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Neurofeedback for Peak Performance Training

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Neurofeedback has been found to be effective in the treatment of a number of clinical disorders, such as attention-deficit/hyperactivity disorder (ADHD/ADD) (Lubar, 2003), obsessive-compulsive disorder (Hammond, 2003), seizures (Sterman, 2000), and substance abuse (Burkett, Cummins, Dickson, & Skolnick, 2005; Saxby & Peniston, 1995). The benefits of neurofeedback have also been found useful in peak performance training. These benefits include improving attention/concentration, imagery, arousal level, and decreasing worry and rumination (Williams, 2006). The combination of cognitive, emotional, and psychophysiological benefits from neurofeedback results in improved performance. Due to individual differences in brain activity, as well as the large diversity of skills required in different sports, neurofeedback for performance training is not a "one size fits all" approach (Wilson, Thompson, Thompson, & Peper, 2011). In order to obtain optimal results, neurofeedback for peak performance training begins with appropriate assessment and evaluation of an individual's brain wave (electroencephalographic) activity. Individualized training plans are based upon the assessment findings and the specific needs of the targeted sport or activity (Wilson et al., 2011). This article will discuss the benefits and applications of neurofeedback for peak performance training and the importance of assessment to create effective training programs.

Research on neurofeedback or electroencephalogram (EEG) biofeedback for peak performance training has been conducted since the mid-1990s. It has been found to improve cognitive skills (e.g., attention, problem-solving), emotional regulation (e.g., decrease worry and anxiety), and psychophysiological functioning (e.g., arousal) (Lubar, 2003; Monastra et al., 2005; Thompson & Thompson, 2003; Wilson, Thompson, Thompson, Thompson, Fallaphour & Linden, 2011). Athletes as well as business professionals (Hill & Castro, 2002), medical professionals (Ros et al.,, 2009), and musicians/performers (Egner & Gruzelier, 2003) have utilized the benefits of neurofeedback to improve their cognitive, emotional, and psychophysiological abilities (Chapin & Russell-Chapin, 2014). With an emphasis on attentional skills, Swingle (2008a) defined the role of neurofeedback peak performance training as "The training of the mind to become insulated from distractions while releasing the mind to be in synch with the energy of the universe. The brain is trained to efficiently

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engage and disengage at the highest level" (p. 186). Wilson, Thompson, Thompson, Thompson et al. (2011) utilize a more holistic definition stating that neurofeedback for peak performance training teaches an individual how "to control attention, thoughts, feelings, thus performance" (p. 178).

Neurofeedback training centers on five brain waves. These brain waves are (in order from slowest to faster brain waves): delta, theta, alpha, beta, and gamma. They are measured in hertz (Hz) according to their frequency. Brain waves with frequencies lower than 10 Hz are considered "slow frequencies" whereas frequencies above 13 Hz are considered "fast frequencies" (Demos, 2005).

The slowest brain wave, delta (frequency range 1-4 Hz), is associated with "sleep, repair, [and] complex problem solving" (Demos, 2005, p. 71). Theta waves (frequency range 4-8 Hz) are linked to "creativity, insight, [and] deep states" (Demos, 2005, p. 71). Alpha waves (frequency range 8-12 Hz) are connected to "alertness and peacefulness, readiness, [and] meditation" (Demos, 2005, p. 71). Beta waves (frequency range of 13-21 Hz) are associated with "thinking, focusing, [and] sustained attention" (Demos, 2005, p. 71). Gamma waves play an important role in learning, problem-solving, organization, mental clarity, and are associated with high cognitive functioning (Chapin & Russell-Chapin, 2014; Wilson, Thompson, Thompson, Thompson et al., 2011). Lastly, sensorimotor rhythm (SMR) is a specific brain wave frequency (12-15 Hz) associated with elevated performance (Demos, 2005). SMR promotes "mental alertness" along with "physical relaxation" (Demos, 2005, p. 71; Wilson, Thompson, Thompson, Thompson et al., 2011).

USES OF NEUROFEEDBACK IN PEAK PERFORMANCE TRAINING

Cognitive Benefits

On the field and in the boardroom, important decisions often have to be made quickly and excellent cognitive skills are required. When discussing peak performance, special attention is given to the alpha brain waves due to their important role in this area. In addition to "relaxed focus, inner calm, peacefulness, or calm attention", alpha waves are associated with "cognitive efficiency" and "intellectual performance" (Chapin & Russell-Chapin, 2014). When alpha waves are slower than ideal, an individual may feel that his or her mind is "sluggish" and experience memory difficulties (Chapin & Russell-Chapin, 2014). Thompson and Thompson (2003) have found that correcting the alpha waves results in an increase of ten points on intellectual test scores.

The relationship between theta (6-10 Hz) and low frequency alpha waves (11-12 Hz) is evaluated to gain information about a person's problem-solving ability (Wilson, Thompson, Thompson, & Peper, 2011). A lower ratio is preferred and suggests that an individual is able to engage in problem-solving in an effective and efficient manner. A "phase reset" (also called alpha theta synchrony) occurs when alpha and theta waves are trained together to increase at the same time (Chapin & Russell-Chapin, 2014). According to Chapin and Russell-Chapin (2014), benefits of the phase reset are "insight, cognitive understanding (often nonverbal), processing, and integration of previously unavailable and sometimes traumatic material" (p. 141).

The game of golf requires calm, focused attention as well as effective problem-solving skills to overcome challenges encountered on the course. Golf performance has been shown to benefit from reinforcing 4Hz, 7Hz, and 13Hz brain waves in sequential order (Chartier, Collins, & Coons, 1997; Sideroff, 2011). This training sequence produces "significant improvement in stroke reduction as well as in mood" (Sideroff, 2011, p. 262). Research has also been conducted on differences between the left and right hemisphere activity and golf performance (Crews & Landers, 1993). Too much activity in the left hemisphere causing excessive cognitive scrutiny (e.g., negative self-talk, disruptive thoughts) was believed to interfere with the right hemisphere's spatial ability and, thereby, to decrease golf performance.

In addition to golf, alpha-theta training is useful in dance performance. Raymond, Sajid, Parkinson, and Gruzelier (2005) conducted a study comparing neurofeedback and biofeedback training impact on dance performance. Subjects were divided into three groups (neurofeedback group, biofeedback group, and control group). The neurofeedback group participated in 10 sessions of alpha/theta training. The biofeedback group participated in 10 sessions of heart rate variability (HRV) training), which is frequently used for peak performance training but not discussed in this article. The control group did not receive an intervention and was asked to "practi[ce] as usual" (Raymond et al., 2005, p. 68). Both the neurofeedback and HRV groups "significantly" improved their dance performance compared to the control group. The areas of technique, timing, and "overall execution" benefited the most from the biofeedback intervention (Raymond et al., 2005, p. 70).

Attention/Concentration

The neurofeedback practitioner pays special attention to brain wave activity during a task to gain insight into an individual's cognitive functioning and emotional state. If a person is distracted, experiencing comprehension difficulties or daydreaming, the EEG activity would likely reflect a high theta to beta wave ratio (also called Theta power/Beta power or busy brain ratio). Theta waves are slower waves whereas beta waves are faster waves (Swingle, 2008a; Wilson, Thompson, Thompson, Thompson, et al., 2011). As this ratio is associated with a person's ability to control his or her attention, a high theta/beta ratio is also associated with problems sustaining attention and Attention Deficit Disorder (ADD) Swingle, 2008a; Wilson, Thompson, Thompson, Thompson, et al., 2011). Swingle (2008a) explains, "Even though the child is trying to concentrate, the brain produces a wave form associated with daydreaming" (p. 71).

In addition to difficulty sustaining attention, intrusive thoughts can disrupt one's concentration and focus, thus hindering performance. According to Sime (2003), brain wave activity with a "sudden upward shift" precedes an intrusive thought. Neurofeedback training can be used to decrease intrusive thoughts while increasing desired beta wave activity in the prefrontal lobe region. The prefrontal lobe region is associated with high order thinking (Sime, 2003).

Baseball demands sustained attention and concentration. In a recent study, Sherlin, Larson, and Sherlin (2013) studied the impact of neurofeedback training on five professional baseball players. Each of the players underwent a quantitative electroencephalograph (QEEG) and 15 sessions of neurofeedback training over 30 days. The players improved in the areas of "attention, decreased intrusive thought patterns and improvements in sleep patterns" after the neurofeedback training (Sherlin et al., 2013, p. 29).

Arousal Level

Arousal is defined as "a general physiological and psychological activation, varying on a continuum from deep sleep to intense excitement" (Weinberg, 2007, p. 78). A certain amount of arousal is required to achieve peak performance. However, too much arousal leads to anxiety, anger, and impulsive behavior and outbursts, while too little can lead to lack of energy or drive and boredom.

Neurofeedback is a helpful tool in achieving an ideal level of arousal in a two-step process (Weinberg, 2007). The first step focuses on increasing an individual's awareness of his or her level of arousal. After the individual has gained this self-awareness, neurofeedback teaches an individual how to appropriately regulate his or her arousal level to improve performance. When an individual experiences low arousal, neurofeedback training can boost or increase arousal. Under high pressure situations or other high arousal situations, training can help reduce arousal, anxiety, anger, or other undesirable behaviors (Hill & Castro, 2009).

Perry, Shaw, and Zaichkowsky (2011) conducted research on SMR and Division I college female gymnasts' performance on the balance beam. This particular event was selected due to its precise nature and susceptibility to performance pressure. Six female gymnasts participated in a 10-session intervention over five weeks using neurofeedback and biofeedback. Neurofeedback training consisted of increasing SMR while decreasing theta. Biofeedback training focused on heart-rate variability training (HRV). An independent judge reviewed and scored the performance of the gymnasts before and after neurofeedback and biofeedback training and found improvements in their performance as a result of the training.

Worry and Rumination

Neurofeedback is able to decrease negative self-talk through enhanced attention skills. As mentioned earlier, neurofeedback can help individuals reduce distraction tendencies while increasing their ability to become alert (Sime, 2003). Wilson, Thompson, Thompson, & Peper (2011) recommend using theta/beta ratio to detect the presence of negative self-talk, rumination, and judgment. They identified "calm athletes" as individuals with a theta/beta ratio between 1 and 1.25. Athletes suffering from excess worry and rumination (also called busy brain) typically experience theta/beta ratios 1.5 and higher.

Neurofeedback training can help individuals reduce negative self-talk and rumination by teaching the brain to engage in "calm" and "focused" thinking (Wilson, Thompson, Thompson, & Peper, 2011, p. 208). This is achieved by increasing sensory motor rhythm (SMR or low beta waves) and lowering theta waves (Wilson, Thompson, Thompson, & Peper, 2011). A study in the United Kingdom examined the impact of neurofeedback training on the performance of microsurgical skills (Ros et al., 2009). Twenty-eight ophthalmic microsurgeons were recruited for the study and placed in either a sensorimotor rhythm-theta (SMR) group, alpha-theta (AT) group, or a control group who received no training. After eight 30-minute training sessions, the subject's performance was captured on video recording and was rated by consultant surgeons. Subjects also completed self-report tests measuring state and trait anxiety. As judged by the consultant surgeons, the SMR group was found to have improvements in overall technique, suture technique, and overall time on the tasks. Self-report measures indicated decreases in "everyday anxiety" or trait anxiety (Ros et al., 2009). The AT group did not show the same level of improvements as the SMR group. However, this group did show a positive correlation between an increase in alpha-theta ratio and overall technique.

Imagery

The ability to visualize an optimal or ideal movement, posture, or behavior is valuable tool to improve performance. Increased alpha waves are associated with visualization skills and visual memory (Chapin & Russell-Chapin, 2014; Swingle, 2008a). Higher slow-frequency amplitude (7, 8, or 9 Hz) brain waves (while an individual's eyes are closed) are associated with greater vividness and imagery skills than lower amplitude brain waves (Wilson, Thompson, Thompson, Thompson et al., 2011). Neurofeedback training can increase the desired brain waves to improve imagery skills.

NEUROFEEDBACK ASSESSMENT AND TRAINING FOR PEAK PERFORMANCE

Neurofeedback Assessment

A neurofeedback assessment can be one of several components in peak performance training assessment. Other areas often taken into consideration include: personality, performance strengths and weaknesses, and psychological interview. Neurofeedback assessments are used to capture information about an individual's brain wave performance. There are many assessments to choose from. Two commonly used assessments are the Optimizing Performance and Health Suite by Wilson (2007) and the QuickQ by Swingle (2008b). Sensors are placed on various parts of the scalp to evaluate the brain wave activity at different parts of the brain. Placement of these sensors can vary depending upon individual goals and needs (Wilson, Thompson, Thompson, & Peper, 2011). When analyzing brain waves, three areas are taken into consideration.

These areas are amplitude (or strength) of the brain wave, the coherence (the "association or coupling" with another part of the brain, and phase (or shape) of the brain wave (Wilson, Thompson, Thompson, Thompson et al., 2011, p. 183). Review of the assessment will evaluate the presence and nature of various brain waves, but will pay special attention to alpha waves due to the relationship of this particular brain wave with peak performance for the reasons mentioned earlier.

Individualized Training and Training Plans

The real-time training of neurofeedback provides opportunities for an individual to learn how to focus one's attention, "let go" when trying too hard, and learn to relax and become calm during challenges and periods of stress. Acquiring information about one's brain wave activity allows an individual to make appropriate changes and learn new, more effective ways of responding to stressful situations that are transferable into real world situations (Wilson, Thompson, Thompson, & Peper, 2011).

Neurofeedback peak performance training frequently utilizes one or two channels. Protocols aim to provide improvements to SMR, alpha, alpha and theta synchrony, low beta, and gamma waves (Chapin & Russell-Chapin, 2014). There are a number of different protocols available to select from depending upon an individual's goals and needs. The amount of training required to achieve optimal functioning varies from one individual to another and is contingent upon his or her unique psychophysiological functioning. It also varies depending upon the sport or activity that is being targeted.

Neurofeedback is not a "one size fits all" approach and must be tailored to meet the needs and demands of the sport or activity as well as the individual. For example, as mentioned earlier, golfers benefit from an increase of right brain activity. However, this has been found to be detrimental in other sports (Vernon, 2005). This emphasizes the importance of selecting a qualified, competent neurofeedback provider. Certified practitioners can be found at the Biofeedback Certification International Alliance's website, www.bcia.org.

Limitations of Neurofeedback

The majority of the research on peak performance training with neurofeedback is based on research conducted with athletes. Several weaknesses of this research have been identified. One weakness is the "individual differences and the demands of various sports", which limit the generalizability of research results to other sports or activities (Hammond, 2007; Wilson, Thompson, Thompson, Thompson et al., 2011, p. 190). According to Wilson, Thompson, Thompson, Thompson et al.(2011), "Further research is necessary to determine the true degree of efficacy of these studies (are they worth the time, effort, and money?)" (p. 191).

Another limitation of neurofeedback is that it may not be able to be performed while an individual is training. As Wilson, Thompson, Thompson, Thompson et al. (2011) state, "almost all the research data has been recorded from people sitting or standing quietly and what athletes do during game performance may not be the same" (p. 213). Neurofeedback equipment is often expensive and may not withstand the wear and tear of certain sports, especially high contact sports. Some may find it awkward, impractical, or socially undesirable to be hooked up to the neurofeedback equipment during competition or other situations (e.g., high pressure presentation or while performing surgical procedures). Lastly, it is assumed that individuals who are using neurofeedback for peak performance training are healthy and typically-functioning individuals. Those suffering from clinical disorders or who are currently functioning below their normal baseline level need to return to a premorbid level of functioning before engaging in peak performance training.

CONCLUSION

Chapin and Russell-Chapin (2014) succinctly summarize the benefits of neurofeedback in peak performance training, stating "efficiency and peak performance can be achieved when using the right brainwave, at the right time, for the right task" (p. 149). Neurofeedback provides a number of benefits for individuals who are pursuing peak performance training with minimal side effects in a relatively short period of time. Although the study of neurofeedback has been around since the 1960s, its application to peak performance training is a newer area of study and practice. Therefore, additional research is warranted to further define its benefits and limitations.

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