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The Effect of Biofeedback Training on One Repetition Maximum Chest Press Performance

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ABSTRACT

International Journal of Exercise Science 10(8): 1105-1115, 2017. Biofeedback is a method of controlling normally automatic bodily functions by monitoring and training to acquire voluntary control over them (13). The purpose of this study was to determine if a heart-rate variability training program utilizing the emWave biofeedback device could increase performance on a simple strength task. Participants (n = 18) were randomly assigned to one of three groups and data were collected for a period of seven weeks. Data collection consisted of participants receiving training (experimental and alternate groups) or no training (control group), followed by a chest press one repetition maximum (1-RM) assessment. A repeated measures ANOVA was conducted to assess group differences in chest press 1-RM improvement over time. While all three groups improved in chest press 1-RM over time, there were no significant differences between groups. Future directions and implications of this research for athletes and coaches are discussed.

KEY WORDS: Motivation, stress, heart rate variability

INTRODUCTION

Athletes and other performers are constantly looking for ways to gain an edge over their competition. Several cognitive variables have been found to consistently influence performance in sport and exercise settings, including self-efficacy and anxiety (2, 10, 14, 23, 27, 33). Self-efficacy, a type of task- and situation-specific confidence, can influence an individual's selection of goals, level of effort, and persistence on sport or exercise tasks (2, 10, 14, 23). Anxiety often has negative impact on performance for most athletes, so the ability to regulate one's anxiety or arousal can have a significant impact on performance (33). There are numerous strategies that can be utilized to regulate arousal, including biofeedback.

Biofeedback is a method of controlling normally automatic bodily functions by monitoring and training to acquire voluntary control over them (13). Sensors are attached to the body to acquire biological signals such as those produced by muscles, sweat glands, body temperature, respiration, and heart rhythm (7). The individual receives moment by moment biological signal information about changes detected by the sensors (e.g., increased heart rate when nervous). The individual continues to train under conditions that elicit elevated biological signals (e.g., heartbeat, breathing, blood pressure, and muscle tension) and works towards gaining mental control over these body functions through the biofeedback training (e.g., controlled, even breathing to reduce heart rate; 5, 7). It is used to help treat and prevent numerous conditions including: high blood pressure, migraine headaches, and chronic pain. One of the prominent biofeedback applications employed in exercise is relaxation techniques (8). The ability of a person to relax during the stressful act of exercise is an important component of the overall emotional control required to improve physical fitness. Biofeedback is useful because it appears to be effective for a range of health problems; improving athletic performance; and decreasing test, public speaking, and stage fright anxiety (13, 24, 29, 31).

Heart rate is constantly changing. "Heart rate variability (HRV) is the variation of beat to beat intervals, also known as R-R intervals" (25). These R-R intervals can be visualized and measured by viewing the QRS complex, or ventricular depolarization, on electrocardiogram (ECG) line tracings (25). HRV is considered to be a prominent indicator of overall health and fitness. "As a marker of physiological resilience and behavioral flexibility, heart rate variability reflects people's ability to adapt effectively to stress and environmental demands" (15). Heart rate variability can be affected by a variety of factors, including: health status, age, genetics, time of day, and body position. Heart rate variability is also largely affected by aerobic fitness. During exercise, heart rate variability decreases as heart rate and exercise intensity increase (25).

An innovative technology that has been developed for biofeedback training is the emWave device. The emWave is used to improve wellness and facilitate individual growth by way of heart rate variability training. Specifically, the emWave focuses on learning to change one's heart rate as plotted over time, also known as a heart rhythm pattern, to create coherence; a measurable state characterized by physiological and psychological synchronization and optimal functioning (15). With the assistance of the emWave individuals learn to control their physiology and heart rhythms by focusing on controlling their breathing and positive emotions. The computer graphs or portable emWave lights will change to reflect the individual's level of coherence as they begin to focus on positive emotions and breathe along with their heart rhythms. The emWave has been utilized by many different people, including athletes and elite military tactical teams to regulate stress levels before deployment (33). Billy Cundiff, a kicker in the National Football League (NFL), began using the emWave in 2012. Cundiff claimed, "Not only were my mental skills continually improving but they were working in game conditions, not just practice…I was killing the ball and having a great time doing it. People, in general, don't deal with stress. Moving forward, stress will be the least of my worries" (34). This personal testimony is very promising for the use of biofeedback devices with not only athletes of all levels, but also anyone engaging in exercise and looking to bring their training to a whole new level.

Athletes, coaches, and sport psychology practitioners often use biofeedback training to regulate athlete's arousal (13), and HRV has been frequently recommended in sport to regulate arousal and enhance concentration, but there are few studies examining HRV in the athlete population (28). The emWave device is an HRV device that has been frequently used by sport and exercise psychology practitioners and athletes given the portability of the device, however there is limited research on the emWave in the sport and exercise literature (28). Therefore, the purpose of this study was to determine if a heart-rate variability training program utilizing the emWave device could increase performance on a simple strength task, a one-repetition maximum chest press task. The researchers hypothesized that the usage of heart rate variability training would increase performance on a one-repetition maximum chest press task. The researchers believed that developing more control over heart-rate through breathing would lead to a better physiological and psychological harmony that in turn would benefit chest press performance. The researchers also hypothesized that the use of the emWave would increase participant's self-efficacy, or task- and situation-specific confidence, for performing the chest press task.

METHODS

Participants

After obtaining Institutional Review Board (IRB) approval from the university, convenience sampling was used to recruit participants by sending a recruitment email to university faculty and staff via several faculty/staff listserves, and also asking faculty to forward the recruitment email to their students. Criteria for participating in the study was the following: adults over the age of 18 with no prior experience utilizing biofeedback devices. Twenty college students volunteered to participate in the study and contacted the primary researcher to schedule a day and time to meet with the researchers in the kinesiology research laboratory. All 20 participants completed the initial data collection session, but two participants dropped out before the study was completed due to data collection scheduling issues. This resulted in a total of 18 participants (11 males, 7 females) who were predominantly Caucasian (77.8%) and ranged from 18 to 25 years of age. The majority of participants (88.9%) were participating in regular physical activity, with most participants (87.5%) having been regularly active for a minimum of one year, including seven participants who were varsity collegiate student-athletes. Additionally, 72.2% of participants also engaged in at least 30 minutes or more of upper body strength training per week. However, only 55.6% of participants regularly performed the chest press exercise one or more times per month (M = 2.89, SD = 3.14).

Protocol

The protocol lasted six weeks. This time frame was selected as other similar studies have utilized shorter biofeedback training protocols lasting anywhere from two hours to six weeks and observed success in various domains including physical activity, musical performance, and fall prevention (9, 18, 30, 32). During the first meeting, prior to participants beginning the chest press protocol, one of the researchers explained the study and participants read through and signed the informed consent. Data were then collected on participants' physical activity history (e.g., how much they typically worked out per week, how often they chest pressed, how much they could lift on chest press, age, gender, etc.), self-efficacy for the chest press, and participants completed the one-repetition maximum (1-RM) chest press to obtain a baseline.

Participants were randomly assigned to one of three groups: an experimental group, a control group, or an alternate group. See table 1 for a breakdown of the demographics of each group. Participants in the experimental group participated in ten minutes of emWave training on a desktop computer, then performed the 1-RM chest press task each week of the protocol. Participants in the control group performed the 1-RM chest press task each week. Finally, the alternate group viewed sport and exercise video clips compiled by one of the researchers for ten minutes prior to performing the 1-RM chest press task each week. Each participant also completed the measure of self-efficacy for the chest press task prior to performing the chest press on each week of data collection. The alternate group viewed videos because viewing videos can be used as to aid imagery and improve performance (16). Therefore, the alternate group viewed videos to eliminate the effect of viewing images on the computer screen and isolate the effect of the biofeedback training in the experimental group. All participants completed maximum testing each week for the six week study given that several strength training studies found strength gains in even a short period of time when conducting maximum testing one time a week or more (17, 35). Additionally, participants were also asked to rate their motivation to perform the chest press exercise on a Likert-type scale before performing the chest press, primarily to assess if viewing the videos affected participant's motivation. There were no differences in this assessment, therefore it can be assumed that viewing the videos did not impact participant's motivation.

Table 1. Participant demographic data.

Group	Gender		Age		Minutes of PA per Week	
	Male	Female	Mean	SD	Mean	SD
Control	5	1	21.16	2.48	533	609
Alternate	3	3	21.33	1.51	583	486
Experimental	3	3	20.16	1.47	618	712

To perform the 1-RM chest press task, participants were walked from the kinesiology research laboratory approximately 100 yards down the hall to the university's Student Recreation Center. The American College of Sports Medicine (ACSM) 1-RM assessment protocol was utilized because it is considered as the gold standard measure of muscular strength (1, 11). Participants were then instructed, per ACSM 1-RM assessment protocol, on how to correctly complete the chest press exercise, and then to complete no more than 10 submaximal warm-up repetitions with a low weight (1). An initial weight was then selected for each participant that was approximately 50-70% the participant's perceived 1-RM capacity. After a successful lift, each participant was asked to rate their effort on a scale from one to ten, with ten being maximum effort and one being very little effort. The weight was progressively increased by five to 30 pounds (2.5 - 20 kilograms), depending on the participant's response, until the participant was unable to successfully complete the chest press repetition (1). The participant's

1-RM was determined within four trials with three to five minutes rest between each trial (1). The final weight that was successfully lifted was recorded as the participant's 1-RM.

The emWave device was utilized in an attempt to increase heart rate coherence in participants in the experimental group. The emWave device was connected to a computer via USB port and also the participant's ear lobe via a clip on sensor. Each of the six weeks utilized a different emWave training program for an approximate duration of ten minutes. For week one, participants were instructed to use the Coherence Coach and the Balloon game. During week two, participants were instructed to use the Garden game and were given the choice of continuing to work in the Garden game or Balloon game from the previous week. During week three participants were again given the choice between the Garden game and the Balloon game. During week four participants were introduced to new game choices, either Healing Hands Visualizer or Portal of Care Visualizer. For weeks five and six, participants were allowed to choose any game they wished. Each week participants were instructed to practice the coherence techniques they learned in week one.

Given that research in sport and exercise psychology has also found an individual's self-efficacy, or task- and situation-specific confidence, can influence an individual's selection of goals, level of effort, and persistence on sport or exercise tasks (2, 10, 23) participant's self-efficacy for the 1-RM chest press task was also collected. Specifically, participants were asked to indicate the weight they were 100%, 75%, and 50% confident they could lift successfully each week before performing the 1-RM chest press. This measurement of self-efficacy is similar to previous studies examining self-efficacy and 1-RM chest press performance (12).

Statistical Analysis

Group differences over time in chest press 1-RM performance were examined by conducting a repeated measures analysis of variance (ANOVA) using SPSSv20. A $p < .05$ was used for indication of statistical significance.

RESULTS

We hypothesized that using the emWave device would increase participant's performance on the 1-RM chest press task more so than the control or alternate groups. There was no significant main effect of group on chest press performance over time F (4.43, 33.20) = .42, p = .81, $\eta_p^2 = .05$ (see Table 2).

Table 2. Chest press performance.

Group	First Trial 1RM		Last Trial 1RM		Improvement	
	Mean	SD	Mean	SD	Mean	SD
Control	207.5	27.34	248.83	56.65	41.33	39.96
Alternate	146.67	58.2	174.17	63.36	27.5	10.84
Experimental	163.33	61.29	191.67	72.98	28.33	20.17

While all three groups improved in chest press 1-RM performance over time, there was no one group that performed significantly better or worse than any other. Therefore, our first hypothesis was not supported.

We also hypothesized that the use of the emWave would increase participant's self-efficacy for performing the chest press task more than the alternate or control groups. Group differences over time in self-efficacy (100%, 75%, 50%) for the chest press 1-RM were also examined by conducting an ANOVA, again with a $p < .05$. These results were also not significant for 100% self-efficacy F (6.07, 45.53) = 1.09, p = .39, η_p^2 = .13, 75% self-efficacy F (5.81, 43.58) = .93, p = .48, η_p^2 = .11), or 50% self-efficacy F (5.14, 38.54) = 1.06, p = .40, η_p^2 = .12). Thus, our second hypothesis was also not supported (see Table 3).

Table 3. Self efficacy.

Group		First Trial		Last Trial		Difference	
	Self-Efficacy Level	Mean	SD	Mean	SD	Mean	SD
Control	100%	164.17	39.68	234.33	57.78	70.17	32.41
	75%	178.33	44.23	242.17	58.47	63.83	32.9
	50%	190	48.27	249.83	61.11	59.83	33.29
Alternate	100%	122.5	61.87	161.67	54.01	39.17	22.23
	75%	132.5	58.12	168.33	55.38	35.83	18.81
	50%	148.33	70.26	174.17	56.87	25.83	28
Experimental	100%	129.17	70.6	175.83	72.28	46.67	31.25
	75%	142.5	72.23	183.33	72.84	40.83	21.55
	50%	156.67	76.14	191.67	73.53	35	15.81

DISCUSSION

The purpose of this study was to determine if a heart-rate variability training program, via the emWave device, could increase performance on a one-repetition maximum chest press task. The heart-rate variability training program was not found to increase participant's performance on the 1-RM chest press task or increase self-efficacy for said task more so than the control or alternate groups. All three groups did improve their chest press 1-RMs throughout the study, but no group improved significantly more or less than the others. It is important to note that the control group seemed to have considerably greater values than the experimental and alternate groups. This may have resulted from the fact that males dominated the control group (five males and one female), while the experimental and alternate groups both consisted of even amounts of male and female participants (three males, three females). Research has found that females are approximately 52% as strong as males in the upper body and that this may be due to the tendency for females to have a lower proportion of lean tissue throughout the upper body (22). Even though our hypotheses were not supported by the data collected, this study adds important information to the limited existing body of research dealing with biofeedback in sports and exercise.

The emWave device is frequently used by sport and exercise psychology practitioners and athletes, however, while there is support for the effectiveness of biofeedback training and HRV in many domains including athletics, the limited other studies specifically examining the emWave and athletic performance (28) do not seem to provide support for the effectiveness of the emWave in an athletic context. Studies utilizing the emWave in other domains, such as musical performance, have examined the effect of the emWave on performance in individuals experiencing stress or state anxiety (29). However, in this study we did not intentionally seek out participants who were struggling with the chest press due to stress, given exercise is a stressful experience in itself (21). The effectiveness of the emWave in sport or exercise may only be limited to individuals experiencing high levels of stress or state anxiety. In other words, while there is support for the use of biofeedback and HRV training in sport and exercise (24, 26) the emWave device specifically may not be a useful tool for the average exerciser or athlete.

While the emWave device is typically used to reduce arousal or anxiety, one participant in the experimental group appeared visibly anxious while using the emWave device. The participant had two negative experiences early on in the protocol when the device froze while the participant was in the middle of the training, which may have resulted in the participant becoming visibly anxious (i.e., tapping feet, fidgeting) during the remaining sessions with the emWave device. There could be a negative relationship with the emWave and performance if an individual does not believe the device is effective or does not have a positive experience with the device, which could have occurred with this participant. However, this participant's reaction may not be too surprising, given at least one participant in Galloway's (13) study on biofeedback training and tennis players' serve accuracy reported not being happy and comfortable hooked up to the equipment and away from the tennis court.

Convenience sampling was used to recruit participants, and therefore participants were primarily kinesiology students who may have been motivated to participate because of extra credit or class credit offered by a few professors. Additionally, a number of participants were on the university varsity swimming team along with the primary researcher. The kinesiology students may have already been comfortable or learned about biofeedback, chest press technique, or have had experience working with a researcher due to some of the courses they had completed. Similarly, those participants who were swimmers had an existing relationship with the primary researcher and may have had more advanced knowledge and self-efficacy for the chest press task. In addition to the make-up of the participants, the small sample size of this study is also a major limitation. A larger sample size may have yielded improvement in chest press 1-RM and/or self-efficacy over the other groups for those participants training with the emWave, similar to the few existing studies that found performance improvements after biofeedback training (3, 13). On the other hand, given the large p-values from our sample, a larger sample could have still revealed no significant difference between the groups, indicating the device may not be effective for strength tasks or with individuals not experiencing high levels of stress or state anxiety. Finally, a larger sample may have uncovered a greater number of participants who felt uncomfortable using the device, thereby demonstrating a need for researchers and practitioners to spend time familiarizing participants with the device prior to use.

Participants were walked from the kinesiology research laboratory approximately 100 yards down the hall to the university's Student Recreation Center to perform the chest press task, potentially creating another limitation. It is possible that the brief time it took to walk down the hall could have affected the participant's motivation, self-efficacy, or the calming effects of biofeedback training.

The length of biofeedback training or the videos may also have created another limitation. There is a possibility that the ten-minute length of biofeedback training or the six-week protocol length may not have been enough time to have the desired effect on participants. A study by Bar-Eli and Blumenstein (3) determined that biofeedback improved performance on a gross motor skill after eight sessions; therefore, it is possible the six-week protocol selected for this study may have been too short to see significant performance improvement from the experimental group. Additionally, while the participants reported the video content did not affect their motivation, it may still have impacted their motivation. The videos contained a mixture of well-known movie clips and quotes, extreme sports, ordinary individuals exercising, famous athletes, various types of music, clips of people in school or work settings, and people who were in a low place persevering to rise out of their rut. Karageorghis et al. (19) suggested that motivational music tracks consist of a high tempo beat (>120bpm) and a strong rhythm. Some of the music in the videos utilized may have had a beat above 120bpm, which may have ultimately affected participant's motivation. Similarly, Barwood et al. (4) suggested that viewing video that portrays competent sports performance might improve performance. It may have been more beneficial to show participants videos not containing any sport or exercise tasks.

Additionally, the researchers did not completely prevent participants from becoming aware of the weight they were lifting. While the researchers did not verbally tell participants what their 1-RM was or what the current weight was they were lifting, some participants purposely checked the weight on the machine and were aware of their 1-RM. Previous studies examining self-efficacy for strength tasks (e.g., Fitzsimmons et al., 1991) have completely prevented participants from becoming aware of the weight they were lifting due to the effect of feedback on self-efficacy beliefs. Furthermore, participants were told not to change their workouts during the data collection period, but it is possible some may have when they became aware of their chest press 1-RM.

Researchers who are looking to develop a similar research study may find it beneficial to explain the purpose of biofeedback and/or the biofeedback device being utilized to their participants prior to use. Future studies may also want to incorporate a formal evaluation of participant's experiences with the emWave or other biofeedback devices or techniques. The evaluation could include if the participants enjoy using the biofeedback device or technique and whether they believe it is helping. Additionally, future studies should utilize a larger sample size and perhaps incorporate a wider variety of videos as well. Finally, researchers should take every precaution to make sure that participants are not aware of the weight they are lifting.

This research is useful and important because there is limited existing research that has dealt with heart wave variability, and specifically, the emWave device, in sport and exercise. There have been studies that have found heart rate variability can improve performance in other domains such as music, school, fibromyalgia, misbehavior, and depression (5, 20, 29, 31). If future studies do find the emWave improves performance in athletics it could have a pivotal impact on how athletes train for their sport. These findings could be used to help reduce nervousness or anxiety prior to and during the competition. Findings from this study could also help athletes improve their training as to how they deal with different stressors that are associated with sport and exercise. Athletes who are more in tune with their physiological processes have a better understanding of their body, how it works, and what it takes to bring themselves back to a state of homeostasis faster (24).

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