Exercise and Stress Part IV—Stress Disorders

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Introduction

As displayed in part 1 of this series, stress is not always a bad thing. In fact, stress is absolutely essential for growth. However, problems occur with abnormal, chronic stress responses, particularly in sedentary circumstances. This is when the stress response can lead to numerous potentially deadly diseases. In this context, the purpose of this paper was to discuss chronic stress disorders.

Stress in the Work Place

The stress response was designed for action and physical activity, and can be very beneficial during acute bouts of physical activity, such as weight training, as it increases your capacity to perform. However, many people today are stressed *and* sedentary. For instance, Americans, operate in a persistently hectic environment. This has contributed to alarming numbers of mental ailments including 16 and 32 million cases of depression and anxiety, respectively (McCullagh, 2005). These same people often make excuses to avoid physical activity; in fact, 50% of American adults are completely sedentary (McCullagh, 2005). Further, even in the exercising population, during times when they are sedentary, such as the work place, they also get stressed. This is when stress can cause serious ailments and diseases. If we do not utilize the nutrients and energy being furnished by our body during the stress response, several diseases result. Thus, these next several paragraphs will deal with chronic stress disorders, particularly in sedentary situations.

Chronic Stress Disorders

Stress has several effects that can cause disease. These next sections will discuss these effects.

Diabetes

As displayed in article 2 of this series, stress causes the release of glucose in the blood stream. When you are stressed and sedentary, the glucose is not being actively taken up by the muscles and utilized. In response to this, your body will release the hormone insulin from the pancreas, to help store glucose. When insulin sensitivity is high, it is an effective hormone that helps shuttle glucose into the musculature, and facilitates an anabolic environment. Here is the role of insulin in a healthy individual (Brown, 2005).

1. After a meal containing carbohydrates both blood glucose and insulin increase proportional to the carbohydrates consumed.
2. Insulin binds to its receptors on the muscle sarcolema (muscle membrane), and enters the cell.
3. The presence of insulin in the cell signals the glucose transports (glute-4 receptors) to move to the cell membrane (sarcolema).

4. Glucose binds to glut-4-transporters and enters the cell.

However, abnormally high levels of insulin can cause insulin resistance, meaning that your body is not as receptive to the effects of insulin. Here is an abnormal insulin response (insulin resistance) (Brown, 2005):

1. The same amount of carbohydrates ingested produces excess insulin secretion. This is hyperinsulemia, and leads to insulin resistance.
2. This leads to a reduction in insulin receptors. This is known as down regulation. Receptors exposed to hormones to unphysiologically high concentrations, or for long periods of time, are down regulated (become less available for hormone action). Thus, insulin's anabolic effects will be decreased.
3. Less insulin enters the cells.
4. Fewer number of glut-4 transports move to membrane of cell.
5. Fewer glucose molecules will enter the cell because there are less glut-4 receptors.

Acute side effects from insulin resistance include lack of energy and fat gain, as glucose is converted to fat for storage. Chronically, this can lead to diabetes, which is a horrible disease.

Type 2 diabetes is the most common type of diabetes (National Diabetes Data Group, 1985). Type 2 diabetics either do not produce enough insulin or their cells are insensitive to insulin. Since the body is unable to absorb glucose into the cells, this results in an accumulation of glucose in the blood. Problems from diabetes include decreased energy, and an increased chance of cardiovascular disease. It is widely recognized that stress can increase risk to Type 2 diabetes (Surwit et al., 2002). As discussed, evidence suggests that psychological stress can directly effect type 2 diabetes as a results of a psychosomatic increase in counter regulatory hormones (hormones that help maintain blood glucose levels) including cortisol and catecholamines, which have the effect of elevating blood glucose levels (Inouye, 2006). And indirectly through an increase in "comfort foods" such as sweets, which further elevates blood glucose levels (Simmons, 2006). Comfort foods will be discussed more momentarily.

In this context, Surwit et al. (2002) investigated whether cost-effective, group-based stress management training program could improve glucose metabolism in patients with type 2 diabetes, and to determine whether stress management is more effective in treating high-anxious than low-anxious diabetic patients. Participants consisted of 72 patients with type 2 diabetes. Participants were divided into a control condition (n=34) and an experimental condition (n=38). Diet, weight, and exercise were monitored closely, as these could potentially confound an improvement. Participants blood glucose levels were monitored and questionnaires assessing perceived stress, anxiety, and psychological health were administered at regular intervals to evaluate treatment effects over a 1 year time span.

During the first two months of the experiment, participants were required to attend 5 weekly small group class sessions. Both conditions were provided general education on diabetes; while the experimental condition was also educated on stress management skills. Stress management consisted of progressive relaxation training, cognitive and behavior skill training, and education on the health and consequences of stress. Progressively relaxation entails tensing and relaxing a set of muscle groups

in the body, starting with the feet and progressing towards the head. Cognitive and behavior skill training consisted of deep breathing, which typically involves inhaling for 4 seconds, and exhaling for 8 seconds; imagery, which was not described in detail, but may have involved imaging feeling controlled and relaxed; and thought stopping, which involves stopping negative thoughts, and replacing them with positive thoughts. Participants were encouraged to practice these skills at least twice daily, as well as brief 30 second sessions throughout the day during more stressful periods.

Results indicated that stress management resulted in a small (-.5%) reduction in blood glucose levels. State anxious participants did not receive better results than less state anxious participants. These results suggest that a cost-effective, group-based stress management training program can improve glucose metabolism in patients with type 2 diabetes.

Insulin resistance can also be caused directly by cortisol. For more information on cortisol and the actions of insulin refer to Wilson and Wilson (2005) Fast Acting Hormones and their Role in Fuel use during Exercise.

In summary, stress in sedentary situations, causes an elevation of blood glucose, that is not readily taken up by muscle cells. This initiates the release of insulin, which acts to store glucose. Chronically high levels of insulin causes down regulation, meaning that your body is not as receptive to the actions of insulin, which results in hyperinsulemia (high insulin levels) in order to store glucose. Hyperinsulemia and a decreased capacity to store glucose in the musculature leads to fat gain and decreased energy acutely. However, chronically, it can cause the disease diabetes. Stress management appears to be an effective treatment for this problem. Stress management will be discussed in detail later in this series.

Obesity

Fat gain is a common side effect of stress. A direct mechanism would be through decreased insulin sensitivity and increased fuel liberation, but not increased fuel utilization, as discussed above.

An indirect mechanism would be behavior changes. As will be discussed later on, stress often results in adverse behavioral changes, such as increased food consumption. For instance, a longitudinal study examined 2,359 men and 2,791 women born in Northern Finland in 1966 (as reported in Danner, 2002). Results found that BMI was highest in those who reported to being stress-driven eaters and drinkers. These individuals tended to over eat junk food, including ice-cream, pizza, and chocolate, as well as alcohol. Stressors for men appeared to be if they were single, divorced, or unemployed. Women with a lack of emotional support tended to be stress-driven over eaters.

Hypersensitivity to Stress

To begin this section, here is a quote from Wilson (2004) The Psychological Refractory Period Paradigm.

The earliest theorists in this field were known as association or behavioral theorists. They were concerned with a concept known as **S-R**. The S stands for stimulus, and would include such things as sound waves traveling to your ears. The R represents the human's response to S. Finally the "–" represents the bond between the two. That is, what exactly is it that strengthens or weakens that bond. The key aspect of behavioral theorists is that they had to "observe" the behavior of the individual. While that may seem obvious, it actually is only a reflection of what cannot be viewed. The reason why so many theories exist in motor acquisition is that the processes are actually within the subject, and cannot be viewed, even with our most advanced technology. Thus, inference must be made. A theoretical framework, whose predictions fit that which is observed, must be in place. Associationists were not interested in these internal processes, but rather the external.

Pavlov conducted the first study in this theoretical framework. The experiment involved a sounding device (a bell), and had canines as the subjects. Pavlov would ring a bell every time the dogs ate. After several trials, the subjects would drool every time they heard the bell. Eventually, he removed the food, and only rang the bell. However, the dogs still drooled. In this case, the bell was the stimulus, and drooling was the response. Such a concept is known as "classical conditioning."

Essentially, Pavlov found that pairing a neutral stimulus or a stimulus that would not normally cause a response with an innate stimulus or a stimulus that causes a reflexive response would eventually lead to the neutral stimulus being able to cause the reflexive response (Pavlov, 1928, 1941, 1955). For example, normally a bell (neutral stimulus) would not cause a dog to salivate. However, if every time an experimenter rings a bell they feed the dog, soon the dog associates the bell with the feeding stimuli (Innate or Unconditioned Stimulus) to the point where they will drool upon hearing the bell.

The same thing occurs with the stress response.

Let's say you go to work, and every day is stressful. Your boss yells at you constantly; your coworkers put you down; and the workload is tremendous. Soon, you would begin to pair the neutral stimuli in the environment, such as seeing your workplace, or your boss, with the stress response (the innate response). This would mean that just showing up at work would initiate the stress response (Simmons, 2006)!

Further, we begin to be hypersensitive to other stressors. Even the slightest thing may set us off, because we are conditioned to initiate the stress response to the every negative stimuli (Simmons, 2006).

This can exacerbate all of the diseases discussed in this article. Again, ways to manage this problem will be discussed further on in this series.

Immune Suppression

The immune system is an organized structure of cells, hormones, and chemicals that regulates our susceptibility and recovery from pathogens which cause various illnesses (Marieb, 2004). This system recognizes potentially harmful substances in

the body, and works quickly to eradicate them before they can do damage. Unfortunately, the enemies against our bodies never cease attacking. Therefore, if our immune system is impaired for even a moment, we risk the chance of acquiring potentially deadly diseases. For this reason, scientists have dedicated countless hours of research on ways to enhance immune function. One such investigation is the effect of stress on the immune system. In this context, it is well documented that chronic stress can suppress immune function (Simmons, 2006).

The primary mechanism appears to be cortisol. Cortisol shifts substrates away from carbohydrates, and towards fats and proteins. One mechanism of action is stimulation of gluconeogenesis, typically of proteins. The implications of this on immune function are that antibodies and white blood cells are proteins, and are therefore, degraded by cortisol. In this context, it has been demonstrated cortisol administration stimulates lymphocytopenia, monocytopenia, and eosinopenia, ("penia" refers to a decrease in these cells, all of which are all vital to immune function), with a peak decline 4 hours after administration (Rabin et al., 1996).

Bachen, Manuck, Marsland, et al. (1992) examined lymphocytes (white blood cells) in 33 healthy males before and immediately after a frustrating laboratory task. Results indicated that T-cells (vital for immune function) significantly decreased and natural killer cells (part of the inflammatory response) increased.

Shimizu, Kawamura, Miyaji, & Oya (2000) exposed mice to stress, and observed a signifigant lymphopenia in all immune system organs. An incredible finding was that, in mice who were adrenalectomized (removal of the adrenal gland, disallowing the production of cortisol, but they still could produce catecholamines through the sympathetic nervous system) had no significant increases in lymphopenia, tremendously supporting the cortisol-immune suppression hypothesis.

Cohen, Tyrrell, and Smith (1991) investigated the effects of stress on rates of sickness. 394 healthy participants were given nasal drops containing one of 5 respiratory viruses, while 26 participants were given saline (the placebo). Participants were asked to answer several questionnaires to determine their degree of psychological stress. Results found that there was a significant and dose-dependent increase in the rate of respiratory infections and clinical colds with increased psychological stress.

Cancer

Cancer cells are dysfunctional cells, which are contained in all humans. By themselves, they do not survive very long and are easily killed, as there strange structures are quickly attacked and destroyed by white blood cells. They also need a lot of food to survive, as they are not self generating. So as long as humans have a functional immune system, problems associated with cancer and typically avoided.

The danger of cancer cells is their propensity to travel, because they can spread rapidly. And once they have viability, they reproduce and divide very quickly, even if not they are not mature cells.

The problem is this: as displayed above, stress results impairs immune function. Thus, under conditions of stress, we are more susceptible to acquiring deadly disease such as cancer (Simmons, 2006).

Interestingly, research says that telling someone who has cancer, that they have cancer, increases cancer growth! Therefore, cancer patients need immediate counseling once they are told they have cancer to depress stress response (Simmons, 2006).

It is interesting that some people respond to terminal diseases by saying they are going to enjoy last year of life by quitting their job, stop worrying, etc. And sometimes, they end up getting rid of their disease and cancer; perhaps because they rid themselves of life stress.

Asthma and Allergies

Allergies are abnormal reactions to various substances. The immune system is hypersensitive to certain substances, and this results in several discomforting reactions.

Asthma, is a lung disorder, in which individuals have hypersensitive airways to irritants, causing their body to respond by narrowing the bronchioles, so as not to let foreign agents in. This results in Dyspnea (labored or heavy breathing).

Dr. Marshall, of the University of Texas, Houston (as reported by Kerri, 2003) states that "There is clearly a relationship between stress and allergic and asthmatic disease."

It appears that stress increases someone's tendency to be hypersensitive to irritants, exacerbating allergies and asthma. For instance, research at the university college of London examined 60 participants with asthma between ages 6 and 13, and found that those under stress were at 4 time's higher risks of suffering asthma attacks within 48 hours.

Mechanisms include altered immune function from stress and increased breathing rates during stress. Stress may also cause behavioral problems such as over reacting to asthma attacks, and taking in too many drugs.

Cardiovascular Disease

Cardiovascular disease is wide spread in the United States, as well as Developing countries. With the impact this disease is having on the world today, studying ways to manage risk factors would be advantageous. One such risk factor is psychological stress. Stress has been linked to an increase in risk for cardiovascular disease in patients who already have cardiovascular diseases, and non-diseased patients (Simmons, 2006). In this context, Merz et al. (2002) reviewed the pathophysiological mechanisms linking psychological stress and cardiovascular disease, and introduced evidence suggesting new therapies that can be effective in lowering cardiovascular disease.

Type A behavior, which is characterized by a strong sense of urgency, an excess of competitive drive, and an easily aroused hostility, appears to be linked to increased markers of cardiovascular disease such as blood pressure. Hostility, depression, hopelessness, and job stress have all be correlated with cardiovascular disease in humans.

Endothelial and vascular dysfunction is an early indicator of cardiovascular disease. Interestingly enough, studies have indicated in humans and animals that psychological stress can cause these dysfunctions, increasing the risk of cardiovascular disease. This was attributed to an increase in hormones by stress such as Vasopressin and catecholamines, which have the effect of increasing blood pressure. As well as the tendency of stress to cause platelet aggregation (blood clotting).

Half of the cardiovascular diseases occur today because of cardiovascular arhythms. This is when you heart beats in a disordered way, by beating in an unsynchronized rapid manner. Evidence suggests that lowered parasympathetic tone and increased sympathetic tone can enhance cardiovascular arhythms. Particularly people with cardiovascular risks such as accumulated plaque. Since stress has been identified to increase sympathetic tone, it has been suggested that this is one mechanism by which stress increases cardiovascular disease. There is direct evidence to support this hypothesis in animals, but more evidence is needed in humans.

Another problem is that practically all of the stress hormones have the effect of increasing blood pressure, which can result in hypertension (abnormally high blood pressure) and several resultant cardiovascular disorders (Inouye, 2006).

Since there appears to be evidence that stress can increase or exacerbate cardiovascular disease ways to manage stress would seemingly be advantageous for this disease. In this context, the authors of this review article reported 3 meta-analyses which indicated reductions of recurrent cardiac events and death by 50-70%. However, these effects have not been demonstrated clearly over the long term, and other analyses have show less impressive results.

Several studies indicate stress increases cholesterol (McCann, Warnick, & Knopp, 1990). Therefore, Another mechanism by which stress may cause cardiovascular disease could be an increase in cholesterol.

Abnormally high levels of cholesterol (typically above 200 ml/dl) has been identified as a primary risk factor for coronary heart disease (Castelli et al., 1986). When cholesterol accumulates and is oxidized at blood vessels, it causes Atherosclerosis, which is a loss in elasticity in arteries, and formation of a atherosclerotic plaque, which can narrow the lumen of blood vessels, and cause pain, and several cardiovascular disorders.

Mechanisms by which stress increases cholesterol are not clear. However, it has been suggested that because the body produces more fatty acids and glucose during stress, this may increase LDL secretion, as well. Another possible mechanism is impaired cholesterol degradation. Under normal conditions, cholesterol acts to repair damaged blood vessels, effectively softening them. When excess cholesterol accumulates, the lipolytic proteins enzymes hormone sensitive lipase and lipoprotein lipase work to cleave cholesterol from arteries. However, the stress response

increases substances such as cortisol which degrade proteins, including those responsible for cholesterol degradation, causing cholesterol to accumulate.

Injuries and Attentional Narrowing

It is well documented that life stress increases the risk of injury (McCullagh, 2005). This increased risk factor has been in large part attributed to attentional narrowing, increased muscle tension, and increased distractibility. In complex sport situations, in which there are numerous cues in the environment that must be focused on, attentional narrowing caused by stress can decrease the amount of cues taken in. For a quarterback, this could mean he or she could miss an in coming defender, who would then crush him to the ground, potentially causing injury. In fine motor skills and work place jobs, tight muscles and attentional narrowing can decrease flexibility, and also results in many more errors (Simmons, 2006).

An entire article could be written on this topic alone. But for the purpose of this series, we shall leave it at that. The primary point, again, is that too much stress can cause serious disorders.

Indigestion

As explained in article 2, the parasympathetic nervous system (the rest and digestion system) acts to shift blood towards the stomach, in order to facilitate digestion. Conversely, the sympathetic nervous system shunts blood away from the stomach, and hinders digestion. This is because, the system was designed for pervasive action; thus, resources need to be allocated to the musculature and away from organs which would not assist movement, such as the stomach.

The problem that arises is when we are stressed, and consume food.

One common stress-digestion disorder are ulcers. Ulcers are the burning of tissue. They erode the stomach and intestinal wall, and can cause immense pain. There is an abundant of evidence supporting the stress-ulcer relationship.

For instance, a study in the Journal of Internal Medicine examined 4500 subjects (as reported by Richard, 1999), and found that incidents of ulcers were twice as great in those who were stressed, compared to stress free participants!

It is suggested that stress stops gastrointestinal motility, and slows digestion. As this occurs, food accumulates in the stomach for several hours. In response to this, your body releases more and more acid to digest the food. Your stomach produces a very strong acid, called hydrochloric acid. While your stomach is typically able to contain this acid, too much may protrude through the stomach lining, causing an ulcer. Another mechanism is impaired defense against bacteria, and delayed healing, due to an weakened immune system. This may be exacerbated further when consuming hard to digest foods such as fats, and beef.

Overall, impaired digestion may cause stomach pains, and delay pre-workout digestion, which is so important for athletes.

Insomnia

Insomnia—characterized by abnormal sleeping patterns—is commonly attributed to stress (Shahab, 2001). There are several possible mechanisms by which stress can cause sleeping disorders.

First, the overall action of the fight or flight response is to increase arousal, activating the system. This state is completely antagonistic to the relaxation response experienced during sleep.

Second, thyroid hormones appear to increase cerebration (thinking; Inouye, 2006). Again, it is difficult to sleep if you are up thinking all night.

Third, the fact that you are stressed is likely because you are worried about something, so with increased arousal, thyroid hormones, and numerous problems in your life, you end up spending the whole night thinking about how to resolve the problems in your life. The end result: insomnia.

Performance and Hypertrophy

It should be exceedingly clear to the reader that chronic stress will impair performance, hypertrophy, and fat loss. Fat loss would be sub optimal due to decreased insulin sensitivity, unutilized fuels, and behavioral changes; hypertrophy would be diminished by increased stress hormone such as cortisol which degrade muscle fibers, as well as decreased performance; and performance would be impaired by decreased hypertrophy, an impaired capacity to store muscle glycogen (due to decreased insulin sensitivity), attentional narrowing, among other side effects of stress. Not to mention all the other serious ailments such as immune suppression, insomnia, and indigestion. Thus, relieving stress should be a top priority for any serious athlete.

Behavioral Issues

Proverbs 23:29-35

> 29 Who hath woe? who hath sorrow? who hath contentions? who hath babbling? who hath wounds without cause? who hath redness of eyes?
> 30 They that tarry long at the wine; they that go to seek mixed wine. 31 Look not thou upon the wine when it is red, when it giveth his colour in the cup, when it moveth itself aright. 32 At the last it biteth like a serpent, and stingeth like an adder. 33 Thine eyes shall behold strange women, and thine heart shall utter perverse things. 34 Yea, thou shalt be as he that lieth down in the midst of the sea, or as he that lieth upon the top of a mast. *35 They have stricken me, shalt thou say, and I was not sick; they have beaten me, and I felt it not: when shall I awake? I will seek it yet again.*

It is well documented that psychological stress increases the probability of adverse behaviors occurring (Simmons, 2006). When we look at proverbs here, King Solomon is harshly warning against drunkenness. Now, pay close attention to the last sentence. Notice that this man is stressed! He is being stricken; beaten, and is obviously not a very wholesome individual. Why does he seek the whine yet again, though? Because it is a *comfort food* to him.

Psychological stress can be absolutely dramatizing to individuals. The death of a loved one, divorce, a bodybuilding adding fat (!), among other dramatizing events. When we are faced with such stress, we commonly try to find anyway out. A common route to go is comfort foods.

Eating, especially foods such as chocolate, or high fat foods, increases the parasympathetic nervous system, and causes the release of various hormones, such as serotonin, which make us feel calm, and relaxed. In fact, often times after a good meal, we will fall right to sleep. As with alcohol and other drugs, these types of substances cross the blood brain barrier, and cause several side effects such as numbness, disorientation, etc.

All of these feelings help individuals disassociate themselves from all the problems in their lives. Thus, people often rely on comfort foods to relieve stress.

Other bad habits are anger problems. We often act very grumpy, and hostile towards people when stressed, due in part to fatigue on our body. This allows us to take some of this flight of fight activity, and frustration out on something. And there are several other bad habits that manifest themselves during stressful situations—each of us has our own tendencies.

Another factor is control.

When we are smothered by tasks such as deadlines, training sessions, strict dieting, etc. we feel like we are not in control. People do not like this feeling. Thus, we do things to make us feel like we are back in control.

Getting angry at others, or road rage, may make you feel superior, and in control over others. Same thing with eating junk food, especially on a strict diet.

Also, have you ever noticed that when you have numerous deadlines due in a day or so, you all of a sudden get the sudden urge to have a cleaning party in your house, or such like activities? Well, this is another way of gaining control. We will often just blow responsibilities off, and do absolutely nothing for a whole day, or longer. Or, we will work on something that has no urgent date to be completed, such as cleaning up the house.

Now, blowing your responsibilities off for a day, or having one cheat food is not going to harm you. The problem is, when this becomes a learned response to stress. If you condition eating certain foods when you are stressed, you will begin to eat when stressed, not because you are hungry, or for satisfaction, but just for the sake of eating. An even more dangerous problem are drugs. Not only can you condition this drug abuse, but you can become addicted.

One factor to consider is modeling. When you are behaving a certain way during situations of stress, think of who you sound or look like. Often times, we model bad habits picked up from our parents, friends, or other close relations.

All in all, these behavioral factors will further exacerbate all of the direct side effects of stress mentioned above.

Summary

Table 1.

Side Effects of an Abnormal Flight of Fight Response

Stress Side Effects	Mechanisms
Insulin Resistance & Diabetes	Hyperinsulemia, hyperglucosemia, & hypercortisolemia
Obesity	Insulin Resistance, sedentary life style
Hypersensitivity to Stress	Chronic Stress
Immune Suppression	Cortisol
Cancer	Immune Suppression
Asthma & Allergies	Dyspnea, immune alterations
Cardiovascular disease	Sympathetic disorders: endothelial and vascular dysfunction, hypertension, cardiovascular arhythms,
Hypercholesterolemia	Cortisol, increased fat and glucose liberation
Injuries	Attentional narrowing, distractibility, muscle tension
Indigestion (Ulcers, etc.)	Sympathetic disorders: less gastrointestinal motility, accumulation of acid in gut; and decreased immune function
Insomnia	High arousal, thyroid hormone induce cerebration, worry
Performance & Hypertrophy	All of the above factors impair this
Behavioral issues	Lack of control; comfort foods; physiological fatigue

Table 1 summarizes the side effects of an Abnormal Flight of Fight Response, which was discussed in detail above. To learn how to manage stress, click Here.

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