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REVIEW ARTICLE

Exercise Therapy in Stress Management

Haorui Zhang[1], Yi Wang[2]

1. Sanya Foreign Language School Affiliated to Shanghai International Studies University, No.1 Fengxiang Road, Tianya District, Sanya City, Hainan Province, 572000, China; andyzhangmm26@gmail.com
2. Crimson Education, 135 E 57th St, New York, NY 10022

ABSTRACT: Feeling stressed is common for individuals, but studies emphasizing the significance of Exercise Therapy (ET) in stress management are limited. This study aims to explain the potential of ET in reducing the negative effects of stress through an analysis of their physiologies. A literature search is performed on Google Scholar. Relevant sample papers or resources are filtered and collected. Accordingly, this study concludes possible trends and explanations based on the data or hypotheses presented in such resources. As a result, two conclusions about stress and ET are drawn. First, duration and intensity are likely significant factors that determine whether a stress response may be harmful. Specifically, duration might be the dominant factor because a high duration indicates insufficient recovery periods. Second, exercise can be considered a milder and more controllable form of stress, which might help train the body's response system. Based on these conclusions, this study gives two reasonable principles for the pragmatic use of ET.

KEYWORDS: Biomedical and Health Science, Pathophysiology, Stress, Exercise Therapy.

Introduction

Stress is a common state that individuals experience in modern society. This may be induced by problems in relationships, academics, or other aspects. Stress-induced diseases, such as obesity and depression, are also becoming more prevalent. Teenagers, who are facing intense competition with their peers, may be exposed to a riskier condition of over-intense stress or chronic stress. In this paper, mechanisms of stress-induced diseases and corresponding treatments are mentioned based on literature reviews. Chronic Low Back Pain (CLBP) and depression are used as examples for illustrating stress-induced diseases.

Many studies reviewed in this research rely on drug therapies and conventional psychological therapies as treatments for diseases likely induced by stress. For instance, a study in 2006 discovered that conventional drug therapies can be effective in the treatment of PTSD, which is a disease commonly induced by stress. Specifically, Paroxetine is used as a licensed medicine for treating PTSD. In this 12-week study, the groups using Paroxetine had an apparent improvement in Clinician-Administered PTSD Scale from the baseline starting from the 4th week compared to the placebo groups.[1] In addition, a study in 2011 pointed out that psychological methods can also help reduce stress-induced symptoms.[2] For instance, significant reductions in systolic and diastolic BP values are observed in some patients after the treatment. These conventional methods have been used for a period and were reported as effective. However, few studies have mentioned that exercise can also be helpful or even highly potent as a treatment for stress-induced diseases, especially in teenagers. In fact, some research, though not much, suggests that Exercise Therapy (ET) may have some advantages and additional benefits to individuals in the long term. For instance, it is reported that in CLBP, there is moderate-certainty evidence that suggests ET's probable effectiveness in eliminating pain in some chronic diseases.[3] Also, both aerobic and non-aerobic exercise interventions reduce depressive symptoms.[4] These demonstrate the possible value of ET. Thus, this paper evaluates the physiological changes of exercise and attempts to explain its potential use as a treatment.

Discussion

1. The mechanism of how stress does harm:

Generally, stress is a state of threatened homeostasis triggered by intrinsic or extrinsic adverse forces.[5] Pressure from the academy, work, or other social responsibilities are all modern stressors to individuals. However, stress may induce negative physiological adaptations in the endocrine system, the skeletal muscular system, and other systems in the human body. These physiological changes may lead to pathological changes and trigger diseases like Chronic low back pain (CLBP). Thus, treatments or precautions are required to train the body and enhance its stress tolerance.

Stress status is originally a natural state of the body, so possible treatments for stress-induced pathological changes need to be based on the mechanisms of human physiological responses to various stressors. The physiological response of the human body to stress primarily relies on the nervous system, specifically the autonomic nervous system, and the endocrine system. Neuroregulation of the nervous system and hormonal regulation of the endocrine system function in collaboration during these responses. The entire response process is divided into two minor steps: perception and regulation. Both steps involve physiological changes in certain organs or glands that contribute to the new homeostasis during stress.

The first step in any stress response is the perception of a threat.[6] This involves two levels: emotional experiences and

DOI: 10.36838/IJHSR87.244

physiological changes. The emotional responses, or an individual's feelings, are generated by the amygdala, hippocampus, and other brain regions.[7] These regions also activate the hypothalamus through nerve signals. In consequence, many of the physiological changes are triggered by activities of the hypothalamus, which is located in the central nervous system. It performs multiple functions related to hormone production and nervous system regulation. Specifically, it sends nerve signals that activate the autonomic nervous system and certain glands of the endocrine system, such as the adrenal gland, during a stress response.[8-10] When addressing the negative effects of stress on body functions, the physiological changes caused by the hypothalamus can be primarily considered, compared to emotional experiences. However, understanding how the emotional parts of the brain regulate the hypothalamus may help improve therapy strategies, benefiting individuals physically and emotionally. To the hypothalamus, the activity level of other brain regions is the main factor of its activation, while the modalities of the stressors that cause such activity in the other brain regions—including psychological, cognitive, and physiological ones—do not appear to be as important.[11] Different stressors may trigger various emotional experiences in individuals, but the same physiological process is initiated by the hypothalamus. Thus, a possible conclusion can be drawn to evaluate stressors' effects on responses. From the perspective of physiological changes, different stressors mainly determine the intensity of the response. However, different individuals may experience different levels of anxiety when facing the same challenge due to their unique emotional backgrounds, as seen in changes to vital signs like cardiac output. Additionally, chronic stress damages the proper functioning of the amygdala and hippocampus, which can impair hypothalamic functions and weaken the response system's adaptability, potentially creating a vicious cycle.[12]

The second step in the stress response process is regulation. Regulation of the body begins after the perception of stress has occurred. There are two main possible pathways that the hypothalamus stimulates. Based on the endurance of the stressor, stress can be classified as acute stress or chronic stress.

In case of an acute stress, which lasts for seconds or minutes, the hypothalamus triggers the adrenal gland mainly through neural pathways to produce epinephrine and norepinephrine, resulting in an instant increase in heartbeat, blood pressure, and muscle blood flow, and suppression of the digestive and immune system. These physiological changes are intense but of short duration, aiming for urgent Fight-or-flight responses.[13]

In the case of chronic stress that lasts for days or even longer, the endocrine system dominates the pathway mainly by triggering the HPA axis, which contributes to maintaining a high concentration of ACTH and cortisol in the blood.[14] This enables the body to cope with possible danger that has not yet existed.[15] This emergency state during stress, functions at the expense of deprioritizing the systems that perform normal metabolism, which makes it destructive to the health of the individuals in the long term. Thus, acute responses to stress have relatively less damage due to their short period. In fact, acute stress induced by mental arithmetic increases the duration of muscle contraction by 46% in men. This demonstrates that acute stress can even improve specific functions.[16] Chronic stress, on the other hand, responses are highly likely to induce detrimental physiological changes.[17] Thus, it is rational to conclude that the key variation between these two types of stress is whether a period of recovery exists. Specifically, acute stresses occur intermittently, allowing the body to regulate itself into a normal state before any subsequent stimulations and actively form adaptations that help the body cope with similar stresses in the future (Figure 1). This mechanism is implied in a study that emphasizes the benefits of napping in 57 healthy teenagers,[18] and another study points out the role of resting in muscle recovery.[19] Chronic stress, on the other hand, leads to compelling physiological changes. For instance, it is discovered that mental stress doubles the subjects' risk of facing myocardial ischemia.[20]

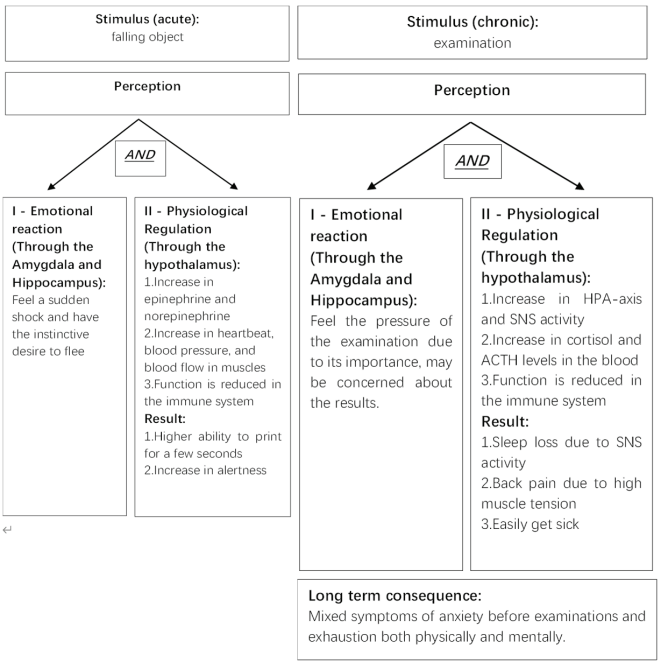

Figure 1: The different processes of stress response in acute and chronic stress (Note: the figure points out that the duration of stress may determine its effect on the body). Acute stress induces instant physiological changes, while chronic stress induces continuous physiological changes that are likely to be detrimental.

The mechanism of the physiological changes induced by chronic stress can be used to elaborate on the cause of some diseases that widely appear in modern society, for instance, CLBP or depression. In fact, stress in modern society is highly associated with the economy, and the global economy loses 12 billion workdays at a cost of about $1 trillion caused by stress every year. This kind of stress, which individuals commonly face, lasts for a long period and leaves individuals with little or no recovery periods. The top stressors include the economy, gun violence, and personal safety, which are all long-lasting problems.[21]

In cases of CLBP, many patients reported that there are no explicit causes for symptoms like soreness of the muscles. However, subjects under chronic stress with higher intensity

or duration tend to have a higher possibility of having such issues.[22] There are no clear mechanisms of this phenomenon, but a rational explanation is that high tension and blood flow in the muscles during stress conditions may cause damage to the muscle tissues, as well as leading to fatigue.

In cases of depression, stress may be a significant cause of depression, and chronic stress is predictive of depression.[23] This may be due to the disturbance of stress hormone release.[24] As mentioned earlier, if the body lacks proper recovery, hormone levels may remain abnormal and, therefore, may cause problems.

In conclusion, if analyzed from the perspective of physiology, the factors that may significantly impact the physiological changes are the stress intensity and duration. Low duration or sufficient recovery periods are important for building beneficial adaptations. To form such adaptations, the proper intensity of the stress is also important, which may vary among individuals due to emotional reasons. Its practice in the therapies will be discussed in "Principles of Using ET as a Treatment of Stress."

2. The theoretical basis of exercise therapy in stress management:

A study in 2005 points out that regular exercise is instrumental in eliminating anxiety and sub-healthy status in individuals suffering from chronic stress.[25] This is possibly relevant to physiological changes during and after exercise. These changes may contribute to the adaptations of the human body systems and make them more resilient to stress.

The physiological changes in the body during a single bout of exercise closely resemble those in conventional acute stress. During exercise, the sympathetic nervous system (SNS) is highly activated. It regulates blood flow by causing vasodilation in skeletal muscles, resulting in active hyperemia and shunting, while inducing vasoconstriction in other organs not directly involved in movement, such as the kidneys. Stress hormones such as epinephrine and norepinephrine, which are also neurotransmitters of the SNS, are produced in higher amounts to facilitate targeted energy distribution that prepares the skeletal muscular system. Additional stress-related hormones, such as glucagon and growth hormone (GH), also increase to break down stored nutrients for energy.[26] Therefore, it is reasonable to conclude that a single bout of exercise can be regarded as a form of acute stress because its physiological response closely aligns with the typical response to acute stress. As mentioned earlier, acute stress causes relatively low damage to the body and is unlikely to trigger harmful adaptations. Similar to acute stressors, exercise generally does not harm normal bodily functions if performed at moderate intensity. However, overtraining can be destructive and lead to overtraining syndrome (OTS), which may result in symptoms such as sleep disturbances and immune problems, similar to the pathological changes that chronic stress might induce (Figure 2).[27]

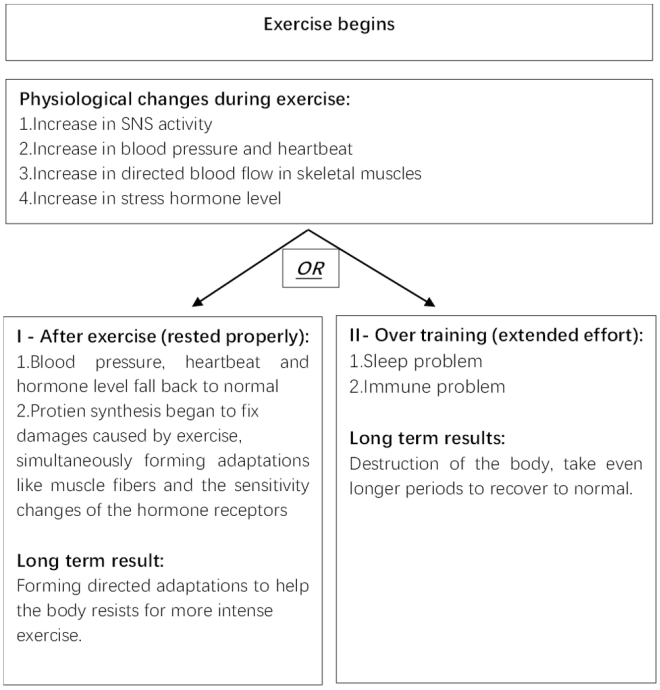

Figure 2: The physiological changes during and after exercise (Note: this figure points out that the intensity of exercise may determine its effect on the body.[26,27]). Proper exercise builds beneficial adaptations, while overtraining may be destructive.

Significant physiological similarities exist between acute stress and exercise, as well as between chronic stress and overtraining. The reason they are closely bonded may be explained from the perspective of evolution. In a natural state, most stresses for humans come from the threat of predators, which requires the individual to be prepared for sprinting, jumping, and other physical movements. Thus, the skeletal muscular system, as well as the cardiovascular and respiratory systems, becomes the priority during stress responses.[28] Exercise impacts the skeletal muscular system and relevant systems with similar objectives as other conventional stressors do, but with lower intensity and duration, since the challenges in sports are not a vital issue nor a continuous and significant challenge. The physiological changes in exercise make it a vivid but mild stressor that trains the body's response system. The method of using exercise to induce adaptations in the human body functions similarly to vaccines, known as exercise therapy (ET).

Based on the way ET functions, it has two key advantages: it can be qualified and customized. These advantages ensure that stimuli to the stress response system can be accurate and precise on the level of both duration and intensity.

From the level of duration, ET can provide the individual with sufficient recovery periods, which are essential to both avoiding exhaustion and forming beneficial adaptations. Through periods of systematic training, individuals' baseline cortisol declines, and during subsequent stresses, the cortisol spike also resolves to the baseline more quickly.[29] Similar mechanisms were concluded in studies relevant to muscle building—new and thicker muscle fibers begin to appear two to four hours post-exercise if rest and nutrition are sufficient.[26] These results indicate that though stress status causes fluc-

DOI: 10.36838/IJHSR87.244

tuations of normal metabolisms and instant instability, the adjustment process may construct a more efficient pathway of coping with future stresses. Moreover, conscious adaptations, for instance, self-confidence, also play an important role besides physiological ones.[30] Even when chronic stress already causes severe physiological changes, some of them, for instance, cognitive disorders in the hippocampus, are still reversible through intensified exercise.[31] The principles of how the recovery periods should be arranged will be discussed in "Principles of using ET as a treatment of stress."

From the level of intensity, ET makes sure the intensity and content of the training sessions are helpful for the adaptation of stress resilience. The intensity and types of stressors affect the long-term adaptations after regular exposure to the stressors.[32] This study points out that the content of the stressor can possibly affect the type of long-term effects formed after exposure to those stressors. Specifically, repeated low-intensity stimuli trigger adaptation, which decreases the magnitude of the response progressively. However, exposure to a stimulus followed by a different and novel stimulus often leads to an enhanced response to the original stimulus, forming a dishabituation. Moreover, when the stimulus is noxious, the response magnitude also increases. According to the physiology mentioned earlier in this paper, this may be attributed to the activation of the amygdala, the hippocampus, or other cognitive encephalic regions.[12] When a new or noxious stressor appears, these regions of the brain might be highly activated. They are likely to generate stronger signals that stimulate the hypothalamus; therefore, they are likely to cause more intense physiological changes and emotional experiences. In contrast, repeated stressors with lower intensity induce less excitement in relevant encephalic regions, and as the stimuli repeatedly occur, the response would be even weaker. Exercise, as mentioned earlier, can be considered a relatively milder stressor compared to other conventional ones, so it can likely trigger adaptations and reduce the magnitude of the physiological changes in future exposures to similar types of stress. Professional therapists can also design training regimens customized for individuals. By arranging ET of various types, the individuals involved would build adaptation in coping with multiple types of stress. The principles of how the intensity and content of the training sessions should be arranged will be discussed in "Principles of Using ET as a treatment of stress."

Such advantages of ET can explain the improved outcomes in CLBP treatment by combining ET into the therapy. Regular exercise increases muscle strength in the lower back of patients, which prolongs the time it takes for the muscles to fatigue in daily activities. SNS activity will also maintain a relatively lower activity, reducing abnormal muscle tension that may cause chronic pain or soreness.

Similarly, the benefits of ET make it applicable for the treatment of depression, and possible mechanisms of exercise's function may lie within the brain. New adaptations may form in the central nervous system after exercising for a period.[33]

However, though ET gives some positive feedback in disease treatments, it is still important to consider some possible limitations when applying ET to the treatment of individuals. Studies have also highlighted that the effectiveness of ET is only evident in subacute diseases, suggesting that this methodology has limitations.[34] Though other studies imply that ET induces no increase in serious adverse events, involving exercise in acute stresses or diseases, especially intense ones, may deteriorate the disease.[34,35]

In conclusion, ET can be a potential method in solving stress-induced negative physiological changes because it can activate the body's stress response system with stimuli of lower duration and intensity compared to conventional stressors.

3. Principles of using ET as a treatment for stress:

As mentioned earlier, the key mechanism of how ET produces positive outcomes may be based on the adaptation it triggers. In some chronic diseases, detrimental adaptations and an unhealthy state of homeostasis have already formed. Exercise helps the body restrain such negative physiological changes, and, in some cases, reverse them by rebuilding healthy adaptations. Exercise can also prevent further pathological changes that might occur if such an unhealthy homeostasis is maintained.

However, since ET is designed for individuals who have underlying diseases or disabilities induced by chronic stress, training regimens for healthy individuals or even athletes will be risky for them. ET constructed for these individuals should be more cautious to eliminate factors that might debilitate the present condition, since cases of negative side effects have been reported. Thus, two essential principles can be proposed for using ET in stress management to ensure its safety and effectiveness based on its mechanism of forming adaptations.

The first principle is that sufficient recovery periods are very important. The whole training process should be designed as a loop of "exposure status" and "resting status." During the exposure status, the individual would participate in certain physical activities and experience stress induced by such activities. After the exposure status, the individual would need enough time to rest so that the body can repair the damage caused by the exposure in the resting status. The resting period, specifically, needs to be prolonged until the individual does not experience any discomfort from the training, both physically and mentally.36 As mentioned earlier, resting, as well as sufficient nutrients, is essential for the body to form directed adaptations. If an individual remains in a restless, stressed state, it is highly possible for negative adaptations to form in response, which exacerbates the symptoms.

Specifically, in the case of designing ET regimens for CLBP, not many studies have mentioned the specific standards or methodologies for the training routines for curing CLBP, but it is reasonable to extrapolate from the regimens designed for healthy individuals and make adjustments to ensure that these routines are proper for individuals with CLBP. For a normal, healthy adult, it is proper to have 1-2 days of rest after intense or moderate training, and it may vary slightly depending on the type of training, which may include aerobic training or resistance training.[37] For individuals with CLBP, the resting period could be suitably extended. For instance, with a young individual with moderate CLBP, two to three days of training

separated by resting days may be appropriate. This training frequency may apply to depression treatments as well. Exercise that was performed 3-5 times weekly and of moderate intensity may be helpful for depression. The entire training process may take 4-16 weeks.[38]

The second principle is that it is beneficial to design training content with relatively low risk and intensity. As mentioned earlier, the intensity and content of the stimuli may determine the type of long-term effects formed. Thus, it is essential to ensure that the intensity of the ET is relatively low to avoid possible risks. The individual who participates in the therapy also needs to have full access to the possible risks and disappointments of the training sessions before they begin. This reduces unexpected or new stress experiences during the training. The participant's emotional experiences need to be considered, particularly because similar training tasks may result in entirely different response intensities in individuals with different backgrounds. In addition, recreational training may enhance the benefits. Specifically, it shows that recreational football helps to decrease systolic blood pressure by 4.20 mm Hg and diastolic blood pressure by 3.89 mm Hg compared to no-exercise controls or continuous running training.[39]

Specifically, in the cases of designing ET regimens for CLBP, regular outdoor activities like walking and indoor specialized training can both be considered, but with low or moderate intensity for each session. In addition, the patient needs to be aware of the most likely risks during training, for instance, having stroke defects or muscle soreness. Thus, this study discusses the possible therapy process (Figure 3).

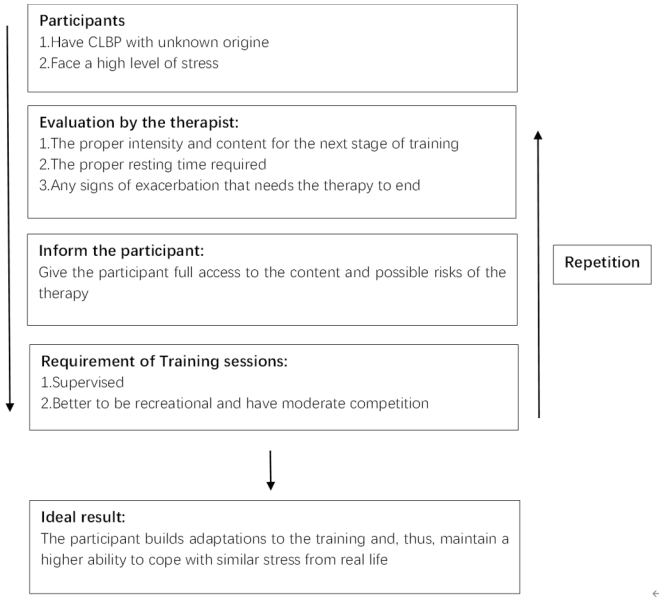

Figure 3: The ideal design of the ET process, as in the example of CLBP (Note: Consistent evaluation and training may be required for a relatively long period to reach the ideal outcome, as explained in "Principles of using ET as a treatment for stress"). The participant may benefit from ET, for example, by forming adaptations to similar types of stress. However, further research on ET is still needed.

Conclusion

Stress status, as a product of evolution, is for facing incidents that may be a threat to the individual's survival. However, due to stress responses' prioritizations on the specific systems of the body, the deficiency of normal metabolism appears after a long duration. When the body lacks recovery time or has limited ability to eliminate negative physiological changes that occur during stress, chronic diseases like CLBP and depression are likely to develop. Thus, exercise therapy may be introduced to help build a more resilient and adaptive pathway for the individuals' stress responses. The similarities between exercise and other conventional stressors help exercise mimic these conventional stressors better. Since the duration and intensity of exercise are relatively low and can be manually quantified, the risk of introducing extreme intensity and overactivating the response system is minimized. Among the studies included in this paper, the evident efficacy of ET indicates that it can be a preferred treatment or precautionary measure for diseases induced by chronic stress if performed with a sufficient recovery period and proper content. Introducing individuals to the habits of exercising can also be beneficial for their quality of life and well-being in the long term.

In addition, further research can be conducted on quantifying the assessment system, improving the accuracy and precision of the evaluation before, during, and after training. This may provide more reliable training regimens and eliminate possible risks.

Acknowledgments

There is no funding support for this work. This work was completed under the mentorship of my mentor, Yi Wang, a former tenured Professor of Public Health at Indiana University.

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DOI: 10.36838/IJHSR87.244

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Author

Haorui Zhang is a student at Sanya Foreign Language School Affiliated to Shanghai International Studies University. He is interested in exercising and is willing to solve problems teenagers face. He has been learning and researching in the field of biology and sports science. He hopes to make further and more constructive contributions to sports science and public health.

DOI: 10.36838/IJHSR87.244