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FEATURE

Heart Rate Variability Biofeedback as a Strategy for Dealing with Competitive Anxiety: A Case Study

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Heart rate variability (HRV) biofeedback (BFB) is a relatively new approach for helping athletes to regulate competitive stress. To investigate this phenomenon further, a qualitative case study examined the impact of HRV BFB on the mood, physiology, and sport performance of a 14-year-old golfer. The golfer met once per week at a university lab for 10 consecutive sessions of HRV BFB training that included breathing at a frequency of 0.1 Hz. The format and duration of sessions followed the HRV BFB protocol outlined previously by Lehrer, Vaschillo, and Vaschillo. Acute increases in total HRV, low-frequency HRV, and amplitude of oscillation at 0.1 Hz were observed during biofeedback practice. This effect became stronger across sessions, suggesting increases in baroreflex gain. Following HRV BFB, the golfer achieved his personal record score for 18 holes of golf, and his mean golf score (total number of shots per 18 holes of golf) was 15 shots lower than in his previous golf season. The golfer received no golf instructions during HRV BFB training. The results of this case study suggest that HRV BFB training may help the athlete cope with the stress of competition and/or improve neuromuscular function.

Introduction

The term "heart rate variability" (HRV) refers to a measure of the beat-to-beat changes in duration of the RR intervals (RRIs) in the electrocardiogram (ECG). The RRI, or interbeat interval, is the distance between one R-spike and the next in the ECG. Psychophysiological models consider HRV as a measure of the continuous interplay between sympathetic and parasympathetic influences on heart rate that yield information about autonomic flexibility and thereby represent the capacity for regulated emotional responding (Applehans & Luecken, 2006). The activation of the sympathetic branch of the autonomic nervous system (ANS) increases heart rate, while the activation of the parasympathetic branch, primarily mediated by the vagus nerve, slows it. Variation in heart rate can be caused by a variety of factors, including breathing, emotions, and various physical and behavioral changes. The heart rate changes as well in response to internal body rhythms, many of which reflect various homeostatic control systems. In general, high HRV represents a flexible ANS that is responsive to both internal and external stimuli and is associated with fast reactions and adaptability. Diminished HRV, on the other hand, represents a less transient, less flexible ANS that is less able to respond to stimuli change (Giardino, Lehrer, & Feldman, 2000). It follows that HRV may provide a promising index of an athlete's ability to respond to both physical and emotional stress and thus of the capacity to perform physically at maximal levels.

Strategies for Managing Competitive Stress

A number of stress reduction exercises have been described in the sport psychology literature to treat child athletes' symptoms of competitive stress. Studies have dealt with the influence of relaxation techniques on anxiety in sport, as well as the integration of cognitive behavioral therapies to diffuse stress in a number of anxiety-provoking sport situations, ranging from athletic practice to competition. The development of mental rehearsal skills has been a staple of traditional sport psychology interventions (Cummings & Hall, 2002). The purpose of imagery interventions has been to reduce state anxiety by familiarizing the athlete with a specific sport task. Through mental simulation of a stress-evoking situation in sport, the athlete is believed to get the "feel" of successful sport-specific motor performances and reduce precompetitive anxiety. Many protocols call for athletes to vividly re-create a particular stress-eliciting situation in their minds and draw attention to the sensation of stress in the body. Yet the vast majority of such relaxation techniques aim to relieve the psychophysiological symptoms of stress rather than address the source of autonomic imbalance in the body.

Resonance Frequency Breathing

According to Vaschillo, Lehrer, Rishe, and Konstantinov (2002), the cardiovascular system is characterized by specific resonance frequencies of HRV that exist at a specific frequency for each individual, within the low-frequency range (0.05–0.15 Hz) of HRV. The spectral distribution of HRV is organized into conventional frequency ranges specified by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996) and in other consensus papers, for instance, Berntson et al. (1997). The resonance frequency for each individual can be detected as the frequency at which maximum HRV is produced, when the system is rhythmically stimulated at that frequency. The resonance frequency in HR for most individuals is close to 0.1 Hz, or about six cycles per minute.

One ready source of rhythmical stimulation to the cardiovascular system is respiration. In a phenomenon known as "respiratory sinus arrhythmia," vagus nerve activity shows a rhythmical ebb and flow associated with rate of respiration. Breathing at about six breaths per minute activates these resonance properties and induces high-amplitude oscillations in heart rate at 0.1 Hz. Individual factors such as total blood volume can render the resonance frequency slightly higher or lower than 0.1 Hz (six cycles/minute). Resonance in the cardiovascular system at 0.1 Hz is caused by frequency characteristics of the heart rate closed loop of the baroreflex system, through which blood pressure changes are modulated by changes in heart rate (Vaschillo et al., 2002, 2006).

Breathing at one's resonance frequency activates and strengthens the heart rate baroreflex system and thereby strengthens an important source of ANS modulation (Giardino et al., 2000; Lehrer et al., 2003). Increased gain in the baroreflex is found both acutely and chronically after biofeedback training (Lehrer et al., 2003). HRV biofeedback (BFB) training appears to bestow a number of benefits to the system. These include (a) maximizing respiratory efficiency by making blood more available when oxygen concentration in the alveoli is at a maximum during inhalation (Giardino et al., 2000); (b) decreasing hypoxic ventilatory response while improving oxygen saturation and increasing resistance to hyperventilation (Bernardi, 2001); (c) increasing the efficiency of the baroreflexes that indirectly modulate general emotional reactivity (Lehrer et al., 2003); and (d) improving the ability of the cardiovascular system to adapt to circulatory requirements (Landeau, Turcotte, Desagne, Jobin, & Boulet, 2000). This results in a system-wide energy efficiency and metabolic energy savings that has been demonstrated to enhance athletic performance.

Literature Review of HRV BFB and Sports Applications

Vaschillo and Rishe (1999) and Vaschillo, Visochin, and Rishe (unpublished data) applied HRV BFB with resonance frequency breathing at the Lesgaft Sport University in St. Petersburg, Russia, to 30 elite wrestlers with encouraging outcomes. The training group, consisting of 15 wrestlers, performed 20 minutes of HRV BFB twice per day for 10 consecutive days. The control group, consisting of an additional 15 wrestlers, did not perform respiratory training. Vaschillo and colleagues found that when athletes breathed at individual cardiac resonance frequencies, they increased the amplitude of their heart rate oscillations. In addition, heart rate decreased (while HRV increased), blood pressure normalized, and skin temperature increased. Further, the group trained in HRV BFB demonstrated a reduction in reaction time, as well as speed of recovery in relaxation of quadriceps muscles, as compared to no change in the control group. Through the implementation of HRV BFB, Vaschillo and colleagues enabled athletes to maintain a state of autonomic balance marked by a cessation of sympathetic dominance during competitive challenges.

Strack (2003) also examined the effects of HRV BFB on high school batting performances in baseball. He reported that the HRV BFB group improved greater than 60% more in batting performance than the control group. In addition, he found that the HRV BFB group demonstrated an increase in the percentage of total low frequencies in the heart rate spectrum.

Raymond, Sajid, Parkinson, & Gruzelier (2005) compared dance performances of 24 Latin and ballroom dancers. Twenty-four participants from a college dance team were randomly assigned to an alpha-theta neurofeedback, HRV BFB, or a no-treatment control condition. Findings indicated that HRV and neurofeedback improved the dance performances of individuals as compared to the no-treatment group. The subscale of timing was increased by neurofeedback, while the subscale of technique was increased by HRV BFB.

All three research studies reported HRV BFB as safe with no side effects. Yet, because of the limited evidence that HRV BFB can be used to enhance sport performance, the sport and psychophysiological community may justifiably question whether these preliminary results can be replicated among varying populations of athletes. Further research is needed to evaluate and define the utility of HRV BFB for athletes of multiple ages, skill levels, and sporting types.

The objective of this case study, therefore, was to evaluate the utility of HRV BFB as a strategy for reducing competitive anxiety in a 14-year-old golfer and to encourage further research in this area. This study was based on the hypothesis that HRV BFB can be used as a coaching tool for young athletes to learn how to regulate emotions and improve their functioning in sports practice, competitions, as well as their

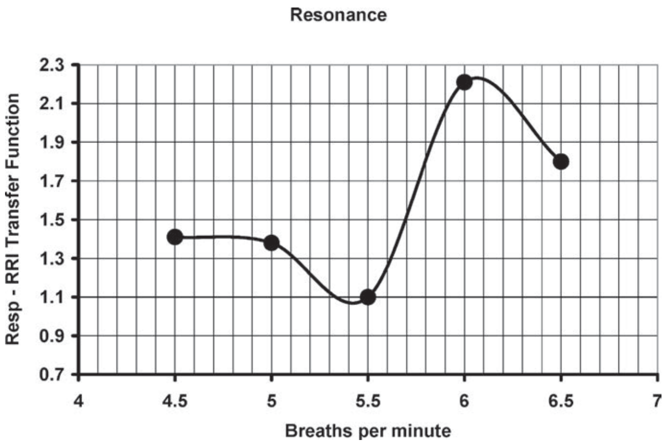

Figure 1. Participant's resonance frequency determination. To determine resonance frequency, the participant was asked to breathe following the pacer at five frequencies, including 4.5, 5.0, 5.5, 6,0, and 6.5 breaths per minute. HR and respiration frequency spectra and transfer function (TF) between respiration as the input and RRIs as the output were calculated separately for each frequency. The TF was computed as a quotient through dividing HR spectral power by respiration spectral power at each frequency. Thus, the TF shows HR response to respiration when participant breathes at each frequency with the same depth of breathing. Resonance frequency is where the TF is at the maximal value.

day-to-day lives. The following information will introduce the background of the participant, methods, and findings associated with HRV BFB training. A larger scale study with collegiate golfers at Rutgers University is underway at our laboratory.

Background of Participant

The participant in this applied case study was a 14-year-old competitive golfer beginning his first year of high school competition. He had played golf since the age of seven, had been an all-state competitor in elementary and middle school, and had lived and trained at a golf academy for the previous two and a half years. During the golf season prior to HRV BFB training, the participant had maintained an average score of 91 in an 18-hole golf competition and an average score of 70 during an 18-hole golf practice. He attributed this discrepancy to his inability to manage stress and anxiety during competitions and cited a general fear of negative social evaluation. He described several panic episodes marked by shortness of breath, rapid heart rate, sweating, and fear of losing control while playing in golf competitions. He experienced similar symptoms during school exams and when speaking in front of audiences. Panic attacks did not occur, however, in golf practice. With his parents' consent, the golfer sought assistance to improve his performance in competition from a sport psychology consultant. During the 10 weeks of HRV BFB training, the golfer did not receive any professional golf instruction or training.

Method

Procedure

The 10-week HRV BFB protocol designed by Lehrer, Vaschillo, and Vaschillo (2000) was implemented with the participant. The protocol integrated 10 HRV BFB training sessions that were conducted at a university lab. Each session lasted 45–60 minutes, included four tasks (A: baseline, B and C: biofeedback training, and D: baseline) for five minutes each. Sessions 1, 4, 7, and 10 served as recording sessions. In the first session, the golfer's resonance frequency was defined as 0.1 Hz (Figure 2). ECG and respiration were recorded during all four tasks. In each recording session, measures of mood and anxiety were obtained. Sessions 2, 3, 5, 6, 8, and 9 were performed without physiological record. During sessions the participant was taught to breathe slowly at his own resonance frequency (but not too deeply) using abdominal and pursed lips breathing techniques. Also the participant was asked to engage in two 20-minute breathing practices each day at home using the "StressEraser" device (Helicor, New York). The participant submitted a weekly log of his score per round (e.g., 18 holes) in golf competition to the experimenter.

Psychological Measures

The Profile of Mood States (POMS): The 65-item POMS measures six mood states, including anger, confusion, depression, fatigue, tension, and vigor, and yields one overall score. The POMS possesses high levels of reliability, with alpha coefficients from 0.80 to 0.91 (McNair, Lorr, & Droppleman, 1971). Further, the POMS has been used extensively in sport psychology research with over 250 sport-related published papers since its introduction (LeUnes & Burger, 1998).

Because the POMS did not address the full range of positive mood states that also influence sport performance,

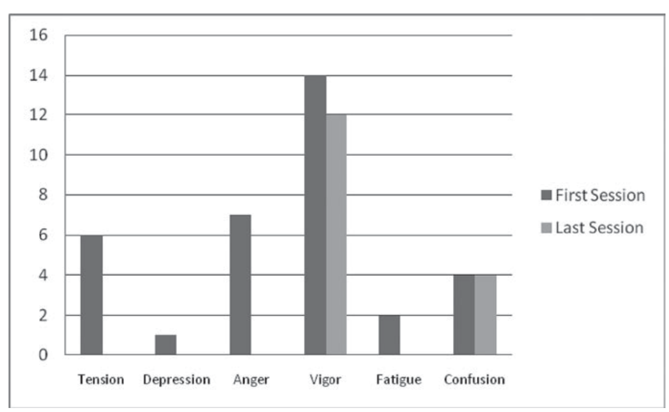

Figure 2. Profile of Mood States (POMS) form. Results on POMS demonstrated significant improvements in tension, anger, depression, and fatigue through HRV BFB training.

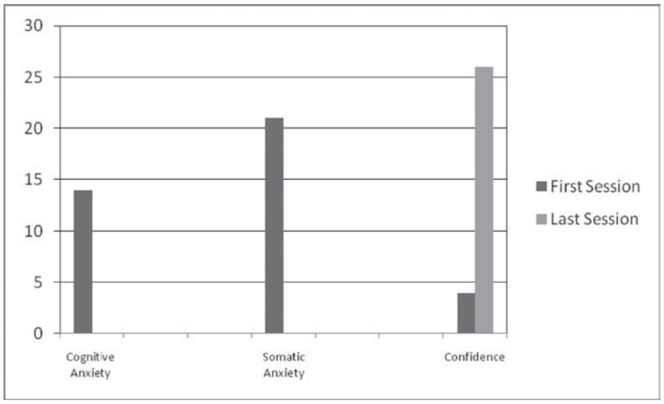

Figure 3. Competitive State Anxiety Inventory (CSAI-2). A comparison between pre and post scores on the CSAI-2 revealed that the golfer felt markedly less anxious prior to golf competition and significantly more confident about his ability to perform.

such as confidence and calmness (Hanin, 2000), the Competitive State Anxiety Inventory (CSAI-2) was used to assess participants' affect and cognitions about competition. Developed by Martin et al. (1990), the CSAI-2 consists of 27-items, each rated on a Likert scale from 1 ("not at all") to 4 ("very much so"). The 27 items represent three nine-item subscales, including somatic anxiety, cognitive anxiety, and self-confidence. Each scale yields a separate score ranging between 9 and 37. Alpha coefficients ranging between 0.79 and 0.90 demonstrate a high degree of internal consistency for the CSAI-2 subscales.

Physiological Measures

A J&J Engineering (Poulsbo, WA) I-330 DSP-12 physiograph unit was used to collect ECG and respiration data. ECG data were collected at a rate of 500 samples per second. To measure ECG activity, a negative electrode was attached to the upper part of the right arm, a positive electrode was attached to the lower part of the left leg, and a ground electrode was attached to the upper part of the left arm. To record respiration, we used two strain gauges: one placed around the abdomen at the level of the navel, and one at the level of the upper chest (thoracic placement). As the gauge stretched, the voltage across the tube changed, and relative changes in length were measured with a range of 0–100 units of relative strength.

Performance Measures

To measure golf performance, the participant recorded his weekly score per golf round. This score represents the number of strokes required to complete 18 holes of golf. He recorded his weekly golf scores for 10 weeks each sport season.

Data Analysis

Raw ECG data were analyzed using the WinCPRS software program (Absolute Alien Oy, Turku, Finland). Beat-to-beat RRIs were assessed from the ECG signal. A spectral analysis of RRIs and respiration was performed for each 5-minute task. Total, low-frequency, and high-frequency HRV indices were calculated. Cross-spectral analysis was used to calculate coherence[1] between heart rate and respiration curve.

Results

Compared to the first baseline session, changes were found in affect, physiology, and sport performance following HRV BFB training.

Affect

The severity of the golfer's self-reported unpleasant moods was reduced following HRV BFB. As indicated in Figure 2, the golfer showed reductions in four out of five negative mood states between session one and session ten on the POMS. Notably, he reported a complete absence of tension, depression, anger, and fatigue after 10 weeks of training. There was a minimal decrease in vigor, from a score of 14 to a score of 12. There was no reported change in confusion, which remained at a four. The golfer's cognitive and somatic anxiety was also reduced, as measured by the CSAI-2. As demonstrated in Figure 3, cognitive and somatic anxiety scores were 14 and 21 in the first session, respectively; the golfer reported experiencing no cognitive or somatic anxiety in the final session. Self-reported confidence increased from a score of 4 to 26 through HRV BFB training. A score of 4 in the initial session indicated that the golfer had lower confidence than the average high school male athlete ($M = 24.5$, $SD = 5.52$; *Competitive Anxiety in Sport*, 1990). A score of 26 in the tenth session demonstrated that the golfer possessed higher confidence than approximately 50% of high school male athletes.

Physiology

High-amplitude 0.1Hz oscillations in heart rate, blood pressure, and vascular tone at the golfer's resonant frequency also were elicited during HRV BFB. The phase shift between HR oscillation and the respiration curve at 0.1 Hz was close to 0°, that is, HR increased during inhalation and decreased during exhalation (Figure 4). Heart rate was synchronized with respiration with a coherence equal

[1] Cross-spectral coherence assesses the interrelationship and overlap in spectral properties of two time series. High coherence between respiration and HRV would occur if a large component of HRV consists of respiratory sinus arrhythmia. In normal breathing rates, spectral coherence is generally high in the high-frequency HRV range (0.15–0.4 Hz).

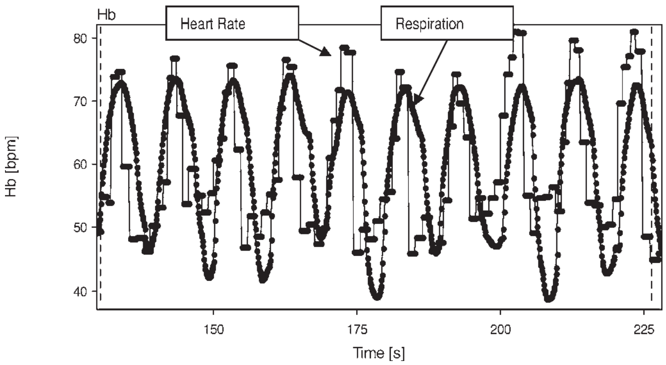

Figure 4. Example of heart rate-respiration synchronization. High synchronization is an evidence that participant was breathing at resonance frequency.

to 0.983. Results show that total HRV[2] (Figure 5a) and LF HRV (Figure 5b) considerably increased during HRV BFB procedure. This effect became stronger across sessions. HF HRV (Figure 5c) decreased during the HRV BFB procedure (tasks B and C) in comparison with baseline (tasks A and D), whereas it considerably increased across sessions. Results show that total, LF, and HF HRV in baseline (task A and D) cumulatively were increasing.

Sport Performance

As illustrated in Figure 6, there was a reduction in mean golf scores after 10 weeks of HRV BFB training. In the season prior to training, the golfer completed an 18-hole golf competition in 91 strokes on average; in the season following training, his mean score decreased to 76 strokes.

Discussion and Future Directions

Training in HRV BFB was followed by large acute and chronic effects on indices of autonomic function, decreases in anxiety and various other negative mood states, and improved athletic performance in this young elite athlete. The mechanism for emotional and performance effects may be biofeedback effects on autonomic regulation. HRV BFB elicits high-amplitude oscillations in the cardiovascular functions, which in turn train autonomic reflexes (Lehrer et al., 2003). The increase in LF and total HRV within sessions reflects resonance effects. The increases in LF HRV at task A across sessions may reflect increased resting baroreflex gain. The large increase across sessions at task A in HF HRV suggests a longer-term increase in vagus nerve activity. There is evidence that HRV BFB elicits high-amplitude oscillations in cardiovascular functions, which in turn trains autonomic reflexes (Lehrer et al., 2003). This training restores autonomic balance and improves autonomic control that supports emotional regulation and movement coordination.

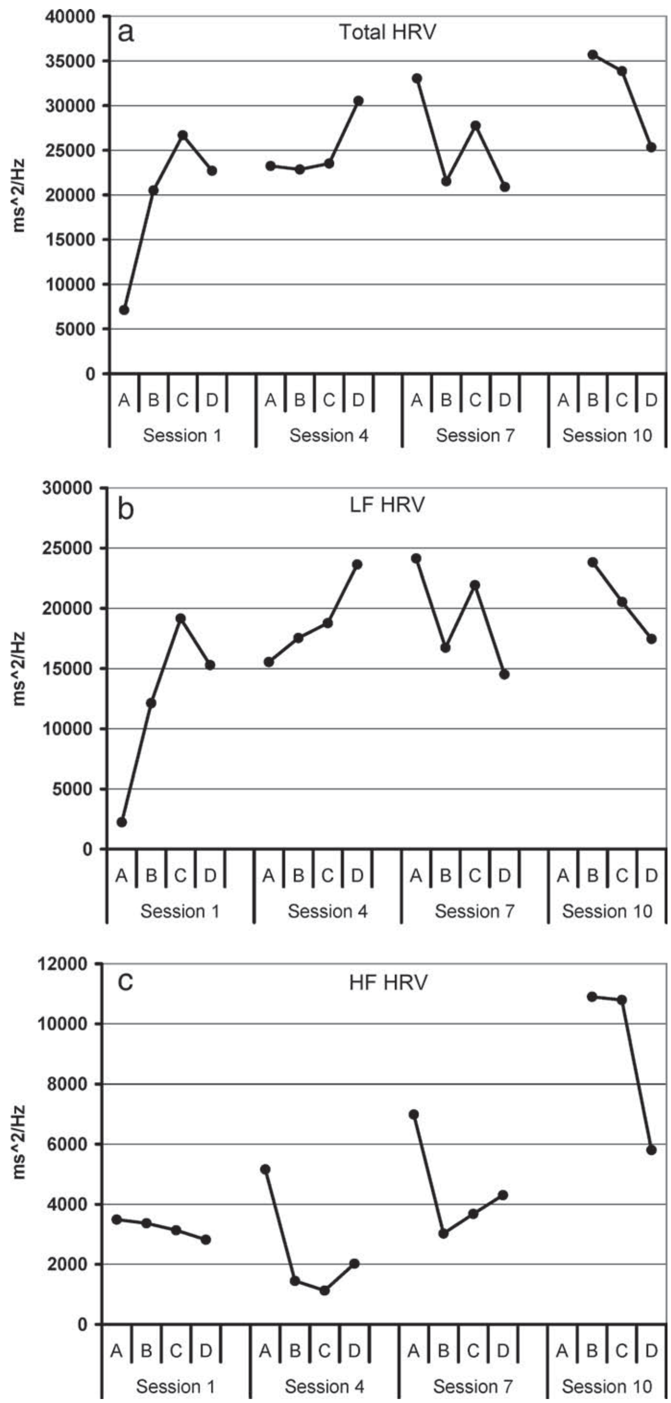

Figure 5. HRV indices across tasks (A, B, C, D) and sessions (1, 4, 7, 10). Increase of total HRV, LF HRV, and HF HRV indices across sessions supports the hypothesis that 10 weeks HRV biofeedback training cumulatively activates and improves autonomic function regulation.

[2] High-frequency HRV (HF HRV) is defined as the frequency component from a Fourier analysis between 0.15 and 0.4 Hz. It usually reflects respiratory sinus arrhythmia, which is mediated by the vagus nerve. Low-frequency HRV (LF HRV) is the component between 0.05 and 0.15 Hz; it appears to have both sympathetic and parasympathetic mediation and is highly correlated with baroreflex activity (Task Force, 1996; Berntson et al., 1997).

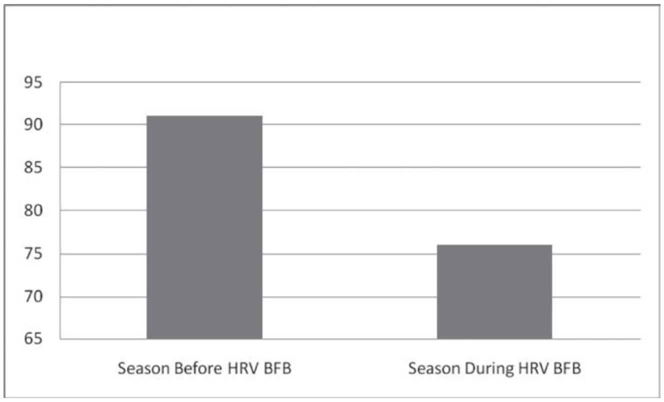

Figure 6. Mean score for 18 holes of golf. Data from pre and post 10 week HRV BFB training indicated significant performance gains. The golfer reduced his mean golf score approximately 15 strokes in an 18-hole golf game.

Future Directions

The golfer's weekly homework logs indicated regular and consistent practice for two 20-minute sessions, six days per week throughout the study. In addition, the golfer reported implementing breathing skills as needed on the golf course. We note that the notion that other golfers, or athletes of any sport type, are able to automatically transfer skills learned in the laboratory to sport performance is not yet supported by evidence. According to the deliberate practice theory, expertise is generated from the development of domain-specific knowledge structures and skills acquired through the process of adaptation and practice (Singer and Janelle, 1999). The development of an automatic process of resonance breathing may be possible but would likely involve extensive, massed practice (consistent stimulus-response mapping) in relevant emotional states and environmental contexts. Further questions concern how biofeedback skills should be taught, applied, and practiced in sport.

Future research may also extend beyond the physiological and psychological domains to include other interesting and important aspects of young athletes' lives. Indices such as substance use, academic grade point average, and number of skipped sport practices would be important measures to gauge how the development of self-regulation skills help define behavioral outcomes.

Caveats and Limitations

It is uncertain whether the immediate training effects of HRV BFB amplify, decrease, or remain consistent over time. Longitudinal research is important for several reasons, the foremost being that researchers lack an understanding of how long the effects of HRV BFB endure after training sessions have terminated. Second, individuals learn skills at different rates, and thus, some athletes may not acquire self-regulation skills until the tenth session or later. Assessments of the effects of HRV BFB over durations that exceed 10 weeks are needed, as is research on the utility of booster HRV BFB sessions following massed training.

Conclusions

The general aim of this study was to demonstrate that HRV BFB is a viable method of improving golf performance, perhaps by reducing competitive anxiety. A detailed understanding of the participant and the psychological, physiological, and sport performance–related findings were presented to highlight the utility of this approach for child athletes. Within this general aim, several aspects of the methodology were described, including (a) the design of the study, (b) session format and structure, and (c) measures for assessing emotional, physiological, and sport performance changes. Accumulated data suggested that HRV BFB training may have enhanced the golfer's ability to cope with stress and increased his ability to perform optimally during competition. HRV BFB elicited resonant oscillations in the cardiovascular system and apparently normalized autonomic regulation. As such, these techniques may have been responsible for the substantial improvements in the athlete's mood and confidence, reduced the stress he experienced during competition, and enhanced his golf performance. It is hoped that the potential benefits of HRV BFB for athletes of varying ages, skill levels, and sport disciplines undergo investigation in controlled experimental studies to define the mechanism(s) of action and advance the development of outcome measures, strategies, and methods to implement HRV BFB in sport settings.

Acknowledgment

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References

Applehans, B. M., & Luecken, L. J. (2006). Attentional processes, anxiety, and the regulation of cortisol reactivity. *Anxiety, Stress & Coping, 19,* 81–92.

Bernardi, L. (2001). Interval hypoxic training. *Advancements in Experimental Medical Biology, 2,* 377–380.

Berntson, G. G., Bigger, J. T., Jr., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., et al. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology, 34,* 623–648.

Competitive Anxiety in Sport. (1990). Champaign, IL: Human Kinetics.

Cummings, J., & Hall, C. (2002). Athletes' use of imagery in the off-season. *Sport Psychologist, 16,* 160–172.

Giardino, N. D., Lehrer, P. M., & Feldman, J. M. (2000). The role of oscillations in self-regulation: Their contribution to homeostasis. In D. T. Kenny, J. G. Carlson, F. J. McGuigan, &

J. L. Sheppard (Eds.), *Stress and health: Research and clinical applications*. Amsterdam, Netherlands: Harwood Academic Publishers.

Hanin, Y. L. (2000). *Emotions in sport.* Champaign, IL: Human Kinetics.

Landeau, J. B., Turcotte, H., Desagne, P., Jobin, J., & Boulet, L. P. (2000). Influence of sympatho-vagal balance on airway responsiveness in athletes. *European Journal of Applied Physiology, 83*, 370–375.

Lehrer, P. M., Vaschillo, E., & Vaschillo, B. (2000). Resonant frequency biofeedback training to increase cardiac variability: Rationale and manual for training. *Applied Psychophysiology and Biofeedback, 25*, 177–191.

Lehrer, P. M., Vaschillo, E., Vaschillo, B., Lu, S., Eckberg, D. L., Edelberg, R., et al. (2003). Heart rate variability biofeedback increases baroreflex gain and peak expiratory flow. *Psychosomatic Medicine, 65*, 796–805.

LeUnes, A., & Burger, J. (1998). Bibliography on the profile of mood states in sport and exercise psychology research, 1971–1998. *Journal of Sport Behavior, 21,* 53–70.

Martens, R., Burton, D., Vealey, R. S., Bump, L. A., & Smith, J. (1990). The Competitive State Anxiety Inventory-2 (CSAI-2). In R. Martens, R. S. Vealey, & D. Burtons (Eds.), *Competitive anxiety in sport* (pp. 117–190). Champaign, IL: Human Kinetics.

Raymond, J., Sajid, I., Parkinson, L. A., & Gruzelier, J. H. (2005). Biofeedback and dance performance: A preliminary investigation. *Applied Psychophysiology and Biofeedback, 30,* 65–73.

Singer, R. N., and Janelle, C. M. (1999). Determining sport expertise: From genes to supremes. *International Journal of Sport Psychology, 30,* 117–150.

Strack, B. W. (2003). Effect of heart rate variability (hrv) biofeedback on batting performance in baseball. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 64,* 1540.

Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. (1996). Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *European Heart Journal, 17,* 354–381.

Vaschillo, E. G, Lehrer, P. M., Rishe, N., & Konstantinov, M. (2002). Heart rate variability biofeedback as a method for assessing baroreflex function: A preliminary study of resonance in the cardiovascular system. *Applied Psychophysiology and Biofeedback, 27,* 1–27.

Vaschillo, E. G., & Rishe, N. (1999). Therapeutic method for a human subject. U.S. patent 5,997,482. December 7.

Vaschillo, E. G., Vaschillo, B., & Lehrer, P. M. (2006). Characteristics of resonance in heart rate variability stimulated by biofeedback. *Applied Psychophysiology and Biofeedback, 31*, 129–142.

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