback intervention?

Before the sixth session, the researcher participated in a bracketing interview. A bracketing interview was used to identify the researchers biases, assumptions and stereotypes which potentially interfere with the interpretation of data (Pollio, Henley, & Thompson, 1997). The intention of this bracketing interview for this researcher/clinician was to create an awareness of her own experiences with biofeedback treatment by answering the same interview questions as the participants.

The data was transliterated from audio to written format. It was transcribed in its original format and was labeled using the participants' code. During this process of transcription, the audio and transcribed data was stored in a locked file at the researchers home.

Data Analysis

A one sample and paired sample *t* test was used to address the hypothesis (H_1), Athletic performance will improve with the incorporation of heart rhythm biofeedback training for women collegiate volleyball players over a six-week period as measured by the rating of four volleyball skills. The null hypothesis (H_O) is: There is no improvement in athletic performance with the incorporation of heart rhythm variability biofeedback training for women collegiate volleyball players over a six-week period as measured by the individual rating of four volleyball skills.

The raw and mean scores from the evaluation rubric implemented in each of the eight conference games before the intervention was compared with the raw and mean scores from the eight conference games during and after the intervention. SPSS software was used to calculate the data, analyzing team and individual scores. The alpha criterion was set at *p* =. 05. If significance was found, the null hypothesis was rejected.

A repeated-measure *ANOVA* was used to address the two hypotheses relating to psychophysiological changes. The first hypothesis (H_1) is: The heart rhythm coherence scores gathered at the beginning of each session without the use of self-regulation will improve each week, reflecting autonomic nervous system homeostasis and a positive physiological shift. The null hypothesis (H_O) is: The heart rhythm coherence scores, gathered at the beginning of each session without the use of self-regulation do not improve and do not reflect autonomic nervous system homeostasis and a positive physiological shift

The second hypothesis (H_1) is: The heart rhythm coherence scores gathered at the end of each session during independent self-regulation will improve each week reflecting the ability to self-regulate. The null hypothesis (H_O) is: The heart rhythm coherence scores gathered at the end of each session during independent self-regulation do not improve and do no reflect the ability to self-regulate. The medium and high coherence scores provided by the biofeedback software were added as the coherence score for that session. Coherence trends for the team and the individual players will be discussed. The coherence scores represented positive and negative physiological shifts and ANS balance, and the ability or inability to self-regulate.

A case study approach was used in the qualitative portion of the study as the researcher sought to blend the performance, coherence, and perception data into a rich description of the biofeedback phenomenon for each participant. A case interview was used as the researcher questioned the participant's thoughts and feelings regarding the biofeedback phenomena (Vernacchia, 1998). Each of the three semi-structured interview questions was treated as individual topics to be explored: perception of the intervention experience, potential benefits of the intervention, and potential detriments of the intervention. Following transcription, the researcher read each of the participants' answers line by line in order to get a sense of the student-athletes responses. This is referred to as line by line coding (Glaser, 1978). Open coding was then utilized as a means to identify potential themes from the data (Agar, 1996). Collective and individual responses were noted, and relationships with the quantitative data were investigated.

Expected Findings

The expected findings of this research study comprised of the following. First, an improvement in performance might not occur as a team. However, individual increases in performance may be evident when the data is disseminated for each player. Second, a physiological shift towards ANS balance should transpire over the six-week biofeedback intervention if the participants were diligently practicing the self-regulation skills. Third, most participants should display the ability to master self-regulation as shown via improved coherence scores over the six-week biofeedback intervention. Finally, the participant's perception, evaluated with the interview, would be affirmative if she believed in the treatment and diligently practiced self-regulation independently and with the direction of the researcher. Regardless, it was expected that a relationship between perception, performance, and coherence scores would transpire. For example, if the participant displayed a positive perception, she would also improve in performance and coherence, and conversely if she did not have a positive perception, her performance and coherence would not improve.

The findings of this study would advance the knowledge of biofeedback use in sport, as it examines the inclusion of emotional focus as a component of self-regulation. It has the potential to become a viable mental skills training tool for sport practitioners and coaches to implement with their clients and athletes.

CHAPTER 4: DATA COLLECTION AND ANALYSIS

Overview of Research Design and Methodology

Research was conducted to investigate the effects of heart rhythm variability biofeedback and emotional regulation on collegiate volleyball performance. The process of self-regulation and the perception of the intervention were also explored. The study was a quasi-experimental, repeated-measure, mixed-methodology, within-subject research design.

Performance data was compiled using a 5-point Likert scale. 1 represents an error and 5 a perfectly performed skill, respectively. Three is the midpoint of the rating scale, which was designated as the performance criterion score. The evaluated skills included serving, passing, digging and spiking. Raw and mean scores were used to compare performance in eight preintervention matches to eight postintervention matches. Inferential statistics were implemented to analyze performance for the volleyball team and individual players. These tests included the one sample and paired sample *t* test.

The heart rhythm coherence scores provided by the feedback device were used to monitor the process of psychophysiological balance at rest without the use of self-regulation. The coherence scores were also used to evaluate the ability of the participant to self-regulate while independently practicing the techniques. A repeated-measure *ANOVA* and *LSD* post hoc test was calculated to compare the mean coherence scores during the six-session intervention and to investigate the differences between the six sessions.

The participant's perception of the biofeedback treatment, its benefits, and negative aspects were examined using a standardized open-ended qualitative interview conducted with each individual (Patton, 1990). The three semi-structured interview questions were treated as separate topics: perception of the intervention experience, potential benefits of the intervention, and possible detriments of the intervention. Line by line (Glaser, 1978) and open coding were utilized (Agar, 1996) to identify emerging themes from the data. A case study approach blended the quantitative and qualitative data (Vernacchia, 1977; Vernacchia, 1998).

Characteristics of the Sample Population

The sample population included 14 female collegiate volleyball players recruited from a small Christian university in southern California. Initially, all 14 student-athletes agreed to participate in the study. However, after the second week of the biofeedback intervention, one participant voluntarily removed herself from the volleyball team which subsequently excluded her from the intervention. Of the 13 participants, there were four freshmen (31%), two sophomores (15%), five juniors (33%), and two seniors (13%). The participant's were full time students completing 12 to 18 units of academic work per semester.

The recruited volleyball team is a member of the National Association of Intercollegiate Athletics (NAIA) along with 241 other teams. Fourteen conferences represent the NAIA, and the recruited team is one of ten colleges and universities in its conference. The top ranked NAIA teams were members of the same conference with the recruited team and these teams competed against each other a minimum of two times throughout the competitive season (NAIA, 2008).

Overview of the Biofeedback Intervention

The study was proposed to the players at the midpoint of the season after the team had played ten conference and eight non-conference matches. All of the participants received their first biofeedback session before the beginning of the second half of the season. The protocol allowed for seven weeks to administer six biofeedback sessions. However, all participants attended once a week for six consecutive weeks resulting in six biofeedback sessions processed in six weeks. Although a few players needed to reschedule a biofeedback appointment, there were no missed appointments, and all of the participant's received six biofeedback sessions. There was an average of 5.58 days between each biofeedback session (*SD* = 1.56), with an average of 27.12 minutes required to complete each session (*SD* = 4.73). The amount of days between each of the six biofeedback sessions and the average time per session for each participant is summarized in Table 1.

Table 1. Average Days Between Sessions and Time per Session

Participant	Days between sessions	Minutes per session
1	5.8	26.67
2	6.2	26.67
3	5.4	26.67
4	5.4	30.83
5	5.6	25.83
6	5.6	29.17
7	5.4	25

Table 1. Average Days Between Sessions and Time per Session *continued*

Participant	Days between sessions	Minutes per session
8	5.6	28.3
9	4.67	24.17
10	5.4	26.67
11	5.6	28.33
12	6	25
14	5.2	29.17

Performance Results

Research question 1: Does athletic performance improve with the incorporation of heart rhythm biofeedback training for women collegiate volleyball players over a six-week period as measured by the individual rating of four volleyball skills?

Validation of Performance Rubric

The rubric was administered by two assistant coaches during 12 preseason, non-conference matches. One coach evaluated passing and hitting, and the other digging and serving. Psychometric evaluation was conducted on the rubric using Cronbach's alpha reliability statistic. The results demonstrated a moderate alpha (.6).

Further analysis revealed that the four skills are not correlated with each other and are considered independent of each other. This is demonstrated by the low inter-item correlation scores between passing and hitting (.07), digging and hitting (.23) and serving and hitting (.20). The coefficient correlation revealed the following: passing and hitting accounted for approximately 4.5% of the variance, digging and hitting accounted for 53.8 %, and serving and hitting accounted for 41.2%. This suggests that the rubric for each skill measures only the specific properties of that skill.

Analysis of variance using Friedman's Test and Tukey's Test for Nonadditivity was calculated to determine the relationship between the four skills of serving, passing, digging, and hitting. Results demonstrated a significant relationship between the four skills $F(3, 167) = 19.92$, $p < .01$. This indicates an interaction between the skills, that when combined, results in the overall performance of the volleyball player. Upon statistical analysis, the rubric was considered a sound tool to measure athletic performance during the competitive season. The assistant coaches evaluated the same skills during conference play that they evaluated during the preseason.

Pre-Post Match Results

The study was designed to begin at the conclusion of the first round of conference play. The biofeedback intervention would then commence, and all participants would receive one session before the second half of the competitive conference season. To make this plausible, one opponent was omitted from the study to provide the researcher four days to propose the study and administer the first biofeedback session to all 14 players individually.

The scoring trends of the recruited team and their opponents during the first and second part of the season were analyzed. The recruited team acquired the same amount of wins and losses to the same teams in the first and second round of conference play. Although the win-loss record was identical, the amount of games per match varied. During the first part of conference play, before the biofeedback intervention began, the recruited team played 37 games. In the second half of the competitive season, while the biofeedback intervention was being administered, the recruited team played 34 games. In collegiate volleyball, the team who scores more points in three out of five games wins the match. The first four games are played to 30, and the fifth game, if required, is scored to 15.

The total points from the nine matches during preintervention were used to calculate average earned points. The recruited team scored an average of 110.11 points per match (*SD* = 13.17) while their opponents scored an average of 100.33 points (*SD* = 28.16). When calculating the average score per games played, the recruited team scored an average of 27.85 points per game (*SD* = 2.6), while their opponent scored an average of 22.98 points (*SD* = 4.27).

In comparison, the total points from the nine matches during the intervention were used to calculate average earned points. The recruited team scored an average of 101.56 points per match (*SD* = 22.57) while their opponents scored an average of 94.56 points (*SD* = 20.89). When calculating the average score per games played, the recruited team scored an average of 27.48 per game (*SD* = 2.69) while their opponents scored an average of 25.34 (*SD* = 3.69). The recruited team scored 8.55 less points per match in the second half of the season, and their opponents scored 5.77 points less per match. The recruited team scored .37 points less per game in the second half of the season, and their opponents scored 2.36 points more per game (Table 2).

Table 2. Summary of Team Scores During Competitive Season

	1st Round/ Before treatment intervention					2nd Round/ During treatment intervention				
	Scores				Games	Scores				Games
Team	Opponent		Recruited			Opponent		Recruited		
	M	G	M	G		M	G	M	G	
Opp 1	97	24.5	118	29.5	4	63	21	90	30	3
Opp 2	47	15.7	90	30	3	101	25.3	119	29.8	4
Opp 3 ∗	125	25	125	25	5	118	29.5	99	24.8	4
Opp 4∗	135	27	117	23	5	90	30	68	23.7	3
Opp 5	95	23.8	117	29.3	4	93	23.3	116	29	4
Opp 6	71	23.7	90	30	3	64	21.3	90	30	3
Opp 7	128	25.6	131	26.2	5	118	23.6	130	26	5
Opp 8∗	105	26.3	100	25	4	90	30	75	25	3
Opp 9	100	25	116	29	4	114	22.8	127	25.4	5

M = Match, G = Game

∗ Denotes loss in both first and second round of conference play. These teams were ranked second, third and fourth in the NAIA.

Team Results

The individual raw scores from the scoring rubric were used to evaluate performance. Raw scores reflect the overall performance of some of the players more accurately than using the mean scores because it represents the amount of times the player actually contacted the ball. However, mean scores were also calculated for the four skills that each player conducted during each game. Although it was the intention to evaluate the participant's athletic performance using the rubric during nine matches, one of the teams had to be excluded during the study. Due to unforeseen circumstances, the scoring rubric from the game against opponent nine, listed in table two, was not completed during the second half of conference play. Therefore, athletic performance was evaluated during the matches with eight teams played during preintervention and postintervention. The differences in *N* for the raw score indicates the amount of times the team contacted the ball. The higher pretest raw score reflects the three more games played during the first round of conference play before the intervention began. The pretest and posttest intervention scores are a compilation of the average score of each skill, performed by each individual during the eight matches. The higher pretest mean *N* also reflects the three more games played during the first round of conference play or it might indicate that more skills were conducted by more of the players in the first part of the season than the second part. Mean and standard deviation results are provided in Table 3.

Table 3. Mean and Standard Deviation Scores for Team Performance

score	*N*	*M*	*SD*
pretest raw scores	3496	3.43	1.30
posttest raw scores	3106	3.39	1.34
pretest mean scores	251	3.44	.78
posttest mean scores	223	3.26	.73

To investigate the ability level of the team during the first and second part of conference play, a one sample *t* test was used to compare the raw scores with the criterion score of three. This criterion score was selected as it is the midpoint of the five-point performance scale. The result was significant for both the preintervention scores $t\ (3495) = 19.57$, $p < .01$ and postintervention scores $t\ (3106) = 16.27$, $p < .01$. The total mean score for the preintervention ($M = 3.43$, $SD = 1.3$) and the postintervention ($M = 3.39$, $SD = 1.34$) were greater than the criterion score of three. Estimate of Cohen's magnitude of the difference was $d = .33$ and .29, respectively. These scores suggest the advanced ability level of the team before and after the biofeedback intervention.

To assess the effect of the biofeedback intervention on the team's athletic performance, a paired sample *t* test was calculated using both the raw and mean scores (Table 4). Results indicated a .04 score reduction using the raw scores from the first and the second part of conference play which were not significant ($p > .05$). However, using the mean scores the results indicated a .18 score reduction which was significant ($p < .05$). Therefore, the null hypothesis cannot be rejected (H_O): There is no improvement in athletic performance with the incorporation of heart rhythm variability biofeedback training for women collegiate volleyball players over a six-week period as measured by the individual rating of four volleyball skills. Estimate of Cohen's magnitude of the difference was $d = .29$, which is considered small (Howell, 2004). Using the raw scores, these results imply no change in performance. Using the mean scores, these results suggest a possible reduction in team performance in the second part of conference play with minimal practical significance.

Table 4. Paired-Sample *t* tests for Team

Score	*N*	*M*	*SD*	*t*	*df*	*sig*
Pretest raw	3496	3.43	1.30	1.6	3105	.11
Posttest raw	3106	3.39	1.34			
Pretest mean	251	3.44	.78	2.5	222	.01
Posttest mean	223	3.26	.73			

Individual Results

To investigate the ability level of the individual players during the first and second part of the season, raw scores were compared to the criterion score of three. Raw scores were preferred to mean scores as a couple of the players did not have ample playing time to warrant the use of mean scores for the test.

Results of the one sample *t* test indicated that five of the thirteen players (38%) had performance mean scores greater than three in both preintervention and post-intervention (Participant 1, 2, 6, 7, 9). Four (31%) had scores greater than three in only preintervention (Participant 3, 4, 5, 14), and one (8%) had a performance score greater than three in only postintervention matches (Participant 8). All of these scores were considered significant at the $p < .01$ or $p < .05$ levels with small to medium effect sizes. Further inspection revealed that all 13 players had performance mean scores greater than three at both preintervention and postintervention, although not all of the participants' results were considered significant. The results of the one sample *t* test suggest the high caliber of play associated with this volleyball team and its individual members (Table 5).

Table 5. One Sample *t* test for Individual Players

Participant		*N*	*M*	*SD*	*t*	*p*	*d*
1	Pretest	921	3.49	1.34	11.23	**	.36
	Posttest	760	3.47	1.37	9.44	**	.34
2	Pretest	285	3.31	1.29	4.04	**	.24
	Posttest	482	3.43	1.34	6.89	**	.32
3	Pretest	859	3.47	1.26	10.95	**	.37
	Posttest	79	3.10	1.36	.66		
4	Pretest	65	3.46	1.32	2.81	**	.35
	Posttest	95	3.20	1.32	1.48		
5	Pretest	141	3.41	1.45	3.36	**	.28
	Posttest	52	3.15	1.64	.68		
6	Pretest	555	3.61	1.24	11.57	*	.49
	Posttest	421	3.65	1.28	10.45	*	.51
7	Pretest	10	4.20	1.48	2.57	*	.81
	Posttest	90	3.42	1.48	2.70	**	.28
8	Pretest	191	3.11	1.31	1.16		
	Posttest	285	3.38	1.32	4.82	**	.29
9	Pretest	81	3.26	1.21	1.93	*	.21
	Posttest	327	3.26	1.35	3.52	**	.19
10	Pretest	21	3.33	1.35	1.13		
	Posttest	59	2.78	1.20	-1.41		
11	Pretest	298	3.07	1.14	1.12		
	Posttest	210	3.07	1.18	.88		
12	Pretest	0					
	Posttest	2	3.00	2.83	0		
14	Pretest	105	3.44	1.54	2.92	**	.29
	Posttest	99	3.23	1.42	1.63		

* $p < .05$ ** $p < .01$

To assess the effect of the biofeedback intervention on the individual player's athletic performance, a paired sample *t* test was calculated using the raw scores. Of the 13 participants, only participant10 demonstrated significant results.

Participant 1 contacted the ball 161 more times (17%) during the first part of conference play before the intervention. Her performance mean score decreased by .02 during the second part of conference play during the biofeedback intervention. This was not considered statistically significant.

Participant 2 contacted the ball 199 (41%) more times in the second part of conference play. Her performance mean score increased by .12, but it was not considered statistically significant. Participant 3 contacted the ball 780 less times (91%) during the second part of conference play. Her mean performance score decreased by .37 and was not considered significant.

Participant 4 contacted the ball 30 (32%) more times in the second part of the season and had a .26 reduction in mean score which was not considered statistically significant. Participant 5 contacted the ball 89 (63%) less times the second part of season play. Her mean score decreased .26 points, which was not considered statistically significant.

Participant 6 contacted the ball 134 (24%) more times in the second half of the season, and her mean performance score decreased by .04, which was not considered statistically significant. Participant 7 contacted the ball 80 (89%) more times in the second part of conference play. Her mean performance score decreased by .78, which was not considered statistically significant.

Participant 8 contacted the ball 94 (33%) more times in the second part of conference play. Her performance scored increased by .27, which was not considered statistically significant. Participant 9 contacted the ball 246 (75%) more times in the second part of conference play. Her performance score stayed the same.

Participant 10 contacted the ball 38 (64%) more times in the second half of the season, and her mean performance score decreased by .55, which was considered statistically significant ($p < .01$). The estimate of Cohen's magnitude of the difference was d =.33, which is considered a small effect size (Howell, 2004). These results imply a possible reduction in this participant's performance from the first to the second part of the conference play.

Participant 11 contacted the ball 88 (30%) less times in the second half of the season, and her mean performance score stayed the same. Because participant 12 contacted the ball only two times during the second part of conference play, the paired sample *t* test could not be conducted.

Participant 13 voluntarily removed herself from the team after the second week of the study, thus her performance statistics are not included. Participant 14 contacted the ball six (6%) less times during the second part of conference play, and her mean performance score decreased by .21, which was not considered statistically significant. Overall, the results of the individual *t* tests do not reflect an improvement in performance in the second part of conference play during the biofeedback intervention. The results do reflect a reduction in performance for one participant, with minimal practical significance (Table 6).

Table 6: Paired Sample *t* test for Individual Players

Participant		*N*	*M*	*SD*	*t*	*p*
1	Pretest	921	3.49	1.34	.72	
	Posttest	760	3.47	1.37		
2	Pretest	285	3.31	1.29	-1.03	
	Posttest	482	3.43	1.34		
3	Pretest	859	3.47	1.26	1.76	
	Posttest	79	3.10	1.36		
4	Pretest	65	3.46	1.32	.87	
	Posttest	95	3.20	1.32		
5	Pretest	141	3.41	1.45	1.68	
	Posttest	52	3.15	1.64		
6	Pretest	555	3.61	1.24	-.14	
	Posttest	421	3.65	1.28		
7	Pretest	10	4.20	1.48	.38	
	Posttest	90	3.42	1.48		
8	Pretest	191	3.11	1.31	-1.4	
	Posttest	285	3.38	1.32		
9	Pretest	81	3.26	1.21	1.15	
	Posttest	327	3.26	1.35		
10	Pretest	21	3.33	1.35	3.02	<.01
	Posttest	59	2.78	1.20		
11	Pretest	298	3.07	1.14	.12	
	Posttest	210	3.07	1.18		
12	Pretest	0			0	
	Posttest	2	3.00	2.83		
14	Pretest	105	3.44	1.54	1.44	
	Posttest	99	3.23	1.42		

Psychophysiological Coherence Results

Psychophysiological Coherence at Rest

Research question 2: Do the volleyball players' heart rhythm variability (HRV) coherence scores improve during the six-week biofeedback treatment as measured by individual accumulated coherence scores provided by the biofeedback output?

Research question 2a: Do the participant's HRV coherence scores gathered at the beginning of each session without the use of self-regulation, improve each week during the biofeedback treatment, reflecting autonomic nervous system homeostasis and a positive physiological shift?

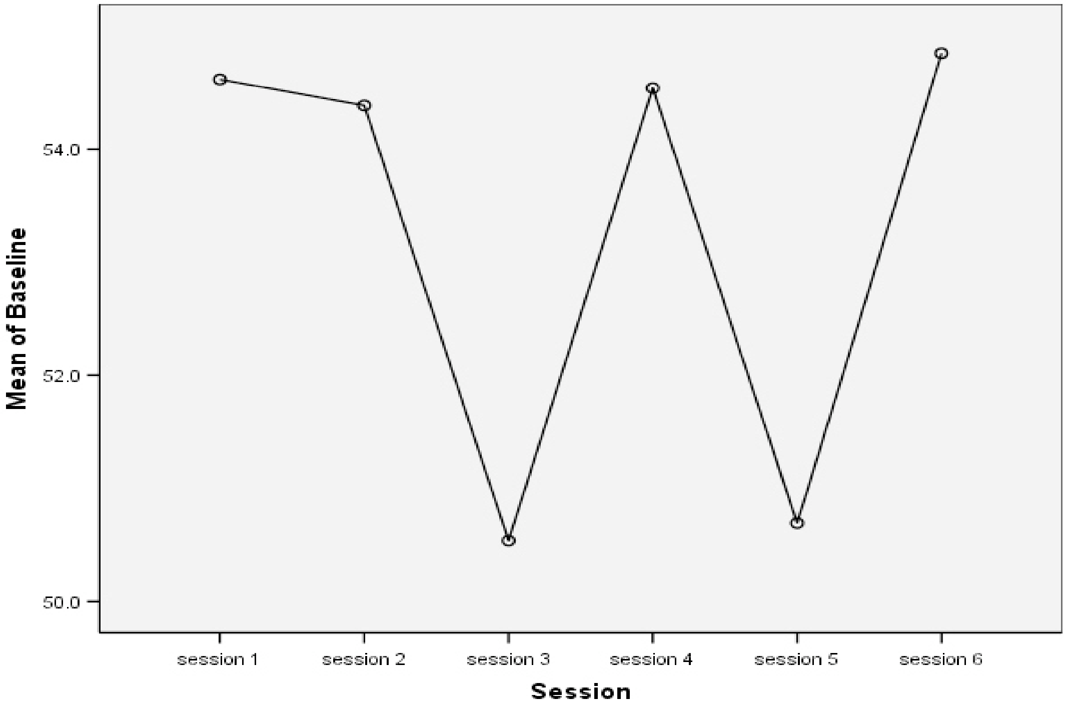
The biofeedback software provided three heart rhythm variability scores (low, medium, high) which represented the coherence or psychophysiological balance of the participant. It also reflected the ability to self-regulate as displayed by higher coherence scores. The participant's coherence score was the sum of the medium and high scores. Two data sets were gathered for each participant during each biofeedback session that included the baseline score and the independent rehearsal score. The baseline score represented the coherence of the participant at rest without the use of self-regulation. This score was gathered at the beginning of each biofeedback session. The independent rehearsal score represented the coherence of the participant during the process of self-regulation. This score was gathered at the end of each biofeedback session. Two separate repeated-measure *ANOVA* tests were conducted to compare the coherence scores across the six sessions, with the independent variable being the coherence score from each session and the dependent variable being the participant's coherence score.

To assess changes in the team's baseline coherence score, the mean score from all 13 participants for each session was calculated (Table 7). According to the repeated measure ANOVA, the change in the mean baseline score gathered for the team during the six biofeedback sessions was not significant $F(5, 60) = .16$, $p = .98$. Therefore, the null hypothesis cannot be rejected: The HRV coherence scores, gathered at the beginning of each session without the use of self-regulation, do not improve each week during the biofeedback treatment and do not reflect autonomic nervous system homeostasis and a positive physiological shift (See Figure 1).

Table 7. Team's Baseline Heart Rhythm Coherence Scores

Session	N	M	*SD*
1	13	54.62	27.89
2	13	54.39	34.85
3	13	50.54	28.10
4	13	54.54	27.59
5	13	50.69	33.23
6	13	54.85	28.99

Figure 1. Graph of team's baseline heart rhythm coherence scores



Psychophysiological Coherence During Self-Regulation

Research question 2b: Do the participant's heart rhythm variability (HRV) coherence scores gathered at the end of each session during independent self-regulation, improve each week during the biofeedback treatment reflecting the ability to self-regulate?

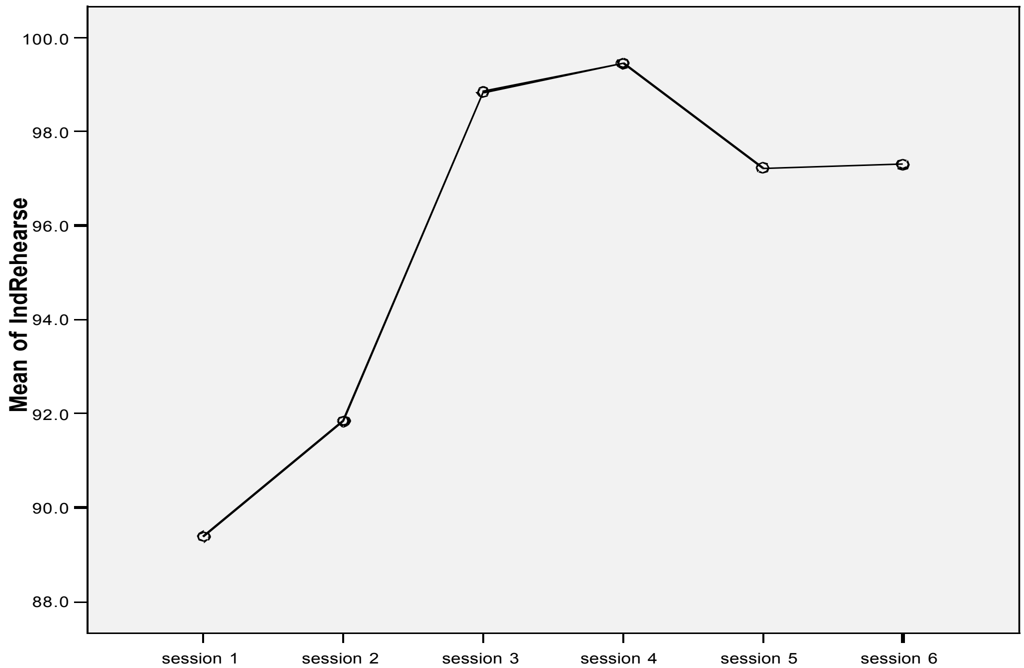
To assess changes in the team's independent rehearsal coherence score, the mean score from all 13 participants for each session was calculated. According to the repeated-measure *ANOVA*, change in the mean independent rehearsal scores during the six biofeedback sessions was significant, $F(5, 60) = 4.2$, $p < .01$. Estimate of Cohen's magnitude of the difference was $d = .52$, which is considered a medium effect size (Howell, 2004). These results reflect the team's ability to self-regulate with statistical and practical significance. Therefore, the null hypothesis is rejected: The HRV coherence scores gathered at the end of each session during independent self-regulation, do not improve and do not reflect the ability to self-regulate. The alternative hypothesis is accepted: The HRV coherence scores gathered at the end of each session and during independent self-regulation will improve each week reflecting the ability to self-regulate (Table 8).

Table 8. Team's Independent Rehearsal Heart Rhythm Coherence Scores

Session	N	M	*SD*
1	13	89.39	16.05
2	13	91.85	11.04
3	13	98.85	3.31
4	13	99.46	1.45
5	13	97.23	5.53
6	13	97.31	8.84

Post hoc analysis using the *LSD* test was administered for comparison of each of the six biofeedback sessions. The changes in mean scores were significant between sessions one and three, four, five and six, and between sessions two and four. Further inspection demonstrates an upward trend in independent rehearsal mean scores beginning in session one (89.39) and peaking in session four (99.46), with a 2.23 decrease between session four and five (97.23), and a .08 increase between sessions five and six (97.31) (See Figure 2).

Figure 2. Graph of team's independent rehearsal heart rhythm coherence scores



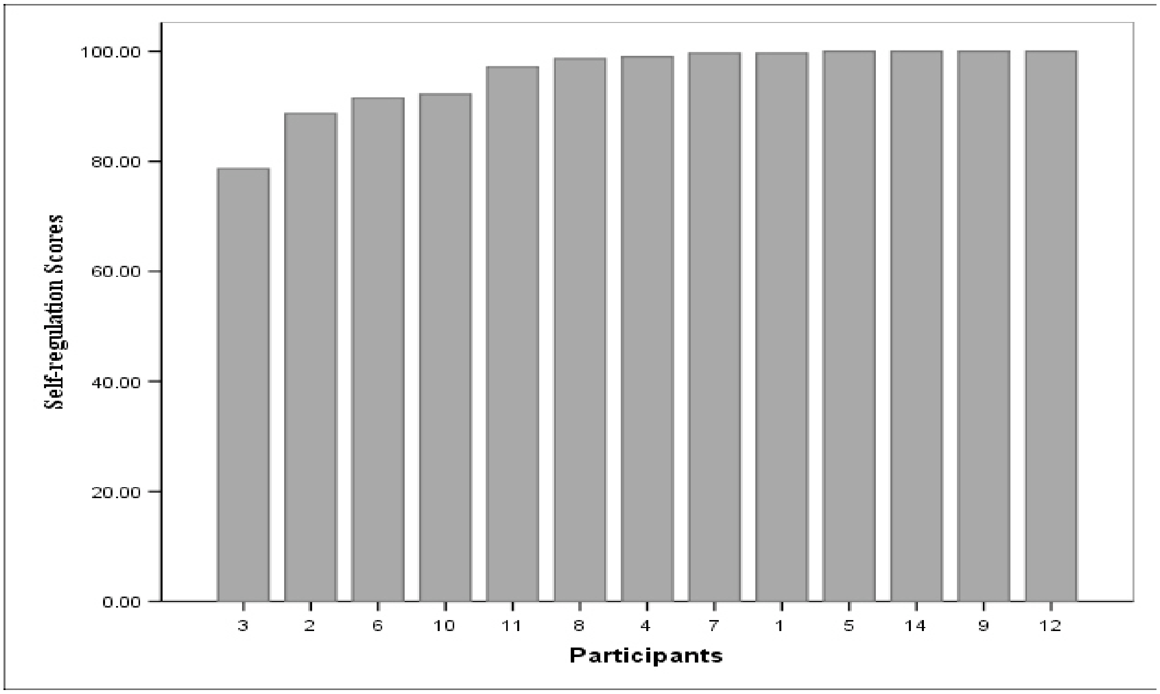
Individual Psychophysiological Self-Regulation

The ability to self-regulate at will is an individual process (Crews et al., 2001). Therefore, it was appropriate to investigate the individual's independent self-regulation score across the six biofeedback sessions. Analysis indicated that the lowest mean and the greatest range of coherence scores occurred with participant's 2 and 3. However, participant 2 demonstrated the ability to self-regulate at the third biofeedback session, whereas participant three displayed unpredictable self-regulation scores throughout the six-session intervention. This reflects a potential difficulty with the self-regulation process (Table 9 and Figure 3).

Table 9. Participants' Self-Regulation Scores

	Sessions								
Participant	1	2	3	4	5	6	M		*SD*
1	98	100	100	100	100	100	99.67		.82
2	70	67	98	100	100	97	88.67	*	15.69
3	60	80	88	95	81	68	78.67	*	12.83
4	98	96	100	100	100	100	99		1.67
5	100	100	100	100	100	100	100		0
6	69	80	100	100	100	100	91.5		13.62
7	100	100	98	100	100	100	99.67		.82
8	100	100	100	100	92	100	98.67		3.27
9	100	100	100	100	100	100	100		0
10	67	86	100	100	100	100	92.17		13.54
11	100	85	100	98	100	100	97.17		6.01
12	100	100	100	100	100	100	100		0
14	100	100	100	100	100	100	100		0

Figure 3: Graph of participants' self-regulation scores



Perception

The final stage of this study included a semi-structured, open-ended qualitative interview (Patton, 1990) conducted individually with each of the 13 participants. The interview transpired in the same private office where the biofeedback sessions occurred and was the final component of the sixth biofeedback session. The interview lasted approximately 20-30 minutes. The three questions were provided for the participant to read so she could anticipate the content of the interview. The researcher proceeded to ask each question using follow-up probing questions only if the response was unclear. The interview questions consisted of the following: What was your experience attending the six biofeedback sessions and independently practicing the self-regulation techniques? Did you experience any benefits from the biofeedback intervention? Did you experience any negative aspects to the biofeedback intervention?

Following this interview, the researcher transcribed the audiotape into hardcopy text for data analysis. The transcription occurred within one week of the interview so the information would remain familiar to the researcher (Patton, 1990). Initially, all 13 transcripts were read separately to acquire a sense of the whole of each transcript. To begin the process of theme recognition, the transcripts were subsequently read line by line according to the responses from each question. Groups of initial themes were derived from the three interview questions for each individual (Glaser, 1978). Following this, the themes from the separate transcripts were merged and compiled for all 13 participant interviews with direct quotes drawn from each transcript to support the themes (Agar, 1996). Finally, the syntheses of all themes were merged into a collective description of the biofeedback experience (Patton).

Question 1
What was your experience attending the six biofeedback sessions and independently practicing the self-regulation techniques?

The first theme that emerged from this question is the dynamic of the experience. The second theme, the process of learning, is comprised of three subthemes: instruction, visualization, and awareness. Instruction focuses on the process of learning about biofeedback and self-regulation. Visualization refers to the impact of seeing the psychophysiological changes throughout the six-week intervention. Awareness suggests the attention to mind-body interactions. The third theme is the product of control.

Dynamic of the Experience

The overall experience was described using affirmative terminology. “It was a good experience” (P1). “It was a good experience for me being the major I am” (P4). “It was awesome” (P3).

“I enjoyed this” (P7). “I enjoyed going to the sessions” (P8). “I enjoyed this a lot, and I think it will carry over in the future” (P14).

“The six sessions were fun” (P9). “It was fun. I've never done anything like this before. It's cool you can give us a technique and we can do it on our own and on the volleyball court” (P12).

“It was very helpful” (P10). “I think the six biofeedback sessions kind of helped me” (P2). “It really helped me calm down” (P5). “For the six biofeedback sessions, I felt like that was the time when I became…the most relieved of stress” (P6). “I went into it pretty excited and hoping that it would work, and sure enough it seems to be doing a lot for me” (P11).

Process of Learning

Instruction.

Some participants identified the learning process as important components of the experience. Gaining knowledge about self-regulation and understanding the influence of feelings and emotions was emphasized. Understanding the context of biofeedback and how it influenced the mind and body was also an important part of the intervention.

“[The biofeedback] taught me to control my emotions…and just control myself a little bit better…and learn about my feelings and how to relax more” (P1).

“Learning and realizing that a couple of positive thoughts and deep breaths can change your whole attitude and mental state. I found that really interesting” (P7). “I learned more of the effects of biofeedback and think about the positive emotion aspect” (P14).

“I seem to have a better understanding of how to calm myself just through the three-step process" (P11). "It was kind of nice to learn from you, just showing me how to do this on my own” (P8).

Visualization.

Some participants emphasized the value of visualizing the self-regulation process. “It helped me see the results on the screen” (P2). “Seeing my progress…obviously means something and its working”(P3). “I could see it on the screen and watch my heart rate…I felt like that was the time that…it was the easiest to be the most focused” (P6). “The six sessions were really fun to…see the difference and just being there and then focusing on breathing on your heart and what you're thinking about” (P9).

Awareness.

Awareness and insight are also important aspects of the biofeedback intervention. This awareness is related to instruction as the participants understood the self-regulation process and their current psychophysiological state as portrayed by their heart rhythm.

“It …made me more aware of …coherence…because I never even knew about any of that” (P5). “I actually enjoyed going to the sessions because it kind of gave me new insight on how I can better become coherent…be balanced in all aspects of life” (P8). “I had no clue that it [heart rhythm] would change so much and that I'm so unbalanced” (P9).

Product of Control

Control relates to the process of identifying unhealthy psychophysiology and balancing the mind-body at will through the process of self-regulation. “Its been a good experience to learn about how to control your own emotions…you have a choice in everything you do” (P1). “Being able to self-regulate and being able to…control myself, like emotions. Being able to…have control over myself and to regulate when I need to, was nice” (P3). “It really helped me to take a step back and see that I CAN calm myself down through the whole heart-felt, heart breathing thing [emphasis from participants interview]” (P4). ”Wow, I can actually…not be so stressful sometimes and be relaxed” (P8).

Question 2
Did you experience any benefits from the biofeedback intervention?

Three themes associated to the different roles of the participant naturally emerged from this question: the role of a student, an individual athlete, and a team member. Within these themes were numerous subthemes which specify how the athlete perceived the biofeedback intervention to be helpful. Regarding the participants' role as a college student, the benefits related to physical and mental stress reduction, improved academics, healthy relationships, and sleep. Regarding the participants' role as volleyball athlete, the perceived benefits related to enhanced physical and mental performance. Concerning her role as team member, the intervention created positive feelings and composure while enhancing team camaraderie.

Student

Physical and mental stress reduction.

Numerous descriptors used to explain physical and mental stress reduction included the following: “stress reliever,” “relax,” “calm down,” “focus,” and “positive outlook.” Some participants explained stress reduction using one of these words, and others portrayed the experience using a combination of such terminology.

“It was a stress reliever. I have so many things on my mind.” ”If you have something that worries you, take time for yourself to focus on your heart and your feelings" (P1).

“If you're stressed...take a deep breath and you will feel a little bit more relaxed.” ‘Like, OK, I can do this, its really not as bad as I'm making it out to be…Just settle down a little bit’” (P7).

“Not being stressed out about the stuff that doesn't mean that much. Before I'd be really stressed out about things that really weren't that big of a deal…when you think about…the little things, you learn not to worry about them. You just be OK [sic] with them” (P 8).

“It was a way to relax” (P1). “I could much more quickly relax and focus” (P2). “I was just relaxed, I was…coherent, and able to concentrate a lot better” (P3). “It helps me to calm down and focus” (P4). “Practicing it really helped me calm down, like when I was really stressed or anything, it just helped me relax” (P5). “It had calming purposes…and was relaxing” (P10).

“Just being able to calm myself down…during stressful situations and just focusing on the moment rather than sometimes I get wrapped up in all the stuff…I just sit and relax and think about my coherent state and I feel a little bit more calm” (P11).

“I had a more positive outlook after doing your biofeedback” (P1). “It made me feel positive about anything…you kind of just feel good about it. You had a sense of peace” (P 8). “When I would drive…in traffic, I would put it (emWave earpiece) on my ear and that helped a lot, because I wasn't mad or anything like that, it just calmed me down” (P12).

Academics.

The benefits of the biofeedback intervention also related to the participant's coursework, presentations, and tests. Again, such terminology as “less stress,” “calm,” “focused,” and “relaxed” were used to explain the benefits.

“When I was stressed with homework…I would put it all away and sit there and do it [The Quick Coherence Technique] even without the hand-held. It would definitely help me not to stress so much about it. I can step back and think about it…’OK, this isn't that big of a deal…It's a paper…it will be done tomorrow’” (P12).

“It calms me down a little bit…I can focus a little more when I'm doing my homework" (P6). When I was studying, it was late at night, 'I don't want to study but I should', and so I would do it [QCT] before. I was just relaxed, I was coherent, and able to concentrate a lot better. I studied and got an A on my midterm” (P3).

“Before tests and presentations I noticed it becoming more automatic like the breathing aspect because I'll get nervous before it. The result is relaxed, calm, at ease” [sic] (P14). “Before tests, I try not to cram and I try to deep breathe before I go out.

Because for me it's [cramming] just not going to do anything and it will help me to relax. If I'm stressed and my brain is scattered, I just do deep breathing. If I have the emWave, [then I'll use the] emWave" (P4).

"I had a big test. It became, 'Oh, this is what I should do because I know its going to work.' I could calm myself down. I got my test back today and got it perfect. See, I feel like it works. I was able to focus myself…I got everything down and got the result I wanted from it…It was cool!" (P2).

Relationships.

The relationships referred to in this section are associated with those outside the volleyball team: family, friends, and boyfriends. "With the whole boyfriend thing and friends, there's no need to freak out about things…It's like, whenever that happens, I'm like, 'OK, deep breathing, calm down'" (P4).

"Being aware of the effects of breathing and positive emotion in just every day life. With an experience happening in your life with family or friends or just something you're thinking about or that's either bothering you or making you anxious" (P14).

Sleep.

"It helps to go to sleep" (P3). "Sometimes I'd do the ear one [emWave earpiece attachment], but that was most of the time when I was going to sleep" (P5). "It definitely has helped me…like going to sleep. I'll do it right before I go to sleep, and it really helps calm me" (P6). "Sometimes when I go to bed, if I have a lot on my mind, or restless, or whatever, I would do my deep breathing and positive thinking and I would seem to fall asleep quicker" (P11).

Individual Athlete

The participant's who reported an improvement in performance emphasized both physical and mental aspects that potentially enhanced their play.

Physical performance.

“For the second half of the season, I think my game improved a little bit more…I became a little bit more stronger as a player” (P1). “In serve-receive, I felt like it's all you and the server, and it's just the two of you…if you can just calm yourself down and focus to make that one pass...it's so much better. I felt like my passing got better. I was able to stay a lot more relaxed, and I tend to get tense during serve-receive, and I was able to stay more relaxed” (P2).

Mental performance.

The mental enhancement described by many of the participants related to improved concentration, confidence, and control. Mindfulness also described the increased state of awareness that occurred.

“I wasn't really trusting myself, but then the breathing and biofeedback helps you to trust yourself and be coherent. I think that it helped overall as an individual player” (P1). “I think it has improved me, in that just stopping for a second and focusing back in” (P10).

“I could control myself better, and know what I'm focusing on. In passing, or serve-receive, I can concentrate on the server and then pass a good "3" ball. In hitting, make sure it doesn't hit the net, or a certain spot to hit it. Or setting, make sure that I'm in the right spot to set so that I don't double the ball" (P3). "It helped me keep myself together, knowing that I can't play [due to injury]….able to control myself and my negative emotions" (P3).

"I was having trouble with my serves. I would get really nervous and really rattled and would hit it long, or I would let everything that was going around me affect my own play. 'Breathe deep, and just focus on what you need to do here and it's going to be fine.' You tuned out everything, and it worked. Even when I did miss it, I was calm. I wasn't nervous feeling or anxious. Having a more sense of peace, and not being so nervous when you're going back to serve…gave you confidence" (P8).

"It just kind of calmed me down…you get too involved sometimes" (P7). "It helped in stressful situations in games…when it was really nerve-wracking" (P8). "It kept me focused more. 'OK, here we go'" (P9).

"When I'm passing, and if you shank a couple balls or you're not doing very well, you're like, 'Oh Gosh, I need to relax and focus' and you breathe a couple times and think about it. I thought that was helpful, because it just refocuses you" (P10). "When things weren't going our way, or my way I would say, 'That's fine. The next ball's going in'" (P5). "I liked knowing that I could do it on the court during practice…if coach got mad, or the drill wasn't working, you could just deep breathe" (P12).

Mindfulness is a heightened state of attention and perspective associated in athletic participation. It is a transcendent experience that goes beyond the conscious (Cooper, 1998) or the typical play and was described by four participants.

"…tuning out the noise. I always thought was a huge deal and never thought I could do it. And that's something I've noticed that I can do now" (P4). "I felt like I better understood the game. I was looking for more things because I wasn't so scattered and nervous about ‘Well, what do I have to do here, and what do I have to do there’” (P4).

“If I would miss a serve, or double a ball, or whatever the goof-up, I'd just deep breathe and get myself together with the steps you have taught us. The result was a clear state of mind, not blissfulness, but clear thinking” (P 11). “To calm down and when I deep breathe, it helps me get in the zone, and focus on my job” (P4).

“I'm a very competitive person when it comes to being on the floor. In situations where I make a mistake or something that happened with me individually as a player, I'd be more inclined to in the past…get upset at myself, and get mad. But…I think now I've been more to be inclined to take a step back…and breathe or just think of a good thought. ‘It's not the end of the world, and it's going to be OK’” (P14).

“In practice and dead balls…it helps me just play. I don't think about technique or anything. I just play” (P 5). “Go into the zone, and focus on what you need to do. Don't think about what's really going on…think about yourself and breathe deep…just focus on what you need to do to get the next play” (P8).

Team

The responses regarding the benefits of the biofeedback intervention also related to the team as a whole. Many team members experienced an increase in positive energy, team camaraderie, and composure.

“We had fun with the linking. I think it was helpful to be able to [link] as a team. We all know what we're working toward and so it was able to help us in that aspect” (P2).

"…Well that worked, why don't we always do this?" (P4). "When we link up, we just so surpass everything that we ever think we could" (P4). "…everyone 'link up' and we were playing really well at the times that we were doing that" (P6).

"It helped us…coach would say 'link up, link up' and it would create positive energy, and we are all smiling…it gave us a positive feeling rather than a negative one" (P7). "We'd do the hand signal you taught us. It would bring a smile to my face…it was a positive feeling right there…it was effective just to know that your teammates are with you" (P11).

"During timeout we would all be, 'OK, just relax, and take a breath' so I think it was helpful in refocusing the team as a whole" (P10). "Everybody was more relaxed…better understanding of being relaxed…and being on the same level…we didn't get rattled so much" (P 8). "

""Linking up" thing…we're laughing…thinking its kind of silly…by recognizing that…triggering in people minds to be calm and consistent" (P 14). ""Link up" made us feel happy…calming effect…more together...on the same page" (P 6). "When it was hectic and we were on the sidelines yelling, 'link it-link it' and I think that calmed everyone down because they know, 'OK, we know what to do, we can calm ourselves down' and that was really good for the team" (P 12).

Question 3

Did you experience any negative aspects to the biofeedback intervention?

Four themes emerged from this question: a "no" response (54%), feeling too relaxed, disruption in skill performance, and competition with or reliance on the emWave PSR.

Feeling too Relaxed

“When I was excited and energetic I would avoid doing it…right before a game because I wanted to keep my energy up…It made me too relaxed or groggy” (P 9). “Sometimes when I would do it, it would make me tired, but I think that's just because I have a lot going on. When I would breathe regularly, it would make me yawn” (P 10). “I get tired when I do it…I get relaxed and kind of tired a little bit. I felt that more often when doing it” (P 14).

Disruption in Skill Performance

“When I focused on being coherent, I would forget about the techniques [serving] and what I was suppose to be doing…and really not thinking for instance about my service. Because my jump-serve isn't second nature yet, if I'd do that, sometimes I would forget on focusing on keeping my arm high…I like to do the QCT before, and think about my technique” (P 1).

Competition or Reliance on emWave

“At the beginning, it was a little bit frustrating because I was, ‘I can't do this.’ Sometimes I can't get the thing to turn green, and it stays blue” (P 2). “Trying hard to think about my breathing…and the emWave would still be red and it would worry me… I was competing against the emWave… I needed it to change to green before the game” (P 6). “ Monday night, when my emWave didn't work…a mental thing…’I'm not going to be able to sleep without it…I need it’” (P 6).

Overall, the biofeedback experience was described by the participants using affirmative terminology. The process of learning about biofeedback and self-regulation while visualizing heart rhythm variability was an important component to its success.

Realizing that one has control over emotions, and ultimately psychophysiological balance was also emphasized. The participants identified the benefits of the intervention as they related to their roles of students, individual athletes, and team members. As students, the participants experienced a reduction in both mental and physical stress, as seen by increased relaxation, and for some, improved sleep. The biofeedback intervention promoted a focused and calm state helpful for academic rigors, and some attributed it to their success in test taking. In relationships outside the team, the process of self-regulation was noted to enhance interactions with significant others. As individual athletes, some participants noted an improvement in physical performance, others commented of mental enhancement, while a few made note of zone play and mindfulness. As a team, the participants reported “linking up” as a means to improve performance, or a process to promote calm, and team unity. A few detrimental experiences of the intervention were also noted. Some felt it made them too relaxed. A few participants shared concern regarding their reliance on or competitiveness with the emWave PSR. The inability to focus on volleyball skills while self-regulating was also noted by one participant.

Relationships Between Performance, Coherence and Perception

Individual case studies were implemented to investigate the association between the participant's interview responses, athletic performance, and self-regulation scores and to blend this data into a rich description of the biofeedback phenomenon for each participant. According to Vernacchia, case studies provide “valuable insights into the appropriateness and effectiveness regarding the influence of performance intervention and enhancement techniques or strategies" (1998, p. 11). Case studies, also referred to as single-case designs, include performance evaluations obtained through statistical information, physiological test results, and personal interviews (Vernacchia, 1977; Kazdin, 1982).

Participant 1 expressed an improvement in performance: "For the second half of the season, I think my game improved a little bit more…I came a little bit more [sic] stronger as a player." Her mean scores did not reflect improvement (M = 3.49 for preintervention and 3.47 for postintervention). According to the performance rubric, she contacted the ball 1,681 times during the entire conference play. Strength is represented in perfectly conducted skills, such as hitting, which is the primary responsibility of this player. Analysis revealed an increase in kills and perfectly performed skills (rating of five) by 1.3% during the second part of the season which may explain the strength this player was experiencing (32.1% for preintervention and 33.4% for postintervention). Participant 1 also articulated that a detrimental aspect of the intervention was self-regulating while serving. She stated, "I focused on being coherent, I would forget about the techniques and what I was suppose to be doing…and not thinking about my serves." Errors and kills (one and five, respectively) are the most obvious way to analyze serving ability. Indeed, participant one's serving during the second part of the season did not show improvement according to the performance rubric which may support the self-regulation difficulty she was experiencing during serves (Table 10). However, she did demonstrate a great ability to self-regulate during the biofeedback sessions with scores between 98 to 100%.

Table 10. Serving Analysis for Participant 1

	Preintervention	Postintervention
error	17.5%	22.3%
kill	15.3%	8%
total serves	137	112

Participant 2 also expressed that the intervention improved her athletic performance. “I felt like my passing got better. I was able to stay a lot more relaxed.” Her mean passing score increased by .1 during the second half of the season, and her overall mean scores were very high (3.9 for preintervention and 4.0 for postintervention). In addition, 33% and 47% of her passes in the preseason and postseason earned a perfect score of five, respectively. Participant 2 stated one detriment of the biofeedback intervention was the difficulty to self-regulate. “At the beginning, it was a little bit frustrating, because I was, ‘I can't do this…sometimes I can't get the thing to turn green, and it stays blue.’” This statement is supported by the coherence scores of this participant during the independent rehearsal portion of the first and second biofeedback session. The scores were 70% and 67% respectively. However, her coherence scores in the subsequent sessions were 97 to 100% suggesting the ability to master self-regulation over time.

Participant 3 also articulated an improvement in performance. “In passing or serve-receive, I can concentrate on the server and then pass a good “3” ball.” 36% and 35% of her passes during the preintervention and postintervention earned a score of “3”, which does not support an improvement in passing according to the scoring rubric.

However, one must also consider this participant only played in two games during the intervention due to injury. She passed the ball 246 times in the preseason but only 17 times in the postseason. During the first two sessions, participant 3 demonstrated difficulty in independent self-regulation as demonstrated by lower coherence scores. This improved over time (Table 9). She stated as one of the benefits of the intervention: "(It) helped me keep myself together, knowing that I can't play…able to control myself and my negative emotions."

The intervention assisted participant 4 to manage daily stress related to both athletic and academic rigors. She stated, "Everyone needs to stop and relax. This has helped me to be able to do that. To start off the day and end the day…it's a healthy lifestyle." During athletic competition, the participant emphasized: "the thing that's hard is tuning out the noise. I always thought was a huge deal and never thought I could do it. And that's something I've noticed that I can do now." …. "Personally, I felt like I better understood the game. I was looking for more things because I wasn't so scattered and so nervous." The participant identified with academics: "…before tests…I try not to cram, and I try to deep breathing [sic] before I go out….it will help me to relax." This participant demonstrated great ability to self-regulate with coherence scores between 96 to100%.

Participant 5 emphasized benefits in academics and athletics. She stated, "When I was stressed with homework, I would put it all away and sit there, and do it [QCT] with the handheld, and it would definitely help me not stress so much about it." "During dead balls, I'll just breathe…and it helps me just play. I don't think about technique or anything, I just play". This individual was one of four participants who had perfect coherence scores in all six biofeedback sessions.

Participant 6 explained that the intervention assisted her more in daily living and academics rather than athletic performance. She acknowledged, “Sometimes in games I feel good, and sometimes bad. I don't know if it [biofeedback] necessarily helped me. If I'm doing well, I take deep breaths. If I'm doing bad, it wasn't a time where I would think about doing my emWave.” She also emphasized that if the emWave PSR would stay red while she performed the QCT, she would worry. “I was competing against the emWave.” However, regarding daily activities the participant stated, “As soon as I become stressed, all of a sudden I think of doing the QCT.” “Also, the biggest relief…[was] when I was doing homework, I would really get stressed out and would stop for a second, do the techniques, and then…I could feel like I could continue with my homework.” This participant displayed lower coherence scores during sessions one and two which improved to perfect coherence scores during the remainder of the protocol, reflecting the ability to self-regulate with time.

The intervention assisted participant 7 in individual and team situations, and during daily activities. She stated, “I think the most that I used it [QCT] is during the games or during practice on the court…It just kind of calmed me down…you get too involved sometimes.” She acknowledged benefits for the team. “It gives us positive energy because then we're all smiling…it just gives us more of the positive feeling rather than the negatives.” When the participant wasn't playing she used the Quick Coherence Technique “at home, if I'm sitting around, or taking a break from homework.” She had independent self-regulation scores of 97 to 100% during the six biofeedback sessions demonstrating the ability to self-regulate.

The intervention provided participant 8 with a sense of control and confidence which assisted her during games. “It helped in stressful situations in games…when it was really nerve-wracking”….”I was having trouble with my serves. I would get really nervous and really rattled and would hit it long, or I would let everything that was going on around me affect my own play”.…”You tuned out everything and it worked. Even when I did miss it, I was calm…it gave you confidence.” Analysis of this participant's serving revealed the following: During the preintervention games she served 59 times (M = 2.49), and during the postintervention games she served 38 times (M = 2.45). However, considering all of the skills, she contacted the ball 191 (M = 3.11) and 285 times (M = 3.38) in preintervention and postintervention games, respectively, with a .27 mean increase in performance scores. She demonstrated great ability to self-regulate and summarized the biofeedback intervention in the following way. “Over the past six weeks…it is more clear that you have control of how you feel about things, and when you have these negative emotions you can stop it just by using this technique and just thinking about positive emotions… and using that for your life is a good thing to have.”

Participant 9 offered multiple benefits and detriments regarding the biofeedback intervention. It assisted her in academics in the following way. “When I had tests or homework or when I just wasn't feeling well. I felt better about myself afterwards.” She specified both benefits and detriments in athletics. “Individually, it kept me focused more…’OK, here we go.’” However, she also emphasized, “…it kind of relaxed me more, and sometimes I didn't want to be relaxed, and I wanted to be excited and energetic. Sometimes I would avoid doing it [QCT] if it was like right before a game or something like that just because I wanted to keep my energy up.” This participant was one of the four who displayed a perfect 100% coherence score for all six sessions demonstrating immediate ability to self-regulate.

Participant 10 did not identify the intervention to assist her with academics. She did emphasize as an athlete, “I think it has improved me, in that just stopping for a second and focusing back in…not getting frustrated and distracted. “ She contacted the ball 21 times in preintervention games (*M* = 3.33) and 59 times in postintervention games (*M* = 2.78) with no improvement in the amount of errors or perfect execution scores. She noted the intervention was helpful and used such descriptives as “calming purposes” and “relaxing.” She noted a negative aspect of the biofeedback intervention was its tendency to make her tired…”When I would breathe regularly, it would make me yawn.” Her coherence scores were lower in the first and second sessions (67 and 86%, respectively), with 100% coherence scores thereafter demonstrating the ability to self-regulate over time.

Participant 11 described mental benefits of the intervention that assisted her during athletic performance, and daily stress. “…able to calm myself down during stressful situations and focusing on the moment”….”get myself together out there [on the court]…result was a clear state of mind…not like blissfulness, but clear thinking.” Another benefit of the intervention occurred during activities of daily living. “Sometimes when I go to bed...if I have a lot on my mind, or restless [sic], I would do my deep breathing and positive thinking and I would seem to fall asleep quicker.” Her coherence scores ranged from 85 to 100% demonstrating the ability to self-regulate.

Participant 12 was the only individual that rehearsed the QCT with the emWave PSR while driving. “During traffic, I would put it [ear-piece] on my ear…and that helped a lot, because I wasn't mad or anything like that, it just calmed me down.” She also noted benefits related to athletic and academic endeavors. She stated, “I really liked knowing that I could do it on the court during practice…when either coach would get mad, or if the drill just wasn't working, and during a play, you could deep breathe between plays. I thought that was really cool…we can calm ourselves down.” This participant forgot about a test in class. She took deep breaths before the exam. “I focused and got it done, and I think I passed. I thought it was really cool cause I was stressing out.” She was one of the four participants who obtained a perfect 100% coherence score during all six biofeedback sessions demonstrating the ability to self-regulate.

The intervention enabled participant 14 to manage stress associated with student-athlete endeavors. One benefit related to increased awareness was addressed as, “being able to be more aware of the effects of breathing and positive emotion even in everyday life.” Another benefit related to athletic activity was emphasized as, “I'm a very competitive person. In situations where I make a mistake, I'd be more inclined to, in the past, get upset and myself and get mad. I think now I've been more inclined to take a step back, and breathe or just think of a good thought. It's not the end of the world, and its going to be OK.” The participant noted “before tests or a presentation, I'll get nervous. The result [of the QCT] is more relaxed, calm, at ease [sic].” Participant 14 also experienced one detrimental aspect of the intervention. “I get tired when I do it [QCT]…I get relaxed and kind of tired. I felt that more often when doing it [QCT].” She was also one of the four participants who obtained a perfect 100% coherence score during all six biofeedback sessions demonstrating the ability to self-regulate.

Summary

The 13 student-athletes from the recruited team competed on a nationally-ranked NAIA team and were high caliber athletes. They won and lost to the same teams in both preintervention and postintervention competitions. The statistical results from the performance rubric did not support an improvement in performance. However, during the interviews, many participants described the intervention to enhance individual and team performance.

The team's baseline coherence scores did not improve over the six weeks. However, the team's independent rehearsal coherence scores did improve during the six-week intervention demonstrating the ability to self-regulate at will as a team and individuals.

Through interviews, the researcher explored the participant’s perception of the biofeedback intervention and independent rehearsal using the Quick Coherence Technique and the portable emWave PSR. The findings displayed numerous benefits and a few detriments relating to the participants' role as students, individual volleyball players and team members. The participants identified the process of learning about biofeedback and self-regulation while visualizing their heart rhythm on the screen as an important component to its success. Physical and mental stress reduction relating to academics and athletics were also noted. Mindfulness, team camaraderie, and improvement in performance were specified. Potential detriments noted by a few participants included feelings of sleepiness and reliance on or competition with the emWave PSR. A case study approach was implemented to emphasize the distinct perspective of each participant and to identify relationships with the performance and coherence data.

CHAPTER 5: RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Overview of Research Design and Methodology

This study evaluated a six-week biofeedback intervention with emotional regulation on volleyball performance. The 13 participants were female student-athletes enrolled at a Christian university located in southern California. Each participant met with the researcher once a week for approximately 30 minutes of individual biofeedback training. A portable biofeedback device known as the emWave PSR was also provided for independent self-regulation. One sample and paired sample *t* tests were used to evaluate change in raw and mean performance scores. The process of self-regulation was evaluated using a repeated measure *ANOVA* and the perception of the intervention was explored using a three-question interview.

Discussion of Results

Performance

The recruited team was ranked fifth in the nation representing the NAIA. They won and lost to the same teams before and during the treatment intervention. These losses occurred to teams ranked second, third and fourth in the nation. The results of the one sample *t* test using the midpoint of the performance rubric revealed the advanced ability level of the team with 77% of the athletes having performance scores greater than three. This demonstrates the high caliber of athletes recruited for this intervention.

According to Petruzzelo et al. (1991), a cause and effect relationship between biofeedback and athletic performance is difficult to demonstrate. Similar difficulties are noted with the performance outcome of this research. The quantitative results from the performance rubric did not support the hypothesis that athletic performance would improve with the biofeedback intervention. However, many participants during the interview reported an improvement in physical and mental performance. A statistical and performance ceiling effect may be one contributor to the quantitative results as most players exhibited above average scores before and after the intervention. According to Breakwell et al. (2000), ceiling effects occur when individuals score too close to the top of the rating scale which was evident of this team. As a result, the dependent variable cannot accurately measure the full range of the independent variable. Consequently, small increases in improvement with advanced athletes are considered meaningful because the ceiling effect leaves only a small margin of improvement (Behncke, 2004).

Other confounders reflected in the performance results include the following. First, the intervention was initiated at the middle of conference play. This allowed eight of the ten games to be used in pretesting and posttesting. Before conference play, the team competed in 12 preseason games. Therefore, the intervention transpired after the team had already played 22 games reflecting a potential peak in team and individual scores.

Second, team dynamics and circumstances during the treatment intervention may have contributed to the performance results. One of the starting athletes did not play in most of the second half of the season due to injury. Another participant was suspended for two games, and a third player voluntarily removed herself from the team. These situations required other players to compete in unfamiliar positions and receive more playing time than expected. According to Weinberg and Gould (2007), a team's performance may fall short of its potential due to the complexity and climate of the group.

Self-Regulation

Coherence scores from the heart rhythm variability software were evaluated at two separate times during each biofeedback session. The first data gathering occurred at the beginning of the session as the participant was sitting quietly but not self-regulating. The hypothesis asserted that this coherence score would improve each week reflecting autonomic nervous system homeostasis and a positive psychophysiological shift. However, the results did not demonstrate such a trend. According to the heart rhythm feedback, the participant's heart rate was often elevated at the beginning of the session but reduced as the session progressed. This temporary elevation may have been contributed by the haste in which the participant walked to her biofeedback session or the fact that many sessions originated immediately after volleyball practice. It may have also been caused by state anxiety which reduced as the participant became more comfortable during the session. Regardless, the five minutes of data collection at the beginning of each session was useful for the participant to relax and prepare for the remaining intervention time. It also enabled the researcher to evaluate the participant's true psychophysiological state and address any concerns she was experiencing. Tiller, McCraty and Atkinson's (1996) statement supports this observation. “Heart rhythm variability is a window through which the ANS can be monitored” (p. 52).

The second data gathering occurred toward the end of the biofeedback session as the participant rehearsed the self-regulation steps while observing her heart rhythm on the computer screen. The participants demonstrated the ability to self-regulate at will, which supported the hypothesis. According to Bar-Eli, Dreshman, Blumenstein, and Weinstein (2002), it is important to build "on what athletes already do when systematically teaching them psychoregulatory techniques" (p. 571). Most athletes utilize deep breathing as a means to control competition anxiety or as a component of their preperformance regimen (Weinberg & Gould, 2007). Thus, it was a natural progression for the participants to implement emotional focus as a component of self-regulation. This may have contributed to their ability to master the process and transfer the self-regulation skill into activities of daily living.

Perception

Individual interviews explored the participants' perception of the biofeedback intervention, its benefits, and its detriments. The data was evaluated as a whole and organized into 13 case studies. According to Smith (1988), "The case study strategy is invaluable when the investigator is asking 'how' and 'why' questions about a set of contemporary events over which he has little or no control" (p. 3). Additionally, case studies provide insights into the effectiveness of performance enhancement techniques (Vernacchia, 1998). The results of the interview revealed the nuances of the biofeedback intervention and its impact on the student-athlete.

The first interview question was: "What was your experience attending the six biofeedback sessions and independently practicing the self-regulation techniques?" The participants acknowledged the biofeedback experience to be enjoyable and beneficial. Receiving instruction about biofeedback and self-regulation, visualizing the heart rhythm variability on the computer screen, and experiencing increased self-awareness were contributors to the intervention's success. The participants' accounts support this theme. “Learning and realizing that a couple of positive thoughts and deep breaths can change your whole attitude and mental state. I found that really interesting.” “It helped me see the results on the screen,” and “it made me more aware of coherence because I never even knew about any of that,” are a few of the comments made in support of this theme.

Daniels and Landers (1981), in their biofeedback study with Olympic and collegiate rifle shooters, considered the additional attention of the researchers and the use of high tech equipment to have a positive influence on the athlete's performance and their motivation to excel. This observation is also applicable in this study as described by the following response: “It was… nice to learn from you, just showing me how to do this on my own.” Furthermore, as demonstrated by the high coherence scores, the use of the innovative emWave PC equipment and hand-held emWave PSR may have encouraged the participants to independently practice the self-regulation techniques.

Increased control was the third theme that emerged from question one. “Being able to self-regulate and being able to control myself, like emotions…was nice,” and “Over the past six weeks…it is more clear that you have control of how you feel about things, and when you have these negative emotions you can stop it just by using this technique and just thinking about positive emotions… and using that for your life is a good thing to have.” These comments reflect the benefit of increase control.

According to Kavussanu et al. (1998), an increase in perceived control results as one gains control over autonomic responses from biofeedback training which may enhance performance. This theme became apparent from the responses to the second interview question: “Did you experience any benefits from the biofeedback intervention?" The participants reported benefits in their roles as students, individual athletes, and team members. Some stated: "When I was studying, it was late at night…I was just relaxed, I was coherent, and able to concentrate a lot better." "I wasn't really trusting myself, but then the breathing and the biofeedback helps you to trust yourself and be coherent. I think it helped overall as an individual player," and "When we [as a team] link up, we just so surpass everything that we ever think we could."

Learning strategies to reduce the effects of physical and mental stress are the sub-themes that emerged from the responses to question two. According to De Witt (1980), the ultimate goal of biofeedback interventions is to assist the client in perceiving detrimental responses to stress and substituting healthier responses. "When I was stressed with homework…I would put it all away and sit there and do it [The QCT]. It would definitely help me not to stress so much about it. I can step back and think about it." Another response supporting this subtheme is: "It just kind of calmed me down…you get too involved sometimes." Psychophysiological coherence allows one to transform feelings of stress and worry into productive energy (Childre, 2003). This transformation is noted in the following response, "It helped us…coach would say 'link up, link up' and it would create positive energy…it gave us a positive feeling rather than a negative one."

Ideal athletic performance states are the outcome of many biofeedback interventions (Hatfield & Hillman, 2001). According to Anshel (2003), these states include mental and physical relaxation, confidence, the ability to focus on the present, improved awareness, and increased control. Many participants reported such experiences from the intervention.

The third interview question was “Did you experience any negative aspects to the biofeedback intervention?” Over half of the participants denied any negative aspects. The detrimental experiences included: feeling too relaxed, experiencing a disruption in skill performance, and competing with or relying on the emWave PSR. Schwartz, Schwartz, and Monastra (2003) stated that some clients are habitually tense and unaccustomed to feelings of relaxation, thus psychophysiological coherence is unfamiliar and potentially undesirable. Another possibility might be that the intervention relaxed the participant too much and removed her out of her Zone of Optimal Functioning (ZOF), which would be counterproductive to performance (Zaichkowsky & Baltzell, 2001).

A disruption in performance might occur if the player was not able to comfortably self-regulate during skill acquisition. This occurrence was expressed by one participant, which suggests that the Quick Coherence Technique was not an automatic skill. Finally, competing or relying on the portable unit might transpire if the participant became too dependent on the device or used it too often (Schwartz et al.). One might consider the participant's competitive nature and temporarily reduce the biofeedback threshold to make higher feedback scores easier to obtain. This might be especially helpful during the first few weeks of biofeedback training as the athlete becomes accustomed to self-regulation.

Conclusions and Recommendations

Numerous problems with biofeedback use in sport were identified in the previous chapters. This biofeedback intervention has addressed many of these issues. First, biofeedback protocols for specific sports did not exist (Sime, 2003), and sessions were arbitrary (Gould & Uldry, 1994). Second, the use of multiple biofeedback devices and self-regulation strategies made the effect on performance difficult to understand (Petruzzelo et al., 1991). Finally, extensive training was often required for the clinician to utilize biofeedback (Sime), and heart rhythm variability using the integration of positive emotions during self-regulation was not implemented in sport.

These issues were resolved through this research and its results. First, a six-session, scripted protocol was used for this study (Appendix A). The protocol aligns with the recommendations established by the HeartMath Institute and Blumenstein et al. (1997). Each session required approximately 20-30 minutes to complete. This was ample time, as demonstrated by the high coherence scores, for the participants to rehearse self-regulation with supervision and feedback. The 100% attendance record suggests that the sessions were not too lengthy. It also suggests that the participants enjoyed the biofeedback intervention. The biofeedback protocol integrated audio, visual, and kinesthetic methods, which promoted understanding and compliance. The volleyball background noise used in sessions 3 through 5 could be substituted by sounds affiliated with any sport. The implementation of positive emotions as a component of self-regulation is a newer concept in biofeedback (McCraty et al., 2001). Since many athletes already utilize deep breathing as a part of their athletic routine (Weinberg & Gould, 2007) and the participants in this study displayed great ability to self-regulate, emotional self-regulation may be a natural progression to previously used mental skills training.

Biofeedback modalities, especially those that measure brain wave (EEG) and muscle contraction (EMG), can be intimidating and require extensive instruction (Sime, 2003). The emWave PC heart rhythm variability biofeedback is uncomplicated to learn and apply. It is also relatively inexpensive compared to many other biofeedback systems, and is convenient to use (Culbert et al., 2004). Sport psychology personnel, coaches, and athletic trainers are viable practitioners to use this intervention with athletes.

Although a direct relationship between the biofeedback intervention and improved performance was not confirmed by the quantitative analysis, the athlete's perception of the intervention was positive. The participants reported that the intervention influenced them as students, athletes, and team members. The participants gained greater awareness into their student-athlete lives, especially in areas of academic and athletic stress. Using the self-regulation skills, they learned how to control such areas and transfer the negative feelings of stress into positive energy. This may have resulted in improved academic and athletic performance. Although this finding was consistent with these participants, it cannot be generalized with other athletic populations. Further research with this team is warranted to determine if the intervention effects carried over. Research could also investigate whether the participants continued to practice the Quick Coherence Technique using the handheld emWave PSR after the completion of the study. This finding would evaluate long-term compliance and strength of the intervention. As noted earlier, the intervention was initiated during the middle of the season. Future analysis could be conducted earlier to measure changes in performance before it peaks. Furthermore, games following the completion of the intervention could be included in the analysis to identify delayed intervention effects.

Further research following this pioneer study is recommended. First, this heart rhythm variability biofeedback and intervention warrants investigation in other athletic venues, in both individual and team sports. It would be intriguing to evaluate performance outcomes with a less skilled team to negate the performance ceiling effect. Second, the emWave PC is currently implemented with groups of junior tennis athletes competing at tournaments. The athletes find the group atmosphere enjoyable and the results are promising (Mind Modulations, 2005). As individual biofeedback sessions were used in this study, it would be helpful to investigate the effects of the same intervention using group sessions. The intervention may be more practical to implement if athletes learned the self-regulation skills in a team setting.

Third, the researcher/practitioner did not provide additional training to the team during practices and games. One might explore if intervention effects improve by having additional contact with the players outside the sessions. The inclusion of such attention might augment the benefits of the intervention. The coaches could be offered the same intervention as their players to evaluate their perspective regarding individual and team coherence.

According to Casebeer and Verhoef (1997), qualitative studies can be initially implemented to explore innovative research which then provides data for instruments to be used in subsequent quantitative work. Numerous themes evolved from the qualitative data that warrant further investigation using quantitative measures. The effects of the biofeedback intervention on improved academic performance could be measured using each participant's GPA. Stress and anxiety could be measured using such scales as the Competititve State Anxiety Inventory (CSAI-2), or the Sport Competition Anxiety Test (SCAT). Team dynamics could be explored using the Group Enviroment Questionnaire (GEQ).

In summary, this research study evaluated the effects of an innovative heart rhythm variability biofeedback system on the athletic performance of women collegiate volleyball players. A newer approach to self-regulation using positive emotions was also included. The quantitative results supported the hypothesis that the team and its 13 participants were able to self-regulate at will. The quantitative results did not support the hypothesis that the intervention would improve performance, although a statistical and performance ceiling effect was present. The qualitative results revealed a positive perception of the intervention relating to the participants' role as students, athletes, and team members. Numerous themes and subthemes emerged from the interviews. These themes reflect the benefits of the intervention. (a) Learning about biofeedback and self-regulation while visualizing the heart rhythm on the computer screen. (b) Improving self-awareness and increasing self-control. (c) Reducing the effects of physical and mental stress relating to academic and athletic rigors. (d) Experiencing enhanced physical and mental states. (e) Improving academic and athletic performance. (f) Enriching team composure and camaraderie. Sport psychology personnel, coaches, and athletic trainers are qualified practitioners for implementing heart rhythm variability biofeedback in sport. Furthermore, this intervention has the potential to enhance academic and athletic performance for collegiate athletes.

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Appendix A

Six-Session Biofeedback Script and Protocol

Session 1

Biofeedback (Read with client)

Biofeedback is a treatment technique in which a clinician assists a client in developing strategies to gain voluntary control of their body using self-regulation skills. Biofeedback is similar to a bathroom scale or thermometer as data is “fed back,” informing you of a recent weight gain, or a temperature. By making changes in your diet, or taking medication, you respond to the feedback provided.

Heart rhythm variability (Read with client)

Heart rhythm variability is a popular kind of biofeedback, measuring changes in heart rate and waveform. It is recorded through an electrocardiogram (ECG), a fingertip or earlobe sensor and plots your heart beats as a pattern on the computer screen. Heart rate variability demonstrates the interaction between the heart and the brain and the dynamics of the autonomic nervous system (ANS). A normal heart shows variations in pattern with changing rates depending on your physical and emotional state. For example, during mental, emotional or prolonged physical stress, the ANS becomes imbalanced which is demonstrated on the computer screen by erratic heart rhythms. However, when the ANS is balanced, the heart rhythm is smooth and consistent and the mind and body are in sync and working well with each other. This is similar to an athlete playing in “the zone” or experiencing “flow” where movement and performance are effortless. Through practice, you will learn to balance your heart and mind, which results in improved health and well being.

Connect and demonstrate the Em-wave PC using finger sensor

1. Launch emWave PC.

2. Demonstrate and connect the finger sensor: The computer will detect your pulse and transmit the impulses onto the screen.

3. Click on the heart rhythm display and the start button.

4. Identify that the finger sensor is picking up a clear signal. Verify that the challenge level is set to “normal.”

5. Collect BASELINE DATA for 5 minutes before explaining components of the screen. Stop and save data. Remind client to refrain from moving or talking during this time (S1: BD).

6. Describe the screen: The heart rhythm variability screen is on the top, the accumulated coherence score screen is on the bottom left, and the coherence ratio scores is located on the bottom right.

Psychophysiological coherence (Read with client).

When heart rhythms show a smooth, consistent pattern on the computer screen, it is referred to as coherence; the higher the coherence, the greater the balance. (Review client's baseline feedback). Research shows that slow and deep breathing will result in coherence, although one cannot sustain this state for long periods. However, with emotional regulation, coherence is maintained and readily achieved at will. When physiological coherence is driven by a positive emotional state it is called psychophysiological coherence.

7. Collect 2 minutes of guided practice: breathe with the heart rate. Stop and save data. “Guided practice: breathe with HR”

Quick Coherence Technique (Read with client)

The Quick Coherence Technique is a three-step process that assists you in achieving coherence. The first step, “Heart focus” guides you to focus your attention in the area around your heart. The second step is “Heart breathing,” As you continue to focus on your heart, visualize that you are breathing slowly and gently through your heart until you find a natural inner rhythm that feels good. The third step is “Heart feeling.” As you continue to breathe through your heart, think and experience a positive feeling such as appreciation, care, or compassion. This could be the thought of a loved one or a pleasant memory that promotes good feelings. Once you've thought of a positive feeling or memory, sustain it by continuing “heart focus,” “heart breathing” and “heart feeling.” Practice without feedback for 2 minutes.

8. Collect 5 minutes of guided practice: QCT Stop and save data. Use these numbers as the COHERENCE SCORE for session one. S1:IR

9. Review Session 1 feedback with client noting changes in coherence from baseline to 3rd data set.

10. Provide and instruct how to use the emWave handheld. Record #

11. Provide and explain the practice diary and tracking system: FORM. (read with client)

This is the form that you will receive each week to track your practice of the QCT, and to note any physical or emotional changes. You can practice this simple 3-step technique to assist you in achieving high coherence just as we saw today during your session. You can use it with or without the emWave. Through daily practice of the QCT, you will find changes in your emotional and physical state such as a reduction in stress, pain, or anger. You may also experience more energy, increased focus, and greater performance in volleyball. Please post this form in a place that is visible to you as a way to remind you of your practice. You will find, in time, that you will reflexively turn to the QCT technique throughout the day as you experience its benefits. Please bring this completed form with you to next week's session. Any questions?

12.Schedule next session and give appointment card.

Session 2

1. Collect and review practice diary for week one. Any questions? Include part # and dates. When was practicing most beneficial for you? Record data on the back of the form.

Connect the emWave PC using fingertip or earpiece: Participant No? Level two difficulty?

2. Collect BASELINE DATA for 5 minutes: Turn computer screen away from client and instruct not to use any self-regulation techniques during this recording, but rather sit quietly and reframe from talking or moving (S2: BD).

3. Review last week's script: biofeedback, heart rhythm variability, psychophysiological coherence, and the Quick Coherence Technique. See script from week one. Any questions?

4. Review QCT using the “coherence coach” computer guide on the desktop (3 minutes).

5. Collect 5 minutes of independent practice. Stop and save data Use this score for the COHERENCE SCORE for session two (S2:IR).

6. Review the data from session one and two: (1) S1: BD (2) breathe with HR (3) S1:IR (4) S2: BD (5) S2:IR

7. Preview games that will be implemented next week while a recorded volleyball game is being played.

8. Provide a new practice diary for the upcoming week. (read the following with client)

Rehearsing the QCT in a variety of emotional states and environments will assist you in transferring its benefits to all aspects of your life. So, its important that you rehearse the technique in both quiet and noisy environments; when you are by yourself and when you are in a group of people; when you are relaxed, happy, and at ease and when you are stressed, anxious, angry or sad. When might you anticipate such situations this week? Mark on journal.

9. Schedule next session and give appointment card.

Session 3

1.Collect and review practice diary for week two. Any questions? Include part # and dates. When was practicing most beneficial for you? Circle incident and record data on back of form.

Connect the emWave PC using fingertip or earpiece: Participant No? Level two difficulty?

2. Collect BASELINE DATA for 5 minutes. Turn computer screen away from client and instruct not to use any self-regulation techniques during this recording, but rather sit quietly and reframe from talking or moving (S3: BD).

3. Collect 5 minutes of independent practice. Stop and save data Use this score for the COHERENCE SCORE for session three (S3:IR).

4. Collect 3 minutes of GARDEN GAME. Explain that through "heart focus, heart breathing, and heart feeling" the screen will progressively change from black to color as your coherence score increases. Play recorded volleyball game. Next week you will play the rainbow game.

5. Review data from sessions 1-3 to demonstrate trends and progress.

6. Submit new practice diary for the upcoming week: Summarize the following with the client:

Rehearsing the QCT in a variety of emotional states and environments will assist you in transferring its benefits to all aspects of your life. So, its important that you rehearse the technique in both quiet and noisy environments; when you are by yourself and when you are in a group of people; and when you are relaxed, happy, and at ease and even when you are very stressed, angry or sad.

7. Schedule next session and give appointment card.

Session 4

1. Collect and review practice diary for week two. Any questions? Include part # and dates. When was practicing most beneficial for you? Circle incident and record data on back of form. Inquire if athlete is using the QCT spontaneously throughout the day. Request the athlete to explain the experience.

Connect the emWave PC using fingertip or earpiece: Participant No? Level two difficulty?

2. Collect <u>BASELINE DATA</u> for 5 minutes: Turn computer screen away from client and instruct not to use any self-regulation techniques during this recording, but rather sit quietly and reframe from talking or moving. (S4:BD)

3. Collect 5 minutes of independent practice at level two. Stop & save data. Use this score as the <u>COHERENCE SCORE</u> for session four. (S4:IR)

4. Collect 5 minutes of RAINBOW GAME. Explain that through "heart focus, heart breathing and heart thinking," a rainbow will appear on the screen with a pot of gold that slowly fills with coins as your coherence score increases but will remove coins if the coherence score decreases. Play recorded volleyball game during this exercise. Stop and save data (S4: Rainbow) Next week you will play the balloon game.

5. Review saved data from sessions 1-4 to demonstrate and discuss progress.

6. Submit new practice diary for the upcoming week: Explain the following with the client:

Rehearsing the QCT in a variety of emotional states and environments will assist you in transferring its benefits to all aspects of your life. So, its important that you rehearse the technique in both quiet and noisy environments; when you are by yourself and when you are in a group of people; and when you are relaxed, happy, and at ease and even when you are very stressed, angry or sad.

7. Schedule next session and give appointment card.

Session 5

1. Collect and review practice diary for week four. Any questions? Include part # and dates. When was practicing most beneficial for you? Circle incident and record data on back of form. Inquire if athlete is using the QCT spontaneously throughout the day. Request the athlete to explain the experience.

Connect the emWave PC using fingertip or earpiece: Participant No? Level two difficulty?

2. Collect BASELINE DATA for 5 minutes: Turn computer screen away from client and instruct not to use any self-regulation techniques during this recording, but rather sit quietly and reframe from talking or moving (S5: BD).

3. Collect 5 minutes of independent practice. Stop & save data Use this score as the COHERENCE SCORE for session five (S5:IR).

4. Collect 10 minutes of BALLOON GAME. Explain that through "heart focus, heart breathing and heart feeling," a hot-air balloon will appear on the screen and will soar fast and high above the ground as your coherence score increases, and will slowly return to earth as your coherence score decreases. The course will also end before 10 minutes if your coherence score remains high. Play recorded volleyball game during this exercise. Stop and save data (S5: Balloon).

5. Review hard-copy data from sessions 1-5 to demonstrate and discuss progress.

6. Submit new practice diary for the upcoming week: Summarize the following with the client.

Rehearsing the QCT in a variety of emotional states and environments will assist you in transferring its benefits to all aspects of your life. So, its important that you rehearse the technique in both quiet and noisy environments; when you are by yourself and when you are in a group of people; and when you are relaxed, happy, and at ease and even when you are very stressed, angry or sad.

7. Schedule final session and give appointment card.

Session 6

1. Collect and review practice diary for week five.

Connect the emWave PC using fingertip or earpiece: Participant No? Level two difficulty?

2. Collect BASELINE DATA for 5 minutes: Turn computer screen away from client and instruct not to use any self-regulation techniques during this recording, but rather sit quietly and reframe from talking or moving (S6: BD).

3. Collect 5 minutes of independent practice. Stop & save data Use this score as the COHERENCE SCORE for session five (S6:IR).

4. Review hard copy and computer data from sessions 1-6 to discuss progress. Discuss maintenance and future practice of the QCT with and without the use of the em-wave for long-term benefits.

5. Administer the audiotaped interview to gather information regarding the student-athlete's perception of the treatment.

Appendix B

Rubric for Volleyball Performance

Hitting

1-Error
2-Give a free ball to opponent
3-Opponent can't run a multiple offense
4-Receive a controlled free ball
5-Kill

Passing

1-Error/Aced
2-Overpass
3-Team can only run one option in their offense
4-Team can run two options in their offense
5-Team can run multiple options in their offense

Digging

1-Error (Shank, overpass kills, ball drops)
2-Team has no attack option
3-Middle of the floor (Team has one good option)
4-High dig to 10 ft line (Team has all offensive offenses)
5-Dig to kill

Serving

1-Error
2-Opponent has three options on offense
3-Opponent has two options on offense
4-Opponent has one option on offense
5-Ace

Appendix C

Quick Coherence Technique

Step 1: Heart Focus: The first step is to focus your attention in the area of the heart.
Step 2: Heart Breathing: As you continue with your focus on the area of your heart, visualize that you are breathing through your heart. Breathe slowly and gently in to a count of five or six, and slowly and easily out through your heart to a count of five or six. As you continue to breathe with ease for a few moments, you will find a natural inner rhythm that feels good.
Step 3: Heart Feeling: Continue to breathe through your heart, and think of a positive feeling such as appreciation, care, or compassion. Once you've experienced a positive feeling or attitude, sustain it by continuing your heart focus, heart breathing, and heart feeling

Suggestions when to practice this technique include, but are not limited, to the following: When you wake in the morning, before volleyball practice/game, between dead balls during practice/games, in the evening before you go to sleep, and any other time you feel increased stress, anxiety or frustration. You can also practice the QCT with the use of the handheld *Em-Wave* to observe the response of your heart rhythm. Please record your practice times below and provide any information regarding your emotional and physical state at the time you practiced the QCT, and immediately after. This will help you identify the subtle and dramatic changes that will occur through this self-regulation process. Please bring this form to the researcher/clinician at your next biofeedback session.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
AM practice Feelings before Feelings after							
Before VB practice/game Feelings before Feelings after							
Between dead balls during practice/game Feelings before Feelings after							
PM practice Feelings before Feelings after							
Other times throughout the day Feelings before Feelings after							