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Positive Visualization and Its Effects on Strength Training

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The following study examines the effects of positive visualization on strength training. Positive visualization is being defined as: visualizing yourself performing a physical movement to best of your capability or beyond. Student-athletes were asked to positively visualize themselves performing lifts that they physically executed frequently in their training regimen (bench-press, back squat, clean or deadlift). A directionality analysis demonstrated that, compared to athletes who did not, participants who positively visualized had a significant increase in weight moved during a lift. The positively visualizing group demonstrated a 10-15 lb. increase in weight moved, while the control group only demonstrated a 5 lb. increase. This suggests that athletes are more successful when incorporating positive visualization into their training. Power movements (clean) dramatically increased, suggesting a follow-up study specific to type of muscle development and movement, could further improve the efficiency of athletic training combined with visualization. This research is important to the field of neurophysiology, as it demonstrates a connection between the mind (visualization) promoting potential change in neural circuity and muscle development (measured by strength). If we are better able to understand how thought and visualization influence the brain and the nervous system, we might be better equipped to understand the mind-body connection, and utilize it to promote health and wellness.

Keywords: Positive visualization, strength regimen, muscular development, neuropsychology

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Introduction

In Norman Doidge's book, *The Brain that Changes Itself,* he discusses the idea of visualization (imaging yourself doing something involving physical movement) and how it can physically change our minds and bodies (Doidge, 2007). He illustrates an experiment where "physical exercise" increased muscle strength by 30% while "imagined exercised" increased muscle strength by 22% (Clark, Mahato, Nakazawa, Law, & Thomas, 2014). Meaning, without any physical activity, visualization/imagery alone could increase muscle strength thus producing a physical change within the body. Visualization has also been proven to enhance athletic tasks and musical performance and skill (Driskell, Copper, & Moran, 1994). Driskell and colleagues illustrated that visualization can improve how neurons respond to stimulus, and therefore improve the efficiency of body movement during a specific task.

Just as moving a body part would activate certain cortical areas, mental imagery has been shown to activate several cortical areas that are involved with actual motor behaviors (Clark et al., 2014). Meaning, there is a relationship between cortex and strength development. Just as performing a movement develops muscle memory, actively visualizing a movement can also improve muscle efficiency during a task (Ranganath, Vlodek Siemionow, Jing Liu, 2004). These two sources suggest that athletes who visualize themselves completing a repetition of a given movement may be able to develop strength and efficiency without ever actually physically performing it. Research shows a relationship between an increase in muscular strength and neural adaptions as well (Carroll, 2012). So, as athletes visualized themselves completing a repetition and created a neural adaption, they may also increase their muscular strength simultaneously. This would help explain why the act of visualization can directly increase muscular strength, as they seem to be functioning as one system (or at least participate in a mutualistic relationship). In corroboration, studies have also proven that if a particular body part becomes immobile, corresponding cerebral cortex area input will decrease (Kaneko, Murakami, Onari, Kurumadani, & Kawaguchi, 2003). Meaning, when a body part is no longer active, part of the brain becomes less active as well. This suggests that by visualizing the movement of the specific immobilized body part, the area of the cerebral cortex would remain active in some way, and recovery of movement may be more successful. This is further evidence to our claim that through athletes positively visualizing they will be able to further increase their strength than if they simply physically performed the movements.

Neurotransmitters and Axon Development

Certain neurotransmitters encourage the development of axon pathways. Research has illustrated that in *Drosophila* embryos, neuromuscular junctions are formed selectively by motoneurons (Johansen, Halpern, & Keshishian, 1989). This research may suggest that if athletes visualize themselves performing the movements and stimulate motoneurons, neuromuscular junctions may be more likely to form which would increase strength and efficiency. For example, research has demonstrated that acetylcholine receptors (AChRs) accumulated within muscle fibers, exactly where synapses eventually form (Jing, et al., 2008). Cholinergic activity manipulation through imagery has been shown in empirical research analyzing humans (Ishii, et al., 2013). If mental imagery has the potential to produce cholinergic effects physiologically, then perhaps synapse formation will be further guided through mental visualization.

Furthermore, the development of new axon pathways can benefit nerve regeneration, and also encourage plasticity of the brain (Skene, 1989). From this research, it may be theorized that through neurotransmitters encouraging new axon pathways, the brain is more likely to change and therefore increase the potential for physical and mental development of the athlete.

Muscle Activation and Neurotransmitters

A muscle is voluntarily activated when force is produced by the recruitment of motoneurons through a chemical signal from the motor cortex. This activation is usually conscious and deliberate. This conscious act requires the subject to exert effort in order for the act to be completed. Influences that impact voluntary activation include excitatory and inhibitory sensory information that may make them responsive to synaptic input. Voluntary activation reflects the nervous system's ability to fully activate muscle and is assessed by electrically stimulating a peripheral nerve during a maximal voluntary contraction and telling the “added force” (Taylor, 2009). Essentially, voluntary activation requires deliberate force, and this deliberation is motivated by a neurotransmitter(s) responding to a stimulus. In this way, neural activity produces muscular activity.

Therefore, through athletes actively stimulating their neural system through visualization, they may improve their ability to activate muscles via motoneurons and motor units. This would be extremely beneficial in strength training, as it would allow for full use of the muscles being recruited, and also increase the maximal force produced. In a way, visualization may provide a practice stimulus for the neural system, and allow it to rehearse activating muscles at some level. Empirical research has demonstrated through EMG, that when imaging lifting a particular weight (heavy, moderate, or light) the brain responds in the same activation level (or effort) as if the athlete were physically lifting the desired weight (Guillot, et al., 2007). This research specifically looked at 9 muscles within the arm being used to move the weight, and found neural firing within related brain regions for these muscles and their motor units.

Strength and Neural Training

Strength is impacted by multiple variables. For instance, research has suggested that the nervous system is also a factor of strength exertion and development (Carroll, 2012). It may be inferred from this research that the brain plays a crucial role in strength performance and development, therefore making it equally important for athletes to train mentally along with physically. It has also been suggested that neural training and strength training interact as sort of a cross-education (Moritani & DeVries, 1979). Research such as this further suggests that training the mind is just as important as physically training. Visualization may be an excellent solution to athletes who aspire to achieve this dual training. To expand, just as unilateral training may increase strength in an untrained body part, neural training may increase strength in body parts that are not being specifically trained physically, or increase strength more than just physical training alone. In this way, the body can be primed to complete the process of chemical signal from cortex to muscle performing the desired act, through visualizing the act (Rm, Pm, & Ja, 2001). We may infer from this knowledge, that visualization may aid to prime the cortex to more efficiently perform during strength exertion, and may lead to strength development as seen with the unilateral training.

Present Study

The purpose of the present study is to observe the effects of positive visualization on strength development, and answer the questions: if an athlete positively visualizes themselves lifting weights, will they become stronger faster than an athlete who does not visualize? If so, what is the most successful duration of visualization, and what lifts are most benefited? These questions are important, as their answers could lead to more efficient strength training, and could be crucial to strength development in humans in general. If athletes are able to build strength more quickly, they are at a greater advantage to perform at a higher level. Furthermore, this research may also lead to further evidence of the brain's involvement in muscle development and activation, and allow for further research involving the brain and its relationship to the constantly evolving body.

We predicted a correlation between visualization and an increase in strength, as well as a relationship between duration of visualization and amount of strength increase. Therefore, we predicted a directionality model. Following the suggestions outlined, variable A (positive visualization) is correlated with an increase in variable B (strength).

Materials and Methods

Participants

133 participants (70 females and 63 males) who participated in the strength and conditioning program at Transylvania University were recruited to participate in the study. Participants ranged in age of 18-22 years with the average being 20 years. Thirty-two of the participants were black, seventy-eight were white, and twenty-three were hispanic/latino. As an incentive, participants were informed that proper execution of positive visualization may improve their strength and therefore their sport performance. Each researcher has completion of NIH training (Protecting Human Research Participants), and received IRB approval for the present study, in order to work with human participants.

Design and Procedure

Participants were randomly selected from eight Transylvania University athletic teams that participated in the strength and conditioning program. Participants were eligible to participate if they were required to attend the strength and conditioning program by their coach (to ensure participation daily). An almost equal number of females and males were drawn by using a stratified sample.

Participants had backgrounds in baseball, softball, basketball, soccer, lacrosse and dance. Each sport had male and female teams (and both were to utilized), except for dance (all female) and lacrosse (only male team). Some athletes reported also training additionally (outside of the training program), in the likes of running and machine-work. The majority reported only working-out during the prescribed training time in the weight room.

Participants completed an informed consent which informed them of the possible risks and benefits of completing the present study. Participants were randomly assigned to groups (control or test). If in the test group, participants were asked to positively visualize themselves performing a lift (lifting heavier weights than normally possible; moving better/more efficiently during the lift; winning a competition by performing a certain lift at a heavy enough weight). If in the control group, participants were not told to visualize, but rather to continue with training as usual. Both groups consisted of participants training in deadlift, bench-press, clean or back-squat with varying frequency.

During the beginning of the strength and conditioning program athletes were asked to attempt a max lift (the type of lift was dependent on sport and season). Participants then rated their strength increase, and frequency/duration of positive visualization (if in the test group), after a three-week period. Both groups rated their strength increase based on their initial max lift (greatest weight that could possibly be completed on a single repetition of a lift) at the beginning of the three weeks, versus their max lift at the end of the three weeks.

In order to positively visualize, athletes were given a suggested recommendation ideal for maximum concentration and consistency. It was recommended that athletes choose a specific time of day to visualize, and attempt to keep that appointment as consistently as possible to eliminate outside factors. It was recommended that athletes lie down in a quiet area free of distractions, and listen to motivational music if they found that helpful before physical performance (to help create a training mindset, many athletes have particular songs they find motivating and helpful in focusing).

Athletes could choose how frequently they visualized, and for how long they visualized as long as it was at least 5 minutes. It was suggested that athletes visualize themselves lifting at around 110% of their one rep max. For example, if an athlete deadlifted 300 lbs, they would visualize themselves deadlifting 330 lbs. It was emphasized that athletes should try to visualize themselves performing the movement as efficiently as possible (fast, good form, confident), and attempt to visualize what it would feel like to actually physically perform the repetition.

At the end of the study, athletes were debriefed on the results of the present study. Control and experimental groups were explained, and the assignment of each athlete to which group was revealed to ensure each participant understood how they had participated. It was also made clear to the control group, that while they had not demonstrated as great of an improvement in strength, there was never any variable working against their improvement in this study. Furthermore, based on the results, athletes were all encouraged to positively visualize regardless of which group they had previously been a part of.

Experimental Materials

Additional materials included a training room with standard equipment (barbells, bumper plates, clips, belts). All athletes performed their lifts on 45 lb. *Rogue* training bars, with bumper plates and clips to secure the weight loaded. Athletes all lifted on cushioned rubber mats and were allowed to wear their preferred lifting shoes. Athletes were also allowed to use weight-belts to help prevent injury if they chose to do so. All of the equipment was provided by the Transylvania University Strength and Conditioning Program.

For measuring strength improvement, participants completed a survey at the end of the experimental trial. The survey consisted of three closed-ended questions that were ranked on a five-point-scale and two additional close-ended questions. Participants ranked their improvement in pounds added to lift (1 = *none*, 5 = *15+ pounds)*, their frequency of positive visualization (1 = *never*, 5 = *7+ times a week*) and duration of visualization (1 = *less than 5 minutes*, 5 = *20+ minutes*). Participants were also asked to identify the type of lift (deadlift, clean, back-squat or bench-press) and how many times a week it was trained (twice or three times a week).

Results

Statistical Analysis

Statistical analyses were conducted using R (build version 1.66 Snow Leopard build) and R Studio “build version 1.0.153.” In order to assess the difference of means between groups of athletes who positively visualized and those who did not, a t-test was calculated. To decide which statistical test was most appropriate for the given data, tests of normality were performed.

The Shapiro-Wilk test calculated normal distribution of data (Table 1), while the Levene’s test for equality of variance found unequal variance (Table 2). Due to these circumstances and assumptions, a Welch t-test was calculated in order to analyze the means of the two groups. The Welch t-test (Table 2) was run with a 95% confidence interval (CI) for the mean difference.

Table 1. The Shapiro-Wilk Test

Group	*Shapiro-Wilks*		
Visualization:	Statistic	df.	Sig.
Yes	.969	66	.732
No	.963	65	.954

Note. The null hypothesis can be rejected (p>0.05) and the data is normally distributed.

Table 2. The Welch's t-test and Levene's Test for Equality of Variance.

<u>Welch t test</u>		Strength Increase (assuming unequal variance)
<u>Levene's Test for Equality of Variance</u>		
F		7.316
Sig.		.0077
<u>t-test for Equality of Means</u>		
t		10.133
df		128
Sig. (2-tailed)		0.0001
Mean Difference		-6.26
Std. Error Difference		0.617
95% Confidence Interval of the difference:	Lower:	-7.48
	Upper:	-5.04

Note. The Levene's test for equality of variance calculated that the requirement for homogeneity was not met. Therefore, a Welch t-test was performed to account for the unequal variance between groups.

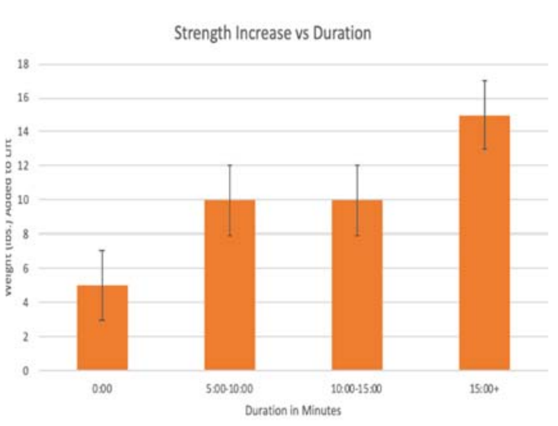

Figure 1 Mean increase in strength influenced by duration of visualization. The y-axis represents the weight added to the lift by the end of the study. The x-axis represents the duration of positive visualization in minutes. Error bars represent standard error.

Lifts and Muscle Recruitment

As seen in Fig. 2, each lift demonstrated different increases in strength. In order to further analyze the results of the present study, the muscles used in each lift were considered for strength increase.

In both groups, the deadlift saw the lowest increase in strength. Because both groups demonstrated a lower increase, it can be theorized that the erector spinae, gluteus maximus, and hamstrings (the main muscles used for the deadlift) may take longer to develop strength. Because both groups demonstrated a lower increase, it can be theorized that the erector spinae, gluteus maximus, and hamstrings (the main muscles used for the deadlift) may take longer to develop strength.

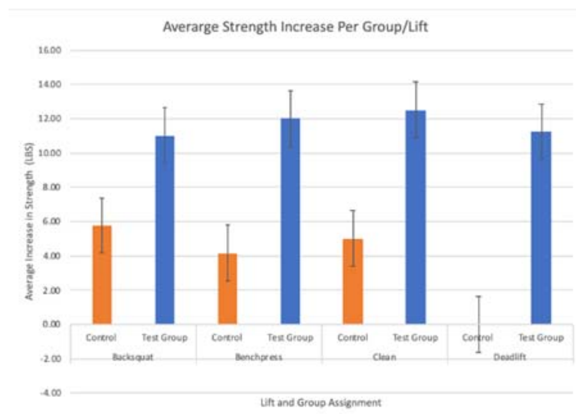

Figure 2. Mean increase in strength per lift and group. The Y-axis represents the strength increase, and the X-axis represents the four lifts and group assignment. The blue bars illustrate the test-group results, while the orange bars illustrate the control group results. Error bars represent standard error.

The back-squat was the highest average in strength increase in the control group. This means that athletes who didn't visualize had most success in the back squat, while athletes who did only saw some increase (on average 5 lb. more than the control group) compared to the increase in other lifts. The main muscles used during a back squat are the upper back, abdominals, lumbar spine, gluteals, thigh adductors, quadriceps, hamstrings, and calves. Clearly, a large number of muscles are activated to perform the lift, and it could be theorized that this could

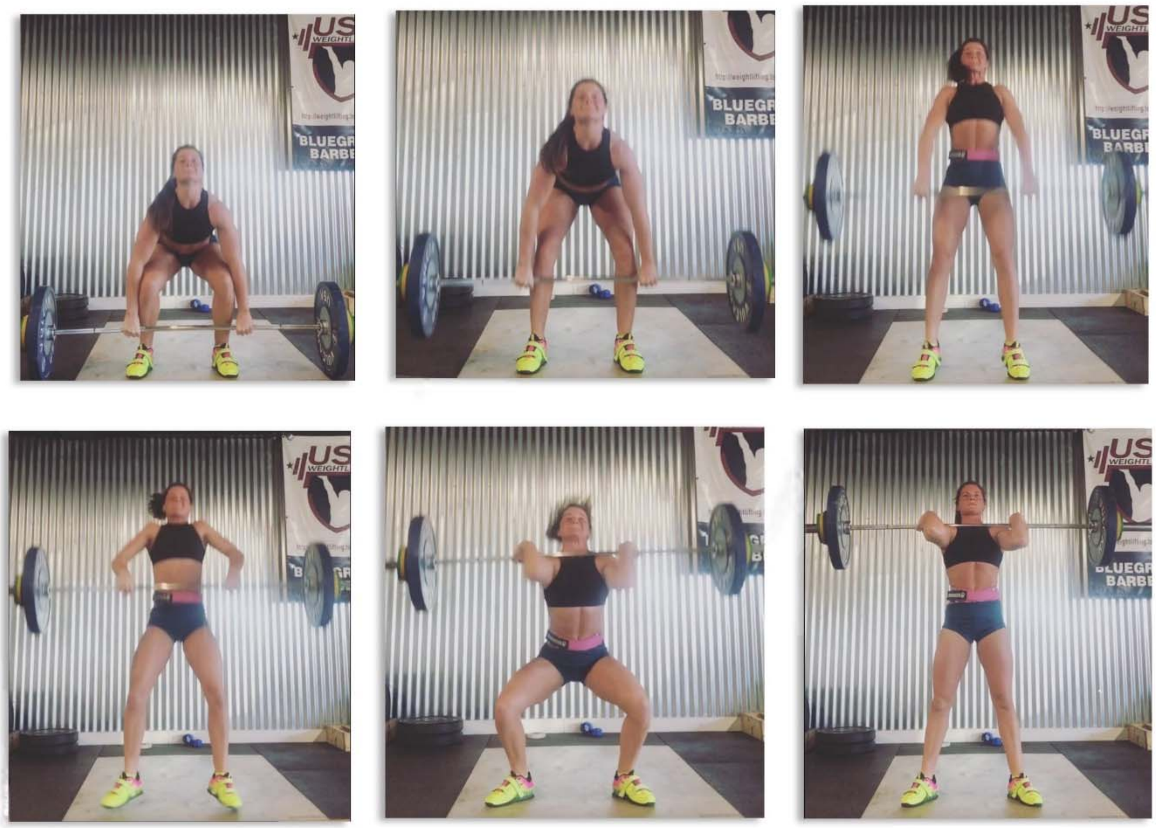

Figure 3. Demonstration of the power clean. The lift begins from the floor with the athlete preparing to pull (panel 1). Next, the athlete pulls the bar to hip level (panel 2-3) while simultaneously using an aggressive thrust of the hips (panel 3) to further the trajectory of the barbell upward. After the hips and legs have driven the barbell upward, the athlete uses their arms to finish pulling to their fullest extent (panel 4). The receiving position of the barbell is above parallel (not in a squat) with the elbows high in the front rack position (panel 5). Lastly, the athlete stands the barbell all the way up to a standing position (panel 6).

limit the ability of visualization to increase strength. Essentially, the higher the number of muscle groups used to perform a movement, the less likely that visualizing will condition the mind to activate all the necessary muscles.

The clean illustrated the greatest increase in strength, averaging at a 15 lb. increase. The group of athletes performing cleans did so in the power style. The lift does not include a squat, rather a pull and hip-pop which guides the barbell to the chest/collar bone without the hips dropping below the knee. This movement requires explosive movement and speed, which activates the shoulders and posterior chain. The lift is shown in Figure 3. Because such a high increase in weight moved was seen, it might be argued that visualization was most successful in increasing explosiveness and speed (even with a higher number of muscles being activated). Further research is needed to test this hypothesis, as speed and explosiveness were not a measure in the present study.

Interestingly enough, the power clean mimics the deadlift in the first part of the lift. The fact that athletes saw limited strength increase in the deadlift, but saw a tremendous increase in the power clean, suggests that athletes are approaching the lifts with different mindsets. While some athletes focus on the speed of the bar and moving fast, some may be focusing on simply completing the lift. I would theorize that if athletes approached the deadlift with the same speed/explosive mindset that they did the power clean, they would see an increase in the deadlift as well. Perhaps when athletes focus more on speed rather than strength alone, more muscle recruitment and motor unit activation occur and thus there is more potential to activate these afferent and efferent pathways when visualizing.

Lastly, the bench-press also demonstrated a large increase in strength, particularly in the test-group. Readers can explore the execution of all of the lifts examined in this research at many web sites dedicated to fitness or weight lifting. “StrongLifts” (https://stronglifts.com/exercises/) provides particularly good examples.

On average, participants in the test-group averaged a 10 lb. increase in their lift versus the control which saw an average of 5 lb. increase. The muscle groups recruited include (but are not restricted to) the pectorals (minor and major), bicep brachii, and deltoid. These muscle groups are smaller in size, and may be more susceptible to positive-visualization based on the results seen in this study.

Discussion

The purpose of this study was to examine the influence of positive visualization on strength development in collegiate athletes. Considering the athletes who visualized, we predicted and found, that participants who positively visualized along with their training correlated with a larger increase in strength than those who did not visualize. Participants who visualized with their training demonstrated greater strength gain and proficiency in their regimen. Furthermore, we predicted that there would be specific durations of visualization that would be most potent in developing strength. Based on the present study data, this duration is within 5-15 minutes, and produces about a 10 lbs. increase. In corroboration, we also predicted that visualization would have a greater effect on certain lifts. As illustrated in the present study, power lifts increased the most substantially.

Duration of Visualization Impact

Based on the results of the present study, a trend can be observed in the increase of visualization and increase in strength (Fig. 1). Positively visualizing is correlated with increased weight moved for back squat, bench press, clean, and deadlift (Fig. 2), compared to the results of the control group.

Based on the data, visualizing between 5-15 minutes will produce similar results, but 15 or more minutes produces a greater increase in strength. There is a greater increase in strength of athletes who positively visualized compared to those who don’t (Figures 1 and 2). Athletes who visualized demonstrated increase in strength (on average seeing 10-15 lb. increase) compared to those athletes in the control group (on average seeing only a 5 lb. increase). It can be theorized that those participants who visualized for over fifteen minutes allowed more time for developing new axon pathways within the brain. This also highlights the importance of time on the efficiency of visualization and its involvement in strength development.

Furthermore, statistical analysis found that the athletes who coupled positive visualization with strength training (11.417 ± 0.461) demonstrated a significantly greater an increase in strength than athletes who only performed strength training (5.513 ± 0.432) ($t(128) = 10.133$, $p < .05$) with a difference of 6.26 (95% CI, -7.48 to -5.04) pounds added (measured in weight moved on testing lift) (table 2).

Because the present study suggests that athletes who positively visualize have a greater improvement in strength than those who do not, it might be argued that these athletes who visualize are improving their neuromuscular junctions are axon development. As discussed previously, cholinergic activation has been shown to occur due to imagery in human participants, and ACh in particular has been demonstrated to help guide synapse and axon formation between motor units and the muscle fibers. If this is the case, and these athletes are able to stimulate a neurogenesis of sorts through visualizing, they could potentially be increasing efficiency between the desired muscle group(s) and motor pathways within the brain.

Perhaps these athletes are not so much building physical strength, but learning to move more efficiently through priming the motor pathways to function with the muscle fibers more proficiently. However, by definition, strength is the ability to exert force onto an object. Therefore, through these athletes theoretically being able to do so more proficiently, does also suggest an argument for an increase in strength.

Our research suggests that potentially more adaptions in neurophysiology occur through neural training, and that it is most beneficial to physiological strength when coupled with physical training.

Limitations

The present study was limited in dependency on participants to properly visualize and physically perform the lifts. There being 133 participants, it was increasingly difficult to ensure all were properly positively visualizing themselves lift and doing so enough times during the week. Some participants were also unable to properly perform the lift physically, compromising the visualization of the lift. Research has already shown that physical movement plays a large role in neurological well-being (Smits-Engelsman & Van Galen, 1997), so it can be theorized that if a participant cannot physically move well, visualizing the movement may not recruit the proper neurological pathways to improve strength, or cause the proper physiological responses such as a release of ACh. To substantiate this claim, consider the effects the brain can have on the body. Neuronal oscillations control and contribute to a number of physiological processes and neurophysiologists have found

that misfiring neurons can lead to physical tremors. Research has suggested that alterations in neuronal firing rates underlie the spectrum of movement disorders (Hutchison, 2004). Essentially, by physically moving poorly during a lift, the mind cannot develop new pathways to increase strength or may develop less efficient pathways.

Furthermore, the collection of data for this study was done through self-report. This creates more potential for human-error regarding the data for the present study (specifically, the duration of visualization and frequency). Therefore, our results cannot be said with certainty to be causal, but rather only a correlation between neural training and strength development. The ability to generalize the results and apply their findings to the general public is erroneous as there is not a direct link of casualty.

Application and Theory

The empirical findings of this study suggest that coupling positive visualization with strength training regimens produces a greater increase in strength than following a regimen without also positively visualizing. In this particular study, collegiate athletes were used for sampling, but these findings could be beneficial to the general population as well. In theory, these findings could be applied to any individual who physically exercises.

Research has demonstrated that intrinsic factors can predict exercise levels (Teixeira et al., 2012). These researchers used the self-determination theory to assess how likely participants were to exercise and consistently do so. The results suggest that the more positive the internal state of an individual is, the more likely they are to exercise and to continue doing so. The present study may build on this research further, through theorizing that positive visualization increases the likelihood of a positive internal state. If this is accepted, then through the general population positively visualizing, there could also be an increase in exercise frequency from the general population. This increase in exercise could also in theory aid in the prevention and treatment of chronic diseases caused by lack of motivation to exercise.

The present study has demonstrated that this positive visualization also promotes a greater increase in physical performance versus groups that do not positively visualize. Therefore, the use of positive visualization coupled with a training regimen could not only promote an increase in exercise frequency, but also in desired outcome through bettering the likelihood of improvement in strength. Therefore, the general population may see better results from training, feel an increase in motivation to continue their training due to experiencing progress, and also see important health benefits that are related to consistent exercise.

Lastly, future directions for the present study may analyze movements and muscle groups specifically. The present study demonstrated that power movements were most benefited by neural training, imploring the question be asked why this is the case. It may be beneficial to implement a test group that only positively visualizes without physical training. This would allow researchers to directly observe the effects of neural training alone, specifically to muscle growth. This could be used to answer if neural training only increases efficiency of movement, or if it has the potential to directly build strength.

Conclusion

The results of the present study support the notion that positive visualization combined with physical training produces a greater increase in strength than physical training alone. While research on visualization and strength development often focuses on regaining strength rather than building on it, we would argue that more attention is needed on the interaction of neurophysiology and physical strength growth. Not only would it be a vital topic for collegiate athletes, but for anyone looking for a more efficient way to improve their physique and health, and overall well-being.

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