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Influence of Deep End Fitness Training on Mental Health in Athletes.

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ABSTRACT

Athletes experience unique physical and emotional stressors during training and competition that can deteriorate performance and mental health. Training apathy can lead to cognitive dissonance and further degrade performance by increasing maladaptive coping strategies. In the present study, we aimed to determine if a community-based aquatic training and underwater breath-hold training program can produce mental health benefits in a group of multi-sport athletes. We evaluated the influence of Deep End Fitness (DEF) training on several outcome measures of mental and emotional well-being in healthy, volunteer athletes. Compared to baseline measures, we observed that DEF training produced a significant increase in positive affect amongst the group of athletes. Measures of healthy coping were also improved following DEF training as indicated by a significant increase in the use of problem-focused coping strategies compared to baseline. Reflective of overall mental health improvements, we found DEF training significantly reduced depression, stress, and anxiety in the group of athletes studied. These results indicate Deep End Fitness is an effective community-based training modality for improving attitudes, coping, and mental health amongst athletic individuals.

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INTRODUCTION

Physical abilities of elite and amateur athletes represent only one factor underlying successful athletic performance. Successful athletes must also focus on psychological training that incorporates motivational techniques, goal setting, cognitive and emotional management, and mental focus training to obtain optimal performance (1, 2). Protecting, preserving, and strengthening the mental health of athletes and competitive performers has become a topic of high societal interest (3). Too much devotion to excelling in the physical domain often leaves athletes with inadequate mental training, leading to maladaptive behaviors and psychological breakdown prior to, during, and following competition.

Although exercise is a known antecedent to positive mental and physical well-being, the pressure one undergoes in sports training and competitions can evoke a myriad of mental health issues including increased stress, anxiety, and depression (4). Studies on athletes have found positive correlations between perceived stress (due to performance anxiety, competition pressure, and post-competition anxiety) and burnout, which in turn can lead to depression (5, 6). Hammond et al. (2013) found the prevalence of depression among elite athletes (34-68%) to be significantly higher than that reported in the general population (17% for adults aged 19-34) or intercollegiate athletes (21%) (7). These mental health issues can deplete athletic performance, reduce the likelihood of competition success, and have a negative effect on an athlete's quality of life and general well-being. In turn, perceived failed athletic performance has been linked to increased anger, depression, and stress, as well as reduced vigor (7, 8). Nearly 80% of athletes who do not reach their goals during the Olympic Games experience a major depressive episode (7). Early detection and ongoing maintenance programs for depressive symptoms in the form of psychophysical training programs should be implemented to improve clinical and performance outcomes in athletes (4)

Increased anxiety has been shown to be a leading cause of poor sports performance in athletes of all levels and genders (1, 9). Anxiety in athletes might take the form of somatic, physical symptoms (e.g., muscle tightness, shortness of breath, rapid heart rate) and/or cognitive symptoms (e.g., emotional distress, over-concerned thinking, rumination, apprehension (1). An athlete's gender, type of sport (i.e., team or individual), and other demographics known to heighten somatic and cognitive anxiety are further said to be negatively correlated with sport performance (1). Nicholls et al. (2008) found that female athletes reported feeling greater levels of cognitive anxiety, higher somatic anxiety, and lower self-confidence compared to male athletes (10). Age has also shown to be a contributing factor to anxiety in athletes, such that

older athletes reported less cognitive anxiety to younger athletes (1). These results suggest that sports psychologists, athletes, coaches, and trainers should include stress and anxiety management techniques integrated into physical training regimes.

It has been suggested that mental resilience training can help athletes mitigate their stress, anxiety, and depressive symptoms as well as optimize performance in sport and life (10). Building mental resilience (or mental toughness) helps improve self-confidence (i.e., one's sense of control) and mental stability, such that they remain relatively impervious to competition or hardship (10-12). A recent study of elite German athletes positively correlates adaptive mental coping strategies with mastery approach goals, which are said to improve one's competence, skills, and knowledge while minimizing burnout and psychosomatic stress (13). Athletes with a high level of mental toughness, more effectively manage training and competition demands while maintaining confidence and control under pressure (10-12). In general, healthy coping is required to appropriately deal with stress, anxiety, and adversity (14). Not surprisingly, an athlete's ability to appropriately cope in stressful situations results in increased positive performance outcomes while managing their physical expectations (10). Consistent with the idea that athletes should incorporate psychological training alongside their physical training, these results underline the importance of including mental resilience methods and positive coping strategies in athletic training.

Deep End Fitness (DEF) was designed to improve athletes' ability to employ top-down cognitive control techniques over emotional and physiological responses to stressful situations (15). This is achieved through a multi-modal training approach applied in inclusive community workout sessions at public and private aquatic centers. Training includes breathwork exercises stressing nasal breathing and diaphragmatic breathing leading into breath-holds during land-based exercises before entering the water. The benefits of deep, diaphragmatic (or meditative) breathing are well-established and have been shown to reduce stress while improving heart rate variability, alpha brainwave activity, and top-down emotional control (16). Upon entering the water training includes treading, static breath-holds, bobbing exercises, and breath-holds during underwater exercises that elicit psychological and physiological stress by producing "hunger for air" (17, 18). We hypothesize that teaching athletes to focus and accomplish tasks under this reflexive stress can translate to improved mental health outcomes and coping strategies. Several lines of evidence show that breath-hold diving and training can produce unique physiological and psychological adaptations (19).

Given the unique structure and approaches incorporated into DEF training, we designed the present study to evaluate whether it can enhance mental health and athletes' ability to manage and cope with stress, as well as improve mental health.

METHOD

Study Participants

Prior to study enrollment, participants were screened and provided informed consent. Participants filled out demographic surveys to assess their age, gender, and experience level. All study procedures and protocols were approved by the Solutions IRB (Yarnell, AZ). Healthy athletic individuals between the ages of 18 and 59 were recruited from the DEF community and general population for the study. Individuals already engaged in at least 180 minutes of vigorous physical exercise per week were recruited across multiple sports (i.e., triathlon, mixed martial arts, rugby, running, cycling, swimming, baseball, American football, surfing, tactical athletes, and others). Athletes with experience in DEF training prior to the study were excluded. The participant pool consisted of 10 females (M_{age} = 28.10, Sd_{age} = 9.07) and 37 males (M_{age} = 34.53, Sd_{age} = 9.28) with diverse backgrounds and broad competitive experience, ranging from amateur to professional athletes.

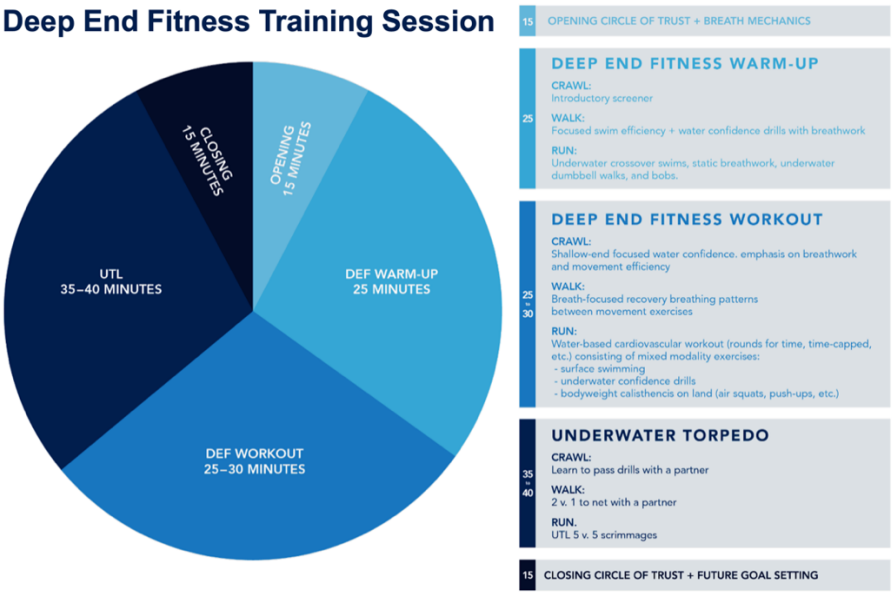

Figure 1. Overview of Deep End Fitness Training Sessions. A typical Deep End Fitness (DEF) training session lasts for 90 minutes. DEF training sessions begin and end with goal setting and performance review sessions conducted in a group manner (i.e., the Circle of Trust). DEF training sessions include stretching, land-based warm-ups, breathwork (i.e., diaphragmatic box-breathing, static breath-holds, dynamic breath-holds, etc.), and underwater physical exercises during.

Outcome Measures

Following informed consent and study enrollment, all volunteer participants completed three scales designed to measure mental health functioning. The mental health outcome scales used were the Depression, Anxiety, Stress Scale (DASS-42; (20), the Positive and Negative Affect Schedule (PANAS; (21), and Brief-COPE (22, 23). Following completion of the study period, these scales were readministered to participants for comparison against baseline measures in a within-subjects manner.

Deep End Fitness Training

Participants were asked to attend at least one DEF training session per week over a one to two-month period. Attendance of a minimum of three DEF training sessions over a four-week period was required for inclusion in the study. Each training session was supervised by at least two certified DEF instructors, a lifeguard, and safety divers. All participants were required to practice safe buddy diving practices during training sessions. Each training session consisted of dynamic stretching, breathwork (e.g., diaphragmatic box breathing), mental focus training, mobility, and strength exercises on land and underwater during breath-holds. As a community and confidence building exercise, all training sessions closed with a group meeting allowing athletes to share and reflect on goals achieved during the DEF workout (See Figures 1 and 2).

Figure 2. Community-based Approach to Deep End Fitness Training. Photographs illustrating the opening circle of trust with warm-up breath work (top-left) and a terrestrial warm-up that includes physical exertion during breath holding (top-right). Under supervised training with safety divers, DEF training includes underwater physical training regimens like 25-meter submerged swims (bottom-left) and underwater dumbbell carries (bottom-right) during dynamic breath-holds.

Statistical Analyses

We used a within-subjects experimental design for the study. Paired t-tests were used to analyze data statistical differences between baseline and post-treatment (post-DEF). Data were analyzed using JASP (JASP 0.16; University of Amsterdam, Netherlands) and R (GNU General Public License). All data are shown as Mean ± SEM. A P-value < 0.05 was considered statistically significant.

RESULTS

DEF Training Improves Positive Affect and Problem-focused Coping

We measured positive and negative affect in the group of volunteer athletes (N = 47) before and after the DEF training treatment period using the Positive Affect Negative Affect Scale (PANAS; (21). DEF training did not produce a significant effect on negative affect in the group of volunteer athletes (baseline = 15.77 ± 0.8, post-DEF = 14.66 ± 0.74, P = 0.08; Figure 3A). We observed, however, that DEF training did produce a significant increase in positive affect (baseline = 36.62 ± 0.87, post-DEF = 39.36 ± 0.93, P = 0.002; Figure 3A).

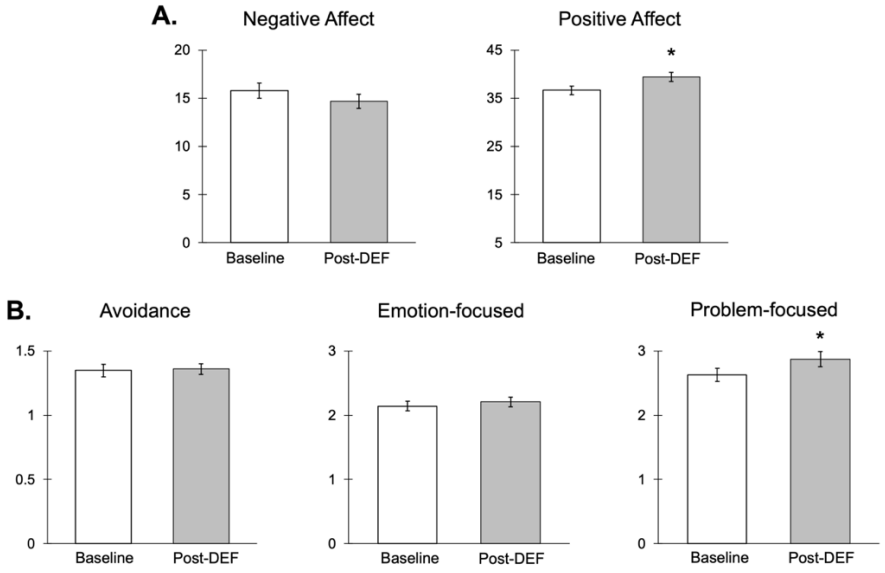

Figure 3. Deep End Fitness Increases Problem-focused Comping Strategies. A. Histograms illustrating results produced by DEF training on PANAS scores, which shows a significant increase in positive affect. B. Histograms illustrating the effects of DEF training on scores from the Brief-COPE survey, which show a significant increase in problem-focused approaches. An asterisk indicates P < 0.05.

We also explored the effects of DEF training on coping methods and strategies using the Brief-COPE survey (22). The BRIEF-cope is a 28-item, clinically validated scale assessing three coping strategies including avoidance, emotion-focused, and problem-focused. Avoidance and emotion-centered coping are indicative of poor mental health functioning, while problem-focused coping reflects healthy and positive mental approaches to dealing with stress (14, 22-24). DEF training had no effect on either avoidance (baseline = 1.35 ± 0.05, post-DEF = 1.36 ± 0.03, P = 0.79) or emotion-focused coping (baseline = 2.14 ± 0.1, post-DEF = 2.20 ± 0.1, P = 0.26; Figure 3B). DEF training significantly increased problem-focused coping by 9.4% (baseline 2.63 ± 0.1, post-DEF 2.87 ± 0.1, P = 0.005; Figure 3B). These data indicate DEF training can improve positive attitude and healthy, problem-focused coping approaches.

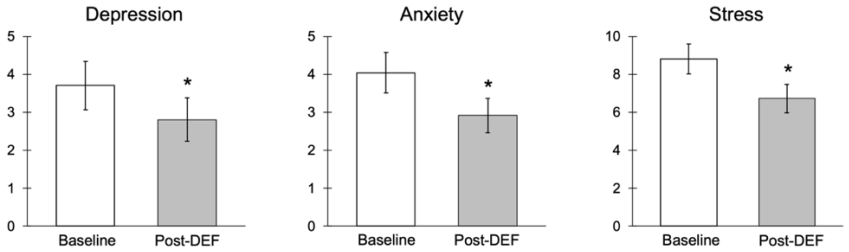

Figure 4. Deep End Fitness Training Improves Mental Health. Histograms illustrating the results produced by DEF training on DASS scores, which show significant decreases in depression, stress, and anxiety. An asterisk indicates P < 0.05.

DEF Training Improves Mental Health Outcomes

Measurements of participants' depression, stress, and anxiety were assessed using the Depression, Anxiety, and Stress Scale (DASS; (20) administered before and after the DEF training period. We found that DEF training produced a significant 24.1% decrease in depression scores compared to baseline measures (baseline = 3.70 ± 0.64, post-DEF = 2.81 ± 0.57, P = 0.04, Figure 4). We also found that DEF training produced a significant 23.7% decrease in stress (baseline = 8.81 ± 0.79, post-DEF = 6.72 ± 0.74, P = 0.0001) and a significant 27.9% decrease in anxiety (baseline = 4.04 ± 0.53, post-DEF = 2.91 ± 0.56, P = 0.02; Figure 4). Collectively, these results indicate that DEF training can produce a significant, positive impact on mental health in athletes.

DISCUSSION

In this study, we observed that DEF training produces positive mental health benefits in a diverse group of volunteer athletes. Previous studies have shown that physical activity can

increase positive affect and decrease negative affect (25-28). In the present study, we evaluated the effects of DEF training in a group of athletes already engaged in at least 180 minutes of vigorous physical activity per week. Our finding that DEF can improve positive affect in physically active individuals indicates the training regime possesses unique qualities beyond physical exercise, which may be responsible for this change. The community-based nature of DEF training is likely to have contributed to some of the improvements we observed. Community-based or group fitness programs have been shown to foster a sense of belonging and foster other health benefits (29-32). The sense of community has been shown to be one of the most appreciated benefits of individuals engaged in CrossFit® training (33). In other work, we have found that more than 70% of athletes participating in DEF training rank the sense of community as one of their favorite aspects of the workouts (data not shown).

Breath-hold diving has other unique aspects that may contribute to the improved mental health outcomes we observed following DEF training. Underwater, an athlete's mammalian diving reflex (DR) is initiated through stimulation of the trigeminal and vagus nerves to produce bradycardia, vasoconstriction, and slow oxygen metabolism (34-38). Breath-hold diving and underwater immersion, as methods of natural vagus nerve stimulation, encourage physiological relaxation. In a manner capable or rewiring pathological brain circuits, vagus nerve stimulation has been shown to enhance brain plasticity and learning (39-41). Recently multiple lines of evidence demonstrate that pairing brief periods (seconds to minutes) of non-invasive electrical vagus nerve stimulation with sensory stimuli, language cues, and physical tasks enhances training and learning outcomes (42-45). DEF training relies on the ability of the body to naturally relax underwater through the DR, which facilitates the learning of strategies for enduring psychological and physical stress to remain focused and goal-oriented when completing submerged exercises. We hypothesize this aspect of DEF training contributed to the significant improvements in problem-focused coping we observed (Figure 3B). It poses an interesting possibility that natural, vagus nerve stimulation occurring during DEF training is acting to reinforce the use of stress coping and cognitive control methods taught. Other lines of evidence show that when conducted with proper training, supervision, and safety support, breath holding can produce distinct neurophysiological states, which can benefit performance under competitive or stressful conditions (19, 46).

Strict safety protocols and supervised training are required to engage in any aquatic activity especially breath-hold diving. Blackouts, narcosis, barotrauma, decompression sickness, drowning, and other pulmonary trauma are known adverse events to occur amongst deep free breathing divers (37, 47-50). Improper training, poor safety preparation, inadequate supervision,

and other environmental factors are leading causes of these traumatic injuries, accidents, and adverse events (49, 51, 52). DEF training sessions are always conducted with at least two certified instructors and under the supervision of a lifeguard and safety divers. Every training session begins with a safety briefing and all participants must use buddy diving practices. The depth and length of time breath-hold divers go to also causes complications. DEF training occurs in pools with average depths of four to six meters and breath-holds typically do not exceed two minutes during workouts. Hyperventilation or "air-packing" techniques are not allowed during DEF training as these poor practices are known to increase hypercapnia and blackouts. We observed no blackouts during our study. Independently, we are working with Red Cross to improve education, regulations, and procedures to enhance drowning prevention and preparedness. Between 19% and 38% of individuals participating in CrossFit® have experienced an injury during training (53-55). These injuries are similar across a variety of other high impact sports. We propose the low-impact nature of DEF training, even during submerged breath-hold physical exertion, provides athletes with a safe and unique alternative to other high-impact, community-based training programs prone to injuries.

Participation in organized sports has also been shown to decrease anxiety, improve management of negative emotions, and enhance prosocial behavior (29, 31, 56). Here, we found that DEF training significantly reduced depression, anxiety, and stress in athletes, as well as improved problem-focused coping. The "hunger for air" and physical and psychological stress experienced during DEF training presents athletes with unique mental and physical challenges (17, 18). DEF training involves the teaching of cognitive control, stress reduction, and focusing techniques that help athletes overcome some of the mental and emotional difficulties of breath-hold diving. Encouraging athletes to set goals for achieving underwater physical challenges and equipping them with a skillset to achieve these goals, builds confidence and reinforces problem-focused coping as indicated by our data (Figure 3B).

In the present study, 56-63% of the athletes experienced improvements in depression, anxiety, and stress. Compared to the pharmaceutical management of mental health, evidence shows that antidepressants and other anxiety medications have a success rate of about 50-75% (57, 58), demonstrating that DEF training produces improvements to mental health similarly to and/or better than other pharmaceutical options. This reduction in depression, anxiety, and stress was also shown to be similar to that of other non-pharmaceutical, fitness approaches like yoga (59) and mindfulness (60, 61); opening the potential for therapeutic embodiments (Figure 4).

Although the athletes in the present study did not suffer from any diagnosed mental health disorders, we are planning studies to evaluate the impact of DEF training on athletes diagnosed with generalized anxiety disorder, post-traumatic stress disorder, and depression. These studies represent a major growing area of interest due to the crucial need for new solutions to the mental health crises amongst competitive athletes and tactical operators. Future studies should also examine the generalizability of our observations across specific groups of athletes and other individuals having different training backgrounds and performance capabilities. Our data indeed indicate that DEF training may positively impact mental health and coping in populations beyond athletes.

Contributions

Contributed to conception and design: DT, PH, WT
Contributed to acquisition of data: RC, JH, AW, DT, PH, WT
Contributed to analysis and interpretation of data: RC, JH, RC, WT
Drafted and/or revised the article: RC, JH, AW, DT, PH, WT
Approved the submitted version for publication: RC, JH, AW, DT, PH, WT

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Data and Supplementary Material Accessibility

Data can be made available by request

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