A Meta-analytic Review Of Aerobic Exercise as a Treatment for Migraine Headaches

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Abstract
Migraine headaches affect a sizeable portion of the population. Treatments for migraine headaches can be costly and complicated to follow. Aerobic exercise can be designed to be simple and cost-effective. It is thought to be effective in the treatment of migraine headaches because it can improve both physiological and psychological functioning. The purpose of this study was to conduct a meta-analysis of aerobic exercise as a treatment for migraine headaches in order to determine: (1) the overall effectiveness of aerobic exercise in the treatment of migraine headaches; (2) how well aerobic exercise as a treatment maintains effectiveness at follow-up measures. Of the eight studies identified for inclusion in this meta-analysis, only six contained the necessary quantitative data for the calculation of effect sizes. Summary analysis revealed a negligible effect size. In three of the six studies included in this meta-analysis researchers reported follow-up data; information necessary for the calculation of effect sizes was only available in two of the studies. Summary analysis revealed a small effect size. Implications of results, limitations of the current study, and directions for future research are discussed.

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ABSTRACT

Migraine headaches affect a sizeable portion of the population. Treatments for migraine headaches can be costly and complicated to follow. Aerobic exercise can be designed to be simple and cost-effective. It is thought to be effective in the treatment of migraine headaches because it can improve both physiological and psychological functioning. The purpose of this study was to conduct a meta-analysis of aerobic exercise as a treatment for migraine headaches in order to determine: (1) the overall effectiveness of aerobic exercise in the treatment of migraine headaches; (2) how well aerobic exercise as a treatment maintains effectiveness at follow-up measures. Of the eight studies identified for inclusion in this meta-analysis, only six contained the necessary quantitative data for the calculation of effect sizes. Summary analysis revealed a negligible effect size. In three of the six studies included in this meta-analysis researchers reported follow-up data; information necessary for the calculation of effect sizes was only available in two of the studies. Summary analysis revealed a small effect size.

Implications of results, limitations of the current study, and directions for future research are discussed.
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Statement of the Problem

Migraine headaches affect 11% of the population, specifically 18% of women and 6% of men (Lipton, Stewart, & von Kroff, 1997). In the United States, one out of four households has a person who suffers from migraine headaches (Lipton, & Bigal, 2005a). In recent years, there have been advances in both pharmacological and behavioral treatments. However, these treatment options can be very costly and complicated. As a result of the debilitating effects of migraine headaches, migraine clients are often unable to comply with complicated treatments (Messina, Calabrese, & Wethington, 2004). Some researchers have suggested aerobic exercise to be a possible preventative treatment for migraines (Darling, 1991a). Aerobic exercise can be designed to be neither costly nor complicated and has been shown to be an outlet for stress, the most commonly cited precipitant of migraine headaches. (Fernandez, & Sheffield 1995; Holm, Lokken, & Myers, 1997).

Purpose of the Study

The aim of this paper is to conduct a meta-analysis of the previous studies in which aerobic exercise has been investigated as a preventative treatment for migraine headaches. Recently, questions have been raised about whether or not migraine and tension headaches are a separate disorder (Leston, 1996; Marcus 1992). Therefore research that addresses both will be included in the meta-analysis. A meta-analysis will be used in order to determine (1) the overall effectiveness of aerobic exercise in the preventative treatment of migraine headaches; (2) how well aerobic exercise as a preventative treatment for migraine headaches maintains effectiveness at follow-up measurements.
LITERATURE REVIEW

In order to fully understand migraine headaches, one must first understand the headache classification system.

Headache Classification System

The first attempt at classifying headaches for purposes of diagnosis was in 1962 by the National Institute of Neurologic Diseases and Behavior (Gladstone & Dodick, 2004). The members of the Ad Hoc Committee divided headaches into 15 categories, including vascular migraine headache and muscle contraction headache. This classification system lacked operational definitions for each disorder and as a result, lacked inter-rater reliability (Silberstein, Lipton, & Dalession, 2001).

The growing dissatisfaction with this diagnostic system prompted the International Headache Society (IHS) to publish a new, operationalized system for headache diagnosis in 1988 (Headache Classification Committee of the International Headache Society, 1988). The committee members identified 13 types of headaches, and two categories of primary and secondary, with migraine and tension type headache being the most common. The criteria for migraine and tension headaches are outlined in Table 1 (IHS, 1988). Primary headaches are defined as headaches not caused by other diseases and include tension, migraine, and cluster headaches. In contrast, secondary headaches are defined as headaches resulting from diseases such as stroke, and brain tumors.
TABLE 1 Headache Diagnostic Criteria

Migraine without aura
A. At least five attacks fulfilling B-D
B. Headache attacks lasting 4-72 hours, untreated or unsuccessfully treated
C. Headache has at least two of the following characteristics:
   1. Unilateral location
   2. Pulsating quality
   3. Moderate or severe intensity (inhibits or prohibits daily activities)
   4. Aggravation by walking stairs or similar routine physical activity
D. During headache at least one of the following:
   1. Nausea and/or vomiting
   2. History and/or physical, and/or neurological examinations do suggest such disorder, but is ruled out by appropriate investigations
   3. Such disorder is present, but migraine attacks do not occur for the first time in close temporal relations to the disorder

Migraine with aura
A. At least two attacks fulfilling B
B. At least three of the following four characteristics:
   1. One or more fully reversible aura symptoms indicating focal cerebral cortical and/or brain stem dysfunction
   2. At least one aura symptom develops gradually over more than 4 minutes or two or more symptoms occur in succession
   3. No aura symptom lasts more than 60 minutes. If more than one aura symptom is present, accepted duration is proportionally increased
   4. Headache follows with a free interval of less than 60 minutes. It may also begin before or simultaneously with the aura.

Tension-type Headache
A. At least 10 previous headache episodes fulfilling criteria B-D. Number of days with such headache <180/year (<15/month)
B. Headache lasting from 30 minutes to 7 days
C. At least two of the following pain characteristics:
   1. Pressing/tightening (non pulsating quality)
   2. Mild or moderate intensity (may inhibit, but does not prohibit activities)
   3. Bilateral location
   4. No aggravation by walking stairs or similar routine physical activity
D. Both of the following:
   1. No nausea or vomiting
   2. Photophobia and phonophobia are absent, or one but not the other is present
The 1988 IHS has been replaced by the 2004 revision in which 10 more types of headaches were added, including chronic migraine and chronic tension headache, both of which are classified by the presence of the headache 15 days or more in a 30 day period for three months (Gladstone & Dodick, 2004).

The development of this system had a major impact on the scientific community, specifically leading to more research on headache disorders. Headache researchers have used this system in order to operationalize different types of headaches in their research. Also, both the World Health Organization and the International Classification of Disease have accepted this system as the standard for headache diagnosis (Gladstone & Dodick, 2004). Researchers, health care professionals, and patients all benefit from the use of this standardized classification system for headache disorders. For example, health care professionals have a common language to utilize when diagnosing and treating headache disorders. Researchers in the field are able to study the basic biology and physiology of each disorder as well as to develop and test the most effective treatment and prevention strategies for each disorder. This allows professionals treating individuals diagnosed with various headache disorders to implement the best practices of treatment, leading to improved outcomes for the individuals suffering from headache disorders.

Limitations of the IHS Classification System

Despite the acceptance of the this classification system, some researchers have questioned a strict classification system for migraine and tension headache, arguing that migraine and tension headache should be viewed on a continuum, with migraines at the more severe end of the continuum (Leston, 1996; Marcus, 1992). The problems with the separate classification of these two disorders include symptom and headache overlap. Muscle pain has been found to occur in both migraine and tension headache (Drummond,
Researchers have found both migraine and tension headache to occur during the duration of a headache episode (Leston, 1996; Marcus, 1992). Additionally, some individuals who experience tension headaches report nausea, sensitivity to noise and light, as well as throbbing head pain, all of which are symptoms of migraine headaches (Rasmussen, Jensen, Schroll, & Olesen, 1992). Finally, some individuals who experience migraines have reported experiencing tension headaches between migraine episodes (Marcus, 1992). After gaining an understanding of the classification of headaches, it is also important to have a clear picture of what an individual experiences during a migraine attack.

The Phases of the Migraine Attack

Wolf and Wolff (1953) were among the first to describe the phases of a migraine to include the pre-headache, headache, and post-headache. Blau (1987) expanded on the phases as described by Wolf and Wolff to include prodrome, aura, headache, resolution, and postdrome. Each of these phases will be described in detail below. However, it is important to note that a person may not experience all of these phases in a given migraine episode.

Prodrome

The prodrome is defined as a period of time prior to the aura or the headache attack in which the individual experiences changes in mood, appetite, and/or energy. This period of time can be as short as a few hours or as long as a few days (Blau, 1987). Following the prodrome, the aura or headache phase will occur.
Aura

Migraines can occur with or without an aura. Women are more likely to have migraine without aura, whereas men are equally as likely to have either type of migraine (Sacks, 1970). An aura is defined as a neurological dysfunction which can manifest in a number of different ways (Bigal, Bordini, Sheftell, Speciali, & Bigal, 2002). Visual symptoms are the most common and include hallucinations such as white dots, wavy lines, or flashes of light; and vision loss. Feelings of numbness and tingling can also be associated with visual symptoms. Vertigo can result, which can be accompanied by nausea and vomiting. Perceptual alterations can also occur in which objects are perceived as farther away, smaller or larger than they actually are. Additionally, auditory and olfactory hallucinations can also occur (Sacks, 1970).

Headache

The head pain of most migraine attacks begins as a dull pain that then increases over time (Blau & MacGregor, 1995). The majority of individuals with migraine headaches described their headaches to be throbbing or pounding, which is thought to be caused by the vasodilation and constriction of the temporal arteries (Blau, 1987). This pain can last from several hours to several days. A number of other symptoms can also occur during the attack including photophobia (sensitivity to light) which is experienced in 60-80% of individuals (Drummond, 1997); phonophobia (sensitivity to sound) which is experienced by 70-80% of individuals; and aversion to some smells (Blau, 1987). In addition, gastrointestinal complaints are also common, with 90% of individuals experiencing nausea, and 50% of those experiencing vomiting. Diarrhea and constipation can also occur. Also, individuals usually do not eat during attacks; although, sometimes individuals may crave specific foods. Fluid retention is also common, especially in
women (Campbell, 1990). Physiological changes of the autonomic system can occur including dilation of the temporal artery, nasal congestion, paleness, cold hands and feet, or profuse sweating and fever (Cortelli, 1994). Changes in thoughts, emotions, and consciousness are also common, particularly feelings of depression or hostility; difficulty concentrating, slowed thinking, impaired memory, difficulty expressing ideas; and the desire to be alone in darkness (Sacks, 1970). Finally, dizziness or light-headedness can also occur during the headache phase (Wolf & Wolff, 1953).

Resolution

The resolution phase can be defined as the end of the head pain. This can occur by sleep, or vomiting for some individuals. However, for the majority of individuals the head pain goes away gradually over a period of time ranging from hours to days (Blau, 1987).

Postdrome

The final phase is the postdrome in which individuals describe to be a time that they still do not feel like themselves. Most individuals are exhausted; others may be depressed or have difficulty concentrating (Warshaw, Lipton, & Silberstein, 1998). Some individuals will limit their physical activities (Sacks, 1970). It is also important to note that some individuals do not experience a postdrome, and feel quite normal after a migraine episode. In rare cases, some individuals even report feeling energetic and enthusiastic (Blau, 1987).

After gaining an understanding of the phases of the migraine attack, it is also important to understand groups of people who may be at a greater risk for the development of headache disorders, specifically migraine headaches.
Epidemiology

The primary aim of epidemiological studies is to identify groups of people who have the greatest risk for the development of a particular disease or disorder. Researchers conducting epidemiological studies often examine the risk of developing a particular disease or disorder in terms of incidence and prevalence rates (Lipton & Bigal, 2005b). Recent findings regarding incidence and prevalence rates for the development of migraine headaches are discussed below.

Incidence

Incidence can be defined as the number of new cases of a particular disease over a specified amount of time (Lipton & Bigal, 2005a). Studies regarding the incidence of migraine are sparse. However, in a recent study, conducted on a Danish sample ages 25-64, researchers found the incidence of migraine in a one year period to be 8/1,000 people. This rate was much higher in women, 15/1,000 people, than in men, 3/1,000 people (Lynberg, Jensen, Rasmussen, & Jorgensen, 2003). In contrast to the limited research on migraine incidence, migraine prevalence is an area that has been heavily researched.

Prevalence

Prevalence can be defined as the number of total cases of a particular disease over a specified amount of time (Lipton & Bigal, 2005b). The prevalence of migraine headache in the United States is estimated to be 4.5 million for women and 1.4 million for men (Martin, Dorfman, McMillian, & McMillian, 1994). Prevalence for chronic daily migraine and tension headache has been reported to range from 3% (Scher, Stewart, Ricci & Lipton, 1999) to 5% (Castillo, Munoz, Guitera, & Pascual, 1999).

The majority of individuals diagnosed with migraine typically report experiencing their first migraine episode prior to the age of 40 (Silberstein, et al., 2001). In addition,
individuals ages 20-50 have the highest prevalence rates (Lipton & Bigal, 2005b). Prior to adolescence, males have higher prevalence rates than females. After adolescents prevalence rates for women dramatically increase, surpassing and doubling the prevalence rates for men (Warshaw, et al., 1998). For example, in a recent study, researchers conducting a retrospective review of the claims made by Medicaid recipients in Georgia found migraine prevalence rates to be 1.39% in females and 0.47% in males (Martin et al., 1994). Stewart, Lipton and Liberman (1996) conducted a telephone survey in Maryland and found the prevalence rate for migraines in women was more than double the rate for men.

Researchers have found mixed results regarding migraine prevalence rates and socioeconomic status. In the United States, researchers have found migraines to be more prevalent in individuals who have do not a college degree and have lower incomes (Lipton & Bigal, 2005a; Stewart et al., 1996). However, studies conducted in Europe have found the opposite results, with migraine prevalence rates higher in those individuals who have a college degree and who have higher incomes (Launer, Terwindt, & Ferrari, 1999). It has been suggested the reason for this lies in the differences between the social structures of the countries. In the European countries, health care is free to all citizens, whereas in the United States citizens pay for their health care. Perhaps the reason migraine rates are increased in lower socioeconomic groups in the United States is due to the fact that these groups often can not afford adequate medical care and have higher levels of stress as a result of their socioeconomic status in a capitalistic society (Lipton, & Bigal, 2005a).

Migraine prevalence rates have been found to differ by nationality. For example in a meta-analysis conducted by Scher, et al., (1999), prevalence rates were reported to be
the highest in North and South America as well as Europe, with the lowest rates in Africa and Asia. Researchers have found similar patterns in the United States. In a recent study conducted, researchers found prevalence rates for Caucasians to be the highest (20.4% for women and 8.6% for men), followed by African Americans (16.2% for women and 7.2% for men) (Stewart et al., 1996).

The Migraine Personality

Wolf and Wolff (1953) were among the first to suggest common personality attributes among individuals diagnosed with migraine headaches. These authors noted that migraine sufferers "are likely to be sensitive, perfectionistic, rigid, and reserved," (p. 43). In a number of more recent studies, researchers have found individuals with migraines have higher levels of neuroticism, emotional over-activity, depression and anxiety. For example, Leijdekkers, and Passchier (1990) conducted a study comparing individuals diagnosed with migraine headaches to controls and found that individuals diagnosed with migraine headaches reported significantly more trait anxiety, as measured by the State and Trait Anxiety Inventory (STAI). Additionally those diagnosed with migraine headaches reported a significantly greater fear of failure, as measured by the Achievement Motivation Test (AMT), than controls. When compared to controls, the participants diagnosed with migraine headaches reported significantly greater levels of neuroticism on the Eysenck Personality Questionnaire (Breslau & Andreski, 1995; Breslau, Chilcoat, & Andreski, 1996). Researchers in China found individuals diagnosed with migraine headaches, when compared to controls, reported significantly higher levels of anxiety, neuroticism, and depression, as measured by the Zuckerman-Kuhlman Personality Questionnaire and the Plutchik van Praag's Depression Inventory (Cao, Zhang, Wang, Wang, & Wang, 2002). Persson (1997) compared individuals diagnosed...
with migraine headaches and their headache-free siblings and also found the individuals diagnosed with migraine headaches have significantly greater levels of trait anxiety. Consistent with the above findings, researchers have found elevated clinical scales on the Minnesota Multiphasic Personality Inventory (MMPI) which are related to depression, anxiety, and neuroticism (Karakurum et al., 2004; Kirkcaldy, Kodylinska, & Furnham, 1993).

Researchers have also found a relationship between individuals diagnosed with migraine and conscientiousness. For example, when compared to controls, individuals diagnosed with depression, anxiety, pain disorders, and migraine headaches scored significantly higher on a number of standardized personality inventories in which conscientiousness was measured (Schafer, 1994). Gallagher, Mueller, Steer, and Ciervo, (1998) conducted a study in which 70 women diagnosed with migraine headaches volunteered to take the Myers-Briggs Type Indicator. A number of profile types were found among the women. However, two types were found to be the most prevalent: ISFJ and ISTJ. Both profile types are characterized by conscientiousness, and hardworking personality traits. Researchers hypothesize that the pressure to meet deadlines and serve others can be perceived as a stressor, contributing to the development of a migraine headache (Gallagher et al., 1998; Schafer, 1994).

Despite the research illustrating specific personality traits characteristic of individuals diagnosed with migraine headaches, other researchers have not found this to be the case. Although Wolf and Wolff (1953) were first to describe common personality attributes among individuals diagnosed with migraine headaches, they also stated that not all individuals diagnosed with migraine headaches exhibited these personality attributes. In addition, in a more recent study, researchers did not find a difference between
individuals diagnosed with migraine and controls on ambition, orderliness, and rigidity (Kohler, & Kosanic, 1992).

Methodological differences might be one possibility for the inconsistency of results among the studies. For example, Schafer (1994) collected his sample from a number of clinics, including pain and psychotherapy clinics. In contrast, Kohler and Kosanic (1992) collected their sample from a neurology clinic. It is possible that personality characteristics could be one factor contributing to where individuals decide to seek services. Much more research would need to be done in this area before the results from these single studies could be generalized to the migraine population. Additionally, there are a number of other methodological flaws to consider when conducting migraine personality research.

Limitations of Migraine Personality Research

Despite the information gained from research on personality traits of individuals diagnosed with migraine headaches, a number of methodological flaws exist. For example the use of general inventories, such as the MMPI and Eysenck Personality Questionnaire, which were not specifically designed or normed for studying clients with migraine headaches, is questionable due to the fact that normative data fails to exist for this group. Additionally, differences between individuals who seek treatment for migraine headaches and those who do not seek treatment for migraine headaches may exist. For example, those seeking treatment might present with more severe and complex symptoms than those who are not seeking treatment. As a result, the findings from studies conducted on individuals seeking medical treatment likely can not be generalized to the overall migraine population. Finally, a number of other disorders can co-occur with migraine headaches. It could be that some of the personality characteristics described as
linked to migraine headaches are actually the result of common comorbid disorders. In order to gain a better understanding of this criticism, comorbid disorders must be explored.

Comorbidity

**Psychological Disorders**

A number of researchers have found a relationship between migraine headaches and depression. Specifically, researchers have determined that a bi-directional and not a temporal relationship between migraine and depression exist. This means that if an individual has one of these disorders he or she has an increased chance of developing the other disorder (Breslau, & Davis, 1993). Researchers have found that individuals diagnosed with migraine headaches have a three times greater chance of developing depression than individuals not diagnosed with migraine headaches. Individuals diagnosed with depression also have a three times greater chance of developing migraine headaches (Bensenor, Tofoli & Andrade, 2003; Breslau, & Davis, 1993; Low, Merikangas, Merikangas, 2004; Torelli & D'Amico, 2004). Some researchers have proposed a biological link between the two disorders because both have been shown to be related to low levels of 5-hydroxytryptamine (5-HT; Glover, Jarman, & Sandler, 1993).

**Stroke**

Researchers have investigated the relationship between migraine and stroke, and found migraine to be a risk factor for stroke; specifically ischemic stroke, in which an artery in the brain becomes blocked and sudden loss of blood circulation to part of the brain occurs (Agostoni, Fumagalli, Santoro, & Ferrarese, 2004). When compared to healthy controls, women diagnosed with migraine, and under age 45, who smoke have a
ten times greater chance of stroke (Tzourio, Tehindrazanarivelo, Alperovitch, Chedru, d'Anglejan-Chatillon, & Bousser, 1995).

**Asthma**

Researchers have found an association between migraine headaches and asthma. For example, in a study conducted in the United Kingdom when compared to matched controls, individuals diagnosed with migraine headaches had a 1.59 times greater chance of having asthma (Davey, Sedgwick, Maier, Visick, Strachan, & Anderson, 2002). Researchers found similar results in a cross-sectional study conducted in the Netherlands. Once again when individuals diagnosed with migraine headaches were compared to headache free controls, individuals diagnosed with migraine headaches had significantly higher rates of asthma (Terwindt, Ferrari, Tijhuis, Groenen, Picavet, & Launer, 2000).

**Limitations of Comorbidity Research**

Researchers have also investigated a number of other disorders that they believed to be related to migraine headache, including hypertension, and epilepsy. However, researchers were not able to find consistent significant relationships. Regarding hypertension, overall small controlled studies have supported the relationship between migraine headaches and hypertension; whereas large scale community studies have not supported the relationship. With respect to epilepsy, the lack of consistent diagnostic criteria utilized for diagnosing epilepsy across studies makes it difficult to verify the relationship between migraine headaches and epilepsy (Low & Merikangas, 2003). Much more research would need to be done in order to fully examine the relationship between migraine headaches and other disorders.

Prior to conducting such research a number of factors need to be considered. For example, one option is that there is not a strong correlation for the proposed relationship.
Another explanation is that the previous researchers' methodologies were flawed. For example, in comorbidity research, standardized diagnostic categories should be utilized. Additionally, prior to determining significant or not significant results, a power analysis should be conducted in order to determine if the sample size was large enough. With rare diseases and fewer participants, a lack of power could cause a lack of significant findings when a significant relationship does exist. The amount of variance accounted for by common risk factors related to both disorders (migraine headaches and disorder X) should be accounted for in order to eliminate possible confounding variables.

The Impact of Migraine Headaches

Comorbidity is one of the numerous ways in which individuals are affected by migraine headaches. In order to gain a better understanding of the severe effects migraine headaches can produce, the impact of migraine headaches on the individual, the family, and society will be explored.

Impact On the Individual

Migraine headaches have been found to affect individuals in all aspects of their lives, work, school, and home. For example, researchers of one study reported that 50% of individuals described an interruption in their normal activities when faced with an attack and 33% reported requiring bed rest (Stewart \& Lipton, 1994).

Individuals with migraine headaches are not only affected during migraine episodes, but also report impairment between episodes, specifically comorbid illnesses, poor school and work performances, as well as impaired social relationships (Essink-Bot, van Royen, Krabbe, Bonsel, \& Rutten, 1994; Lipton, Hamelsky, Kolodner, Steiner, \& Stewart, 2000; Osterhaus, Townsend, Gandek, \& Ware, 1994). For example, 1,810 women, ages 18-35, diagnosed with migraine headaches from nine European countries
were interviewed in order to assess their quality of life. Participants reported impairments in a number of areas as a result of suffering from migraine headaches. Fifty-six percent of the participants reported impaired social functioning, specifically that they had less time for interacting with others through vacations, hobbies, and special events, as a result of migraine headaches. Participants also reported impairments in work and school performance. For example 46% of the sample reported missing work or school, and 75% reported reduced productivity as a result of migraine headaches (Frediani, Martelletti, & Bussone, 2004). Similar results were found in another study conducted on a college student population, in which 62.7% of individuals interviewed reported decreased school productivity as a result of migraine headaches (Bigal, Bigal, Betti, Bordini, & Speciali, 2001).

Impact On the Family

Impaired social relationship directly effect family members, particularly the partners and children, of an individual diagnosed with migraine headaches. In a recent study, individuals with migraines and their families were interviewed (Lipton, Bigal, Kolodner, Stewart, Liberman, & Steiner, 2003). The individuals with migraines and their partners independently reported that they were more likely to have a disagreement as a result of a migraine. One third of those surveyed stated that their relationship with their partners would be better if they did not have migraine headaches. The majority of those interviewed also stated that they were less involved with their families because of migraine headaches (Lipton et al., 2003). Another study conducted in Europe produced similar findings, with 60% of those surveyed reporting that as a result of migraine headaches, they spent less time with their family and friends (Frediani et al., 2004).
Smith (1998) interviewed individuals with migraine headaches and asked them what they thought about the effects of their migraine headaches on the family. The majority reported that their relationships suffered as a result of migraines. Five percent of the sample reported divorce to be a result of migraine headaches. Seventy percent of the sample reported canceling activities or important plans, and 60% stated that they abandoned care of younger children. Fagan (2003) reported that children in families with a parent diagnosed with migraine headaches often take on tasks that are not developmentally appropriate because of dysfunctional parenting often associated with migraine headaches. For example, because of the debilitating results of migraine headaches, the caretaking role of the parent suffering from the migraine attack can be significantly impaired. This can result in inappropriate expectations for the child, such as taking care of a younger sibling or the parent, and a lack of empathy and attunement regarding the needs of the child on the parent's part (Fagan, 2003; Smith, 1998).

**Impact On Society**

Migraines not only affect the individual and the family of the individual, they also affect the larger society of the individual. The impacts of migraine headaches on society are usually expressed in economic terms, specifically direct and indirect costs (Stewart & Lipton, 1994). Direct costs can be defined as medical treatment, including office visits, over the counter medications, and prescription drugs. The sales of triptans, a class of selective serotonin re-uptake agonists prescription drugs commonly used to treat migraine headaches, is estimated to be over one billion dollars a year (Lipton & Bigal, 2005b). Additionally, 32 billion dollars each year is spent on over the counter pain medication, with headache treatment accounting for one third of these sales (Lipton & Bigal, 2005a). Indirect costs can be defined as missed work, or lack of productiveness due to migraine.
headaches (Stewart & Lipton, 1994). Nineteen to 43% of individuals with migraine headaches miss one or more days of work per year and 31% of individuals with migraines miss six or more days of work per year (Lipton, et al., 1997). As a result, estimated costs for missed work range from 14 to 17 billion dollars per year (Lipton et al., 1997).

The Causes of the Migraine Attack

After gaining an understanding of the effect migraines can have on an individual, his or her family, and the larger society, it is also important to understand some of the possible causes of a migraine episode. Two important concepts in this area are predisposing factors and triggers.

_Predisposing Factors_

Predisposing factors can be defined as anything that increases a person's susceptibility to developing a particular disorder or disease. A person's genetic make-up is thought to be a predisposing factor for migraine headaches. For example, 40-50% of the variance in developing a migraine is attributed to genetics (Montagna, 2004). Twin studies also provide support for a genetic component to migraines. In a recent Danish study, researchers found concordance rates for migraines with aura were significantly higher for monozygotic twins (34%) when compared to dizygotic twins (Ulrich, Gervil, Fenger, Olesen, & Russell, 1999).

_Triggers_

Triggers can be defined as stimuli in an individual's external or internal environment that precipitate the migraine episode (Warshaw et al., 1998). The identification of triggers can be a difficult task because a migraine may not occur after exposure to a trigger every time, and migraines can result from the interaction of several
factors or combinations of events (Wolf & Wolff, 1953). A number of factors have been studied in order to determine if they are in fact potential triggers for migraines, these include: dietary factors, hunger, sleep, exertion, environmental factors, hormones, and stress.

*Dietary factors.* Ten to 50% of individuals diagnosed with migraine headaches believe that their migraines are caused by a particular food or foods (Peatfield, 1994). For example, in a study conducted on 578 participants diagnosed with migraine, 19% reported sensitivity to cheese, chocolate, or citrus fruits (Peatfield, 1994). All of these products contain vasoactive amines or tyramine. Both can cause vasodilation of the blood vessels in the brain, which has been linked to migraine pain (Scharff & Marcus, 1999). In the same study conducted by Peatfield (1994), 18.4% of those surveyed reported sensitivity to alcoholic beverages. However, there is limited evidence from controlled studies illustrating a relationship between foods and migraine headaches. Discovering specific trigger foods is a difficult task because not all individuals' migraines are triggered by foods, and specific foods may not always trigger a migraine episode in the same individual.

*Hunger.* Hunger is another factor thought to be associated with the onset of migraine headaches. For example, in a study conducted by Dalton (1975) he found migraines significantly increased in women who did not consume food for a 5 hour time period during the day, or a 13 hour time period during the night.

*Sleep.* Despite the fact that sleep has been found to relieve migraine pain, it has also been found to be a trigger of migraine episodes. Researchers have found too little or too much sleep can precipitate migraine attacks (Marcus, 2006; Robbins, 1994).
Exertion. Just as inadequate rest can precipitate a migraine attack, so too can physical exertion (Sacks, 1970). For example, in a case study conducted by Thompson (1987) the participants developed a migraine episode after unusually strenuous exercise. However, it is important to note that the participant also reported minimal food consumption prior to physical exertion. Additionally, other factors such as improper nutrition, dehydration, and improper warm-up have also been linked to a migraine resulting from exertion (Dalession, 1974).

Environmental Factors. A number of environmental factors have been implicated as migraine triggers. These include changes in weather and sensory stimuli. Changes in weather have been studied with respect to geomagnetic activity and seasonal changes. In one study, researchers correlated migraine episodes to changes in weather, specifically humidity and temperature changes, over a 4 month period. Researchers did not find any significant correlations. However, migraine frequency was lowest in June (De Matteis, Vellente, Marrelli, & Villante, 1993). These findings support the work of other researchers who found the lowest incidence of migraine episodes in the summer, specifically August, and the highest incidence of migraine episodes in the winter, specifically January (Cugini, Romit, di Palma, & Giacovazzo, 1990).

Just as changes in weather have been linked to changes in migraine incidence, so too have changes in outdoor pollution levels. For example in a 9 month study, researchers obtained levels of carbon monoxide and nitrogen dioxide in the air from a monitoring station. The 32 participants kept a headache diary in which they recorded the time and severity of their headaches. A significant relationship was found between increased concentrations of carbon monoxide and nitrogen dioxide and headache occurrence within a few hours after the pollutant levels peaked (Nattero & Enrico, 1996).
Pollution is one of the numerous environmental factors thought to be associated with migraine episodes; other factors include glare, intense light, or flashing lights (Hay, Mortimer, Barker, Debney, & Good, 1994), blaring noises, and various smells such as paint, smoke, diesel, gas, detergents, chlorines, perfumes, and industrial chemicals (Robbins, 1994).

**Hormones.** Hormone changes are another factor thought to be linked to migraine episodes, specifically changes in estrogen levels associated with menstruation, pregnancy, and menopause (Warshaw, et al., 1998). For example about 15% of women who are diagnosed with migraine headaches report migraine episodes only during menstruation (Mannix, 1999). It is hypothesized that the rapid decline in estrogen levels prior to menstruation may be linked to the occurrence of the migraine attack (Warshaw et al., 1998). The majority of women experience fewer headaches, or an end to their headaches during pregnancy. However, some may experience no change during pregnancy (Chen & Leviton, 1994). Generally migraine attacks decline with age. However estrogen replacement therapy, which is prescribed to relieve menopausal symptoms, has been found to worsen migraine episodes (Warshaw et al., 1998).

**Stress.** Stress can exacerbate or cause migraines. Stress is the most commonly reported precipitant to migraine headaches (Holm, et al, 1997). Additionally, both acute and prolonged stressors have been linked to attacks. The pain of a migraine can also be conceptualized as another stressor. Researchers have found it is not that individuals with migraine headaches experience more daily hassles or major life events than headache free individuals, but that they appraise events to be more stressful than headache free individuals appraise events (Martin & Theunissen, 1993). Additionally, a number of researchers found a significant relationship between increased daily hassles
3 days prior to a migraine episode (Fernandez & Sheffield, 1995; Holm et al., 1997; Kohler & Haimerl, 1990; Levor, Cohen, Naliboff, McArthur, & Heuser, 1986; Sorbi, Maassen, & Spierings, 1996). It is hypothesized that individuals diagnosed with migraine headaches may respond to stress differently than headache free individuals at the physiological level. This hypothesis has been tested in a number of laboratory studies in which individuals have been placed in stressful situations, such as mental math, cold pressor tasks, and presentations. The results from these studies indicated that individuals who experience migraine episodes also experience a prolonged cardiac response (Hassinger, Semenchunk, & O'Brien, 1999; Holm, Lamberty, McSherry, & Davis, 1997). Additionally, some researchers have found individuals diagnosed with migraine headaches utilize less effective coping strategies, such as social withdrawal, than headache free controls (Ehde & Holm, 1992).

After examining the possible causes of migraine attacks, the next step is to explore possible treatment options for migraine headaches.

Treatment

Management of migraine headaches is often multi-pronged and involves educating the individual about migraine headaches including possible triggers; medication treatment; and behavioral techniques.

Avoidance of Triggers

Due to the fact that triggers are specific to each individual client, different things will be avoided or eliminated for each individual. One way to systematically evaluate triggers is through the use of a headache diary. A headache diary is a space where individuals record the onset, duration, and severity of their headaches; as well as any precipitating events, and medication taken in order to help relieve their headaches.
Through this process, individuals can attempt to see if there are specific triggers or precipitating factors that contribute to the development of migraine headaches.

**Pharmacological Treatment**

A number of different types of medications have been utilized in order to treat migraine headaches. Pharmacological treatments fall into two main categories, abortive and prophylactic medications. Abortive treatments are taken in order to reduce the pain of a migraine episode once it has occurred (Low, et al., 2004). In contrast, prophylactic medications are taken daily as a means in which to prevent future migraine episodes.

**Abortive.** Over the counter analgesics such as ibuprofen, aspirin, and acetaminophen are often used to alleviate mild migraine headaches (Gilkey, & Ramadan, 1996). Ergot alkaloids, such as Ercaf and Cafergot, have been utilized to treat migraine headaches for which analgesics are not effective. However, these cannot be taken if an individual is pregnant or has heart disease (Warshaw et al., 1998). Additionally, these drugs can cause a number of side effects, such as nausea and vomiting. The triptans, such as Imitrex and Zomig, are newer drugs that have been demonstrated to be effective in the treatment of migraine headaches (Bussone, D'Amico, McCarrol, Gerth, & Lines, 2002; Cady, 2000; Featherstone, 2001). These drugs have been shown to cause fewer side effects than the ergot alkaloids (Featherstone, 2001). For individuals with whom abortive treatment is not effective, or who report experiencing more than two migraines a week, prophylactic treatment may be utilized (Warshaw et al., 1998).

**Prophylactic.** A number of different medications can be taken daily in order to assist in preventing future migraine episodes. These medications include beta blockers, anticonvulsants, calcium-channel blockers, and anti-depressants. The unique needs and situations of each individual should be considered when determining which of these
drugs should be prescribed. Additionally, it is important to note that researchers have not found any of these drugs to reduce the frequency or severity of migraine episodes by more than half (Low et al., 2004). Due to the fact that pharmacological treatments are not completely effective in treating migraines for a number of individuals other non-pharmacological means of treating migraine headaches has been developed.

Non-Pharmacological Treatment

A number of non-pharmacological treatments for migraine management have been developed. These include biofeedback training, relaxation training, coping skills training, acupuncture, hypnosis, and exercise.

Biofeedback Training. Biofeedback training refers to a process whereby an individual's physiological states are monitored. Through this process information about an individual's internal states is made available to him or her through a monitoring device. The idea behind this is to increase the individual's awareness and promote voluntary control over physiological states that could be contributing to his or her disorder (Martin, 1993). Three types of biofeedback training are commonly utilized in the treatment of migraine headaches, electromyographic (EMG) biofeedback, thermal biofeedback, and blood volume pulse (BVP) biofeedback.

The purpose of EMG biofeedback is to enhance an individual's voluntary control over the pericranial muscles. Electrodes are placed on selected muscles on the surface of the skin. The electrodes are also connected to a display that illustrates the electrical activity of the muscles. The individual is advised to focus on decreasing the electrical activity of the muscles (Arena, & Blanchard, 2002). When compared to wait-list groups, EMG biofeedback has been shown to be significantly better in treating migraine headaches than no treatment (Gauthier, Ivers, & Carrier, 1996).
Thermal biofeedback is a process by which an individual is able to control his or her skin temperature through the use of electronic feedback. Specifically a thermometer is attached to the finger of the individual. This enhances in the control of the peripheral temperature, which is thought to decrease vascular activity in order to prevent pain (Blanchard et al., 1997). Thermal biofeedback has also been shown to be significantly more effective in treating migraine headaches than no treatment (French, Gauthier, Roberge, & Bouchard, 1997; Gauthier, Cole, & French, 1994).

The purpose of BVP biofeedback is to enable the individual to have greater voluntary control over blood volume pulse amplitude. A plethysmographic transducer is placed over an extracranial artery and changes in blood volume pulse are made available to the individual. The individual is instructed to decrease the pulse amplitude (Eakin, 1990). Penzien, Rains, and Adrasik (2002) found BVP biofeedback to be as effective in treating migraine headaches as relaxation training, thermal biofeedback, and coping skills, specifically improvement rates of 33-43%.

Relaxation Training. Relaxation training is another treatment modality often employed for the treatment of migraine headaches. The idea behind this treatment is to help the individual decrease the physiological changes that occur when he or she is experiencing stress (Gauthier et al., 1996). A number of different relaxation techniques may be taught, these include progressive muscle relaxation, autogenic training, and breathing exercises. Progressive muscle relaxation is a technique in which the individual is instructed to focus on different muscle groups by tensing, holding, then releasing, and relaxing specific muscle groups. This is repeated until the individual has contracted and relaxed all of the muscles in his or her body. Autogenic training is a process whereby an individual is instructed to silently repeat or concentrate on a series of phrases or visualize
him or herself in a calm, safe place. The concentration, repetition, and/or visualization are thought to promote a relaxed state (Martin, 1993). Finally, breathing exercises come from eastern meditative practices. The basic idea behind this technique is that slow, deep breathing leads to muscle relaxation (Gauthier et al., 1996). When individuals who received relaxation training for their migraine headaches were compared to wait list controls, the relaxation group reported a significantly greater improvement in the frequency of their migraine headaches (Friedman, & Taub, 1984). As previously stated biofeedback, relaxation, and coping skills have all demonstrated similar effectiveness in migraine management (Penzien et al., 2002).

Coping Skills. Coping skills are based on some of the underlying ideas of cognitive behavioral therapy. One such idea is that a person's emotions and behavior is influenced by the way in which he or she appraises an event. The premise behind coping skills is to teach the individual skills that he or she can utilize in order to better handle some of the stressors that may lead to developing migraine headaches. Additionally, an individual's ability to recognize and evaluate maladaptive patterns of thinking and believing can allow the individual to change his or her appraisals of events and as a result have more control over the development of migraine headaches (Martin, 1993).

Researchers have found coping skills training to be an effective treatment for migraine headaches, but not statistically significant from biofeedback and relaxation training (Penzien, et al., 2002).

Acupuncture. Acupuncture is another treatment that has been employed for migraine headaches. The traditional idea behind acupuncture is that it redirects the flow of vital energy along the meridians of the body. More contemporary research has found acupuncture to cause endorphins to be released, stimulating the central nervous system.
(Allias et al., 2002). Twenty-six patients headache activity was monitored 5 weeks prior to receiving acupuncture, while receiving acupuncture, and 3 years after receiving acupuncture. Eighteen patients reported a 33% improvement after treatment, and 15 patients reported a 58% improvement at 3 year follow-up (Baischer, 1995). In another study, individuals who received acupuncture were compared to individuals who received medication treatment. No differences were found between the two groups at 6 month follow-up (Allais et al., 2002). In sum, benefits from acupuncture are not as significant as treatment from biofeedback, relaxation, and coping skills.

**Hypnosis.** Hypnosis is another treatment that is also used to treat migraine headaches. The basic idea behind hypnosis is to create a relaxed state for the individual that will lead to a decrease in the individual's perception of pain (Yeoh, 1998). Anecdotal evidence for hypnosis as an effective treatment for migraine headaches exist (Emmerson & Trexler, 1999; Yeoh, 1998). However, there are limited controlled studies supporting the efficacy of hypnosis as a treatment for migraine headaches. In one study, a group of individuals who received hypnosis were compared to a group of individuals who did not receive hypnotic treatment. No significant differences in migraine activity or medication consumption were found between the two groups (Nolan, Spanos, Hayward, & Scott, 1995). It appears that while hypnosis may be an effective treatment for some individuals, overall it does not appear to be as effective as biofeedback, relaxation, or coping skills.

**Exercise.** Prior to addressing the research regarding aerobic exercise as a treatment for migraine headaches it is important to have an understanding of the possible explanations regarding why it would be an effective treatment for migraine headaches.
There are a number of possible explanations as to why aerobic exercise would be an effective treatment for migraine headaches, these include physiological and psychological changes that can occur.

The physiological changes that occur include cardiovascular changes, as well as changes in neurological chemicals that are released. Migraine headaches have been found to have a vascular nature. There are a number of cardiovascular changes that are associated with aerobic exercise that may be helpful in the treatment of migraine headaches such as increases in blood pressure (Darling, 1991a; Drummond, 1984). Researchers have found that individuals with migraine headaches have lower endorphin levels (Fettes, Gawell, Kuzniak, & Edmeads, 1985). Aerobic exercise increases endorphin levels. As a result, it is hypothesized that aerobic exercise can help to alleviate the deficits in endorphin levels. Finally, serotonin has been found to be decreased during migraine episodes, and during exercise serotonin levels increase. An increase in serotonin levels may help to decrease the severity of the pain experienced during migraine attacks (Darling, 1991a).

There are a number of ideas regarding the reasons why aerobic exercise is an effective treatment for migraine headaches, at the psychological level. The distraction and relaxation hypotheses offer two possible explanations. The main tenet behind the distraction hypothesis is the idea that an individual cannot ruminate as easily when he or she is involved in exercising, basically the activity serves as a distraction. In contrast, the idea behind the relaxation hypothesis is that exercise serves a way to release the stress, and tension that often precipitates headaches (Darling, 1991a; Hughes, 1984).
As previously mentioned, migraine headaches, depression and/or anxiety often co-occur. Aerobic exercise is a well-documented treatment for both anxiety and depression (Folkins & Sime, 1981; Greist, Klein, Eischens, Faris, Gurman, & Morgan, 1978). For example, in one study, researchers compared a group of individuals diagnosed with depression in two treatment groups. One group received therapy, and the other group participated in regular aerobic exercise. The aerobic exercise intervention was found to be just as effective as therapy in improving symptoms (Greist, et al., 1978).

Additionally, in an article that reviewed research on physical fitness as a treatment for anxiety and depression, positive effects were found on mood and self-concept (Folkins, & Sime, 1981).

As previously stated, stress is the most common reported precipitant of migraine headaches. Additionally, the experience of migraine headaches is perceived by many individuals to be a stressful event (Holm et al., 1997). Researchers have found that individuals who are aerobically fit recover faster when they experience stress. For example, when aerobically fit individuals were compared to non-aerobically fit individuals on a number of physiological measures during and after a stressful event, it was determined that during the stressful event both groups experienced similar physiological reactions. However, the aerobically fit group returned to baseline faster after the stressful event ceased (Sinyor, Schwartz, Peronnet, Brisson, & Seraganian, 1983). In another study with a similar design, researchers also found similar results, and hypothesized that the faster recovery exhibited by fit individuals may also allow them to cope better with stress (Keller & Seraganian, 1983). Perhaps it is for these reasons that aerobic exercise as a treatment for migraine headaches was first investigated.
A number of case studies looking at the relationship between migraine headaches and aerobic exercise have been conducted. The findings regarding these studies has been mixed, with some researchers finding that exercise can precipitate migraine attacks, and others finding that exercise can decrease the intensity, severity, or frequency of migraine attacks.

Two independent researchers utilizing case studies reported that exercise precipitated a migraine attack (Lambert, & Burnet, 1985; Thompson, 1987). However, both of these studies involved extremely strenuous exercise without a warm-up. Additionally, one reported a lack of sufficient food intake prior to exercise (Thompson, 1987). As a result, of these limitations, it is difficult to derive any conclusions from these two case studies.

A number of researchers, also utilizing case studies, have reported that exercise was an effective treatment for migraine headaches. In one case study, the female participant reported that if she engaged in exercise when she had a headache, that the exercise would cause a relief in her headache. The participant cited exhaustion and stress to be the causes of her migraine headaches (Darling, 1991b). In another case study, the participant reported that running for 20 minutes also caused pain relief. He also cited lack of sleep to be the cause of his migraine attacks (Van Gijn, 1987). In another case study, the participant reported a decrease in the frequency of her migraine headaches through the treatments of daily running and biofeedback (Rapport & Sheftell, 1980). As with the previous studies, it is difficult to derive any definitive conclusions from these case studies.

In response to this anecdotal evidence a group of researchers conducted a study in which nine participants, who suffered from migraine headaches, participated in a 10...
week exercise program. The participants walked or ran for 30 minutes three times a week. It was found that the frequency, but not the intensity, of their headaches was significantly reduced (Grimm, Douglas, Hanson, 1981). In addition, a group of researchers devised a wellness program for the treatment of migraine headaches and exercise was considered to be part of an effective treatment (Simons, Solbach, Sargent, & Malone, 1986).

Since this time, a number of studies have investigated exercise as a treatment for migraine headaches. These studies were included in the meta-analytic review.

Purpose of the Study

As previously mentioned, migraine headaches affect 11% of the population, specifically they affect 18% of women and 6% of men (Lipton, et al., 1997). There have been advances in both pharmacological and behavioral treatments in recent years. However, these treatment options can be expensive and complex. As a result of the debilitating effects of migraine headaches, migraine clients are often unable to comply with complicated treatments. As a result, it would be beneficial to utilize aerobic exercise as a treatment for migraine headaches because it is cost effective and simple. The purpose of this study was to conduct a meta-analytic review of aerobic exercise as a treatment for migraine headaches in order to determine: (1) the overall effectiveness of aerobic exercise in the treatment of migraine headaches; (2) how well aerobic exercise as a treatment maintains effectiveness at follow-up measures. As discussed previously, due to the fact that current researchers question the distinction between migraine and tension headache, research that addresses aerobic exercise as a treatment for either will be included in the meta-analytic review.
METHOD

Search for Studies

A computerized literature search was employed utilizing Medline, PsychINFO, PsychLIT, and Dissertation Abstracts databases, with the following key words: headache, tension headache, migraine, migraine headache; combined with exercise, aerobic exercise, walking, swimming, and running. The search covered studies published in the English language from 1970-2006. All articles found were considered and reviewed. The reference list of each article was also examined in order to find additional relevant studies.

Inclusion Criteria

In order to be included in this meta-analysis, studies had to meet the following criteria: (1) the participants must be diagnosed with migraine or tension headache, (2) an analysis of the efficacy of aerobic exercise as a treatment for headache must be involved in the study; and (3) pre-treatment and post-treatment scores of headache activity must be available in order to calculate or estimate the effect size. A total of eight studies were identified for inclusion in the current meta-analysis. However, the researchers did not report sufficient data for the calculation of effect sizes for two of the studies. In both cases, attempts were made to obtain the necessary information from the researchers. These attempts were unsuccessful, as the queried researchers did not provide the necessary data. As a result, a total of six viable studies were located and retrieved for
inclusion in the current meta-analysis. Due to the small number of identified studies, no limits were placed on the quality of the studies.

Coding Strategies

Each article was independently reviewed and coded by two clinical psychology graduate students (the author and a doctoral candidate). The training protocol consisted of the author setting up a meeting with the doctoral candidate in which the author described the coding criteria for each variable and then the coders (the author and doctoral candidate) were given one article to practice on. The doctoral candidate and the author then independently coded the articles. Another meeting occurred in which the coding results were compared. A percentage of agreement of 96% was found between the two authors. Coding disagreements were discussed until they are resolved and consensus was obtained. The process of coding was to identify the following for each condition of the study: (1) treatment setting (individual, group, or other); (2) duration of treatment (number of weeks of treatment and amount of treatment in minutes per week); (3) age (mean age in years); (4) gender (% of women); (5) method of participation recruitment; (6) number of participants who completed treatment; (7) percentage of participants who dropped out; (7) type of outcome measure; (8) year of publication (9) type of source (published article, or thesis/dissertation); (10) research design (single case or multiple case); (11) research methodology (control group or no control group); (12) type of concurrent treatment(s) received (as reported by the participants); (13) follow-up time (in weeks). The coding sheet is provided in Appendix A.
Data Analysis

Data analysis included a number of steps. The process included coding and entering data, calculating descriptive statistics, effect sizes, confidence intervals, and the fail safe n. Each step is described in detail below.

First, coded data was entered into a Microsoft Excel spreadsheet and then transferred to the Statistical Package for Social Sciences (SPSS) software and Meta Win. Next, SPSS was utilized in order to obtain descriptive statistics. Then, Meta Win was utilized in order to calculate the effect size for each study based on Hedges' d, which is commonly used when calculating the effects of small sample sizes. The results are essentially equivalent to Cohen's d (Rosenberg, Adams, & Gurevitch, 2000). In this study the difference between the mean post-intervention score and the mean pre-intervention score was divided by the pooled standard deviation. The headache index was used in order to calculate the effect size for each study. In one study, researchers failed to report the means. In this case, the effect size was calculated by converting the results from the statistics reported in the t test.

After effect sizes were calculated for each study, a cumulative effect size for all of the studies was calculated through the use of Meta Win. A fixed-effects model, which is based on the idea that data is normally distributed and that studies with similar characteristics share a common effect size, was utilized. Thus, differences in effect sizes among studies are considered to be the result of sampling errors. In contrast, the premise behind the random effects model is that sampling errors and a true variation of effect sizes among studies exist (Rosenberg, et al., 2000). The guidelines put forth by Cohen (1988) were utilized in order to interpret the results in which 0.20 is considered to be a small effect, 0.50 a medium effect, and 0.80 a large effect. When interpreting effect sizes,
it is also important to note that effect sizes can be used as an absolute value, meaning -0.20 is considered to be a small effect, -0.50 a medium, and -0.80 a large effect.

Following, the calculation of the cumulative effect size, bootstrapping resampling statistics were utilized to calculate a confidence interval regarding the mean effect size. Resampling statistics can be utilized in order to determine the significance of meta-analytic data because meta-analytic data often have small sample sizes. Bootstrapping confidence intervals are appropriate to use with meta-analytic data with small sample sizes in order to determine significance. Specifically, the number of studies from a sample size $n$ is randomly chosen with replacement. As a result of sampling with replacement, some of the studies will be selected more than once, and others will not be selected. This procedure is replicated a number of times in order to deliver a distribution of possible values for the mean effect size (Rosenberg, et al., 2000). When considering a 95% confidence interval the lowest and the highest 2.5% of the values are selected to represent the lower and upper limits of the confidence interval (if the procedure were calculated a number of times, then 95% of the time the interval would include the parameter.)

Finally, in order to account for the file drawer problem, fail safe $n$ calculations were employed (Rosenthal, 1979). The central tenet behind the file drawer problem is the idea that research with only significant results are published. In order to account for any unpublished, non-significant studies, Orwin's (1983) fail safe $n$ formula was utilized. This calculation represents the number of studies that would be needed in order to decrease the significance of the meta-analysis to non-significance. If the fail safe $n$ is small, especially in comparison to the number of studies, then results from the meta-analysis should be interpreted with caution (Rosenthal, 1979).
RESULTS

Descriptive information for coded variables is provided in Tables 2 and 3. Peer reviewed journal articles composed 67% of the studies retrieved and the remaining 33% consisted of dissertations. The mean year of publication was 1994. In 100% of the studies a multiple case design was utilized. In 50% of the studies a mixed design was utilized in which a control group was compared to an experimental group, participating in aerobic exercise, pre-intervention and post-intervention. In the remaining 50% of the studies a within-subjects design was employed in which participants' pre-exercise and post-exercise scores were compared. The mean age of the participants was 36.56, (SD= 3.30). Ninety-three percent of all participants were female. The mean number of participants was 9.83 (SD= 5.38), with a mean drop-out rate of 12.33%. In 17% of the cases, participants were recruited by medical referrals. The participants were recruited by advertisements in 33% of the cases, and in the remaining 50% of the cases, researchers utilized both methods for participant recruitment. The treatment setting across studies varied: 33% utilized a group setting, and 67% utilized a combination of a group and individual setting. The average duration of treatment was 8.67 weeks (SD= 2.73), and the average amount of treatment was 172.5 minutes per week (SD = 34.37 minutes). In all of the studies, a headache diary was used as the outcome measure. The participants reported using medication as a concurrent treatment in 50% of the studies.
Table 2

*Descriptive Statistics for all of the conditions (n=6).*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Range (Min-Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Publication</td>
<td>1994 (5.00)</td>
<td>1988-2003</td>
</tr>
<tr>
<td>Mean age (year)</td>
<td>36.56 (3.30)</td>
<td>32.50-40.60</td>
</tr>
<tr>
<td>Duration of treatment (weeks)</td>
<td>8.67 (2.73)</td>
<td>6-12</td>
</tr>
<tr>
<td>Amount of treatment (minutes/week)</td>
<td>172.50 (34.37)</td>
<td>135-240</td>
</tr>
<tr>
<td>Number of participants</td>
<td>9.83 (5.38)</td>
<td>5-20</td>
</tr>
<tr>
<td>Percentage of drop-outs</td>
<td>12.33 (14.33)</td>
<td>0-30</td>
</tr>
</tbody>
</table>
Table 3

*Descriptive Statistics for all of the conditions (n=6).*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number (Percentage) of conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of publication</strong></td>
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</tr>
<tr>
<td>Published article</td>
<td>4 (67)</td>
</tr>
<tr>
<td>Dissertation</td>
<td>2 (33)</td>
</tr>
<tr>
<td><strong>Research design</strong></td>
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</tr>
<tr>
<td>Mixed Design</td>
<td>3 (50)</td>
</tr>
<tr>
<td>Within-subjects Design</td>
<td>3 (50)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>55 (93)</td>
</tr>
<tr>
<td>Men</td>
<td>4 (7)</td>
</tr>
<tr>
<td><strong>Treatment Setting</strong></td>
<td></td>
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<tr>
<td>Individual</td>
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</tr>
<tr>
<td>Group</td>
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<tr>
<td>Combination of Individual and Group</td>
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</tr>
<tr>
<td><strong>Method of Subject Recruitment</strong></td>
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<td>Medical referral</td>
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<td>Advertisement and Medical referral</td>
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</tr>
<tr>
<td>Concurrent Treatment (medication)</td>
<td>3 (50)</td>
</tr>
</tbody>
</table>
Effect sizes for the studies included in this meta-analytic review are presented in Table 4. The effect sizes for the within-subjects data, comparing the pre-intervention headache index and the post-intervention headache index for each of the participants ranged from -1.31 to -0.06. A fixed effects cumulative meta-analysis for all of the studies produced a negligible effect size of -0.03, with a 95% confidence interval of -0.51 to 0.46 (-0.51 to 0.51 95% Bootstrap confidence interval). It is important to note that confidence intervals that include zero are indicative of non-significant results. It is also important to note that Orwin's fail-safe n did not exceed the recommended 5:1 (5n + 10) ratio minimum, as put forth by Rosenthal (1979). If the results are below .20 effects can be attributed to chance (Orwin, 1983).

For three of the studies, follow-up data was collected. However, information necessary for the calculation of effect sizes was only presented in two of the studies. The effect sizes for the within-subjects data, comparing the pre-intervention headache index to the follow-up headache index for each of the participants were -0.92 and -0.12. A fixed effects summary analysis yielded a small effect size of -0.43, with a 95% confidence interval and Bootstrap confidence interval of -0.92 to -0.12. It is important to note that Orwin's fail-safe n did not exceed the recommended 5:1 (5n + 10) ratio minimum, as put forth by Rosenthal (1979). This indicates that the results need to be interpreted with caution because it would take a small number of additional non-significant studies to alter the results from significant to nonsignificant.
Table 4

*List of studies reporting quantified outcome data.*

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of publication</th>
<th>Treatment</th>
<th>Participants</th>
<th>Effect Size</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitterling, et al., 1988</td>
<td>journal article</td>
<td>Within-subjects design</td>
<td>5</td>
<td>-1.24</td>
<td>-0.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual, group tx setting</td>
<td>100% female</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration of treatment 12wks</td>
<td>40.2 mean age</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>240 minutes (80 min 3x/wk)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medication concurrent tx</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recruitment: Ad &amp; physician</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Follow-up 12 wks (used for analysis) and 24 wks</td>
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<td></td>
</tr>
</tbody>
</table>

Findings: Post-intervention 4 out of 5 participants reported a 44% decrease in headache activity, deemed to be clinically significant by the authors.

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of publication</th>
<th>Treatment</th>
<th>Participants</th>
<th>Effect Size</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locket &amp; Campbell, 1992</td>
<td>journal article</td>
<td>Mixed Design</td>
<td>11/9</td>
<td>-1.31</td>
<td>Data not available for calculation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group Treatment Setting</td>
<td>100% female</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration of treatment 6 wks</td>
<td>32.5/32.2 mean age</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>135 minutes (45 min 3/wk)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No concurrent treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recruitment: Ad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Follow-up 2 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Findings: The control group consisted of wait list controls and no significant changes were observed for these participants. Pain severity significantly decreased for the intervention group. The frequency, intensity, and duration also decreased for the intervention group, but did not reach statistical significance.
<table>
<thead>
<tr>
<th>Study</th>
<th>Type of publication</th>
<th>Treatment</th>
<th>Participants Intervention/Control</th>
<th>Effect Size</th>
<th>Follow-up Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>McSherry, 1994</td>
<td>dissertation</td>
<td>Within-subjects design</td>
<td>7</td>
<td>-0.06</td>
<td>-0.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual, group tx setting</td>
<td>71% female</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration of treatment 12wks</td>
<td>36.85 mean age</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>150 minutes (50 min 3x/wk)</td>
<td>No concurrent tx</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Recruitment: Ad</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Follow-up 4wks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Findings:</td>
<td></td>
<td>Statistically significant decreases in the headache index were found between baseline and one month into treatment. From baseline to the last month of treatment 6 out of 7 participants experienced a decrease in the headache index. From baseline to follow-up 4 out of 7 participants experienced decreases in the headache index, but these were not at the statistically significant level.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peters, et al., 1996</td>
<td>journal article</td>
<td>Within-subjects design</td>
<td>7</td>
<td>-.18</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual, group tx setting</td>
<td>100% female</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration of Treatment 6 wks</td>
<td>40.6 mean age</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>150 minutes (50 min 3x/wk)</td>
<td>Medication concurrent tx</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Recruitment: Ad &amp; physician</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No follow-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Findings:</td>
<td></td>
<td>Post-intervention participants reported significant decreases in medication consumption, and symptoms of anxiety and depression. There was a lack of improvement in headache activity.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Type of publication</td>
<td>Treatment</td>
<td>Participants</td>
<td>Effect Size</td>
<td>Follow-up</td>
</tr>
<tr>
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<td>---------------------</td>
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<td>-----------</td>
</tr>
<tr>
<td>S Osun Narin et al., 2003</td>
<td>Journal article</td>
<td>Mixed Design</td>
<td>20/20</td>
<td>-.11</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group Treatment Setting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duration of Treatment 8 wks</td>
<td>100% female</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>180 minutes (60 min 3x wk)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medication concurrent tx</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recruitment: Physician</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No follow-up</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Findings: The control group received medication. After 8 weeks both the intervention and the control group reported significant decreases in the intensity, frequency and duration of pain. The intervention group reported greater improvement in pain relief and quality of life than the control group.

| Witucki, 1993       | Dissertation        | Mixed design                        | 9/9          | -0.43       | NA        |
|                     |                     | Individual, group tx setting        | 78% female   |             |           |
|                     |                     | Duration of treatment 8 wks         | 34/31 mean age |           |           |
|                     |                     | 180 minutes (60 min 3x/wk)         |              |             |           |
|                     |                     | No concurrent treatment             |              |             |           |
|                     |                     | Recruitment: Ad & physician         |              |             |           |

Findings: The control group received the following treatment: progressive muscle relaxation, stress management, and biofeedback. There were no statistically significant changes in the headache index from baseline to post-treatment between or within groups. Gradual improvements were observed overtime for both groups.
DISCUSSION

Migraine headaches affect a sizable portion of the population. Specifically, 11% of individuals are affected (Lipton et. al., 1997). As previously discussed, many treatments for migraine headaches can be costly and complicated to follow. Aerobic exercise can be designed to be simple and cost-effective. Additionally, it is thought to be effective in the treatment of migraine headaches because it causes both physiological changes (increases in blood pressure, endorphin, and serotonin levels) and psychological changes (serves as a distraction and relaxation) that are thought to address some of the difficulties, experienced at both the physiological and psychological levels, associated with migraine headaches. The purpose of this study was to conduct a meta-analytic review of aerobic exercise as a treatment for migraine headaches in order to determine the degree of influence exercise can add to treatment protocols. By combining the studies through a cumulative meta-analysis, a more accurate representation of effect can be obtained than by merely examining the effect size of each individual study. Specifically, the overall effectiveness of aerobic exercise as a treatment for migraine headaches was examined; as well as how well aerobic exercise treatment maintained effectiveness at follow-up measurements. Researchers questioned the distinction between migraine and tension headaches as separate disorders (Drummond, 1987; Leston, 1996; Marcus, 1992; Rasmussen et. al., 1992). As a result of this, studies with participants diagnosed with tension headaches were also included in this meta-analysis.
Summary and Conclusions

A total of eight studies were identified for inclusion in the current meta-analysis. Of the eight studies, only six contained the necessary quantitative data for the calculation of effect sizes. For all six studies, within-subjects design data, specifically the headache index, was compared pre-intervention and post-intervention, yielding a negligible effect size. The summary effect size below .20 was considered non-significant and attributable to chance. Additionally, confidence intervals that include zero, as is the case with this study, are indicative of non-significant results.

The effect size for the individual studies included in the current meta-analysis ranged from large to negligible. In two of the studies included in this review, large effect sizes were found. In contrast, a small effect size was found for one study, and in the remaining three studies examined in this review negligible effect sizes were obtained. Each study is discussed below.

Large effect sizes

As previously discussed, two studies were found to have large effect sizes, Fitterling, Martin, Gramling, & Cole (1988) -1.24 effect size, and Locket and Campbell (1992) -1.31 effect size. In both of these studies 100% of the participants were female. The researchers of each study utilized different research designs including treatment settings, and duration of treatment. Each study is described below, and the limitations for each study are discussed.

Fitterling et al., (1988) employed a within-subjects design in which 5 female participants diagnosed with migraine headaches by their physicians participated in 240 minutes of aerobic exercise per week (80 minutes, three times a week) for 12 weeks. The weekly aerobic exercise sessions consisted of one session supervised on-site and two
sessions in which the participants exercised individually off-site (e.g. in their homes, at a jogging trail etc.). Participants were required to keep a daily headache diary in which they recorded the intensity, duration, and frequency of their headache activity, as well as any medication they consumed, any doctor's visits, and missed days from work. These measurements were recorded pre-intervention, post-intervention and 3 month and 6 months follow-up periods. At post-intervention 4 out of 5 participants reported a 44% decrease in headache activity, deemed to be clinically significant by the authors. Additionally, at 6 months follow-up measurement, a large effect size was also found, although it was smaller than the large effect size obtained at the post-intervention measurement. The researchers hypothesized that this could be due to participants not adhering to the prescribed exercise regimen post intervention. In fact, of the 5 participants, 4 reported continuing exercise at the 3 month follow-up period and only 3 reported maintaining exercise at 6 month follow-up period. As a result, lack of adherence to the exercise regimen was one possible limitation cited by the authors. The authors also cited placebo effects to be another possible limitation. Additionally, because a control group was not utilized, it is difficult to tell if the changes result from the intervention, or if they are best accounted for by outside factors such as maturation of the group.

Locket and Campbell (1992) utilized a mixed design in which participants diagnosed with migraine headache with aura (according to the IHS criteria) were divided into two groups: (1) 11 females who participated in 45 minutes of aerobic exercise three times a week for 6 weeks; and (2) 9 females who served as wait list controls and received medication only. The exercises sessions took place in a group setting and were taught by a certified aerobics instructor. Participants recorded the severity, frequency, intensity, and duration of their headaches pre-intervention, mid-intervention, post-intervention, and...
weeks follow-up in a headache diary. No significant changes were found for the control
group post intervention. At post-intervention pain severity was found to significantly
decrease for the intervention group. The frequency, intensity, and duration were also
found to decrease for the intervention group, but the measurements were not found to be
statistically significant. Information was not provided for the calculation of the effect size
for 2 weeks follow-up period. The use of the control group eliminates the limitation
related to maturation over time. Additionally, the use of the supervised group setting also
eliminates the limitation concerning the difficulties with verifying exercise compliance
rates. However, the use of the group setting poses another potential limitation. It is
difficult to ascertain if the results obtained are accounted for by the exercise intervention,
or by the increase in social support obtained from the group setting. Social support has
been found to be a protective factor against stress; and stress is the most commonly cited
precipitant of migraine headaches. Thus, it is possible that increases in social support,
rather than exercise were the cause of the improvements.

Small effect size

In one study, conducted by Witucki (1993), a small effect size, -0.43, was
obtained. In this study a mixed design was utilized in which participants diagnosed with
tension headache (according to the IHS criteria) were divided into two groups. The
intervention group consisted of 7 females and 2 males who participated in 180 minutes of
aerobic exercise weekly (60 minutes three times a week) for 8 weeks. These sessions
occurred in a group setting and were supervised by a certified aerobics instructor. The
control group consisted of 7 females and 2 males who participated in a traditional
headache treatment of progressive muscle relaxation, stress management, and
biofeedback. They attended weekly sessions and also utilized the skills learned at home.
Each participant kept a headache diary in which the frequency, intensity, severity, and duration of headache activity was recorded. The researcher obtained information one month pre-treatment, each month during treatment, and one month follow-up. Upon examination of this information, the researcher reported no statistically significant changes in the headache index from baseline to post-treatment between or within groups. Gradual improvements were observed overtime for both groups. The researcher cited the small sample size as a possible limitation. The researcher reported that upon conducting a power analysis post data collection it was determined that in order to discern a true difference between pre-treatment and post-treatment scores 22 more participants would have been required. Additionally, social support as a result of the group exercise setting is another possible limitation. The limitation related to maturation overtime was mitigated as a result of the use of the control group. Also, the use of the supervised group setting also mitigated the confound regarding the difficulties in verifying exercise compliance rates.

**Negligible effect size**

In contrast to the two studies in which large effect sizes were obtained, no similarities were found among the three studies in which negligible effect sizes were yielded; McSherry (1994) -0.06 effect size, Peters, Turner, and Blanchard, (1996) -0.18 effect size, and S Osun Narin, Erbas, Ozturk, and Idiman, (2003) -0.11 effect size. Differences in treatment setting, participants, and treatment duration were found across the studies. Each study and the possible limitations for each study are discussed below.

McSherry (1994) utilized a within-subjects design in which 7 participants diagnosed with migraine headache (5 females and 2 males) participated in 150 minutes per week (50 minutes three times a week) of aerobic exercise for 12 weeks. All exercise
sessions were supervised by individuals certified in CPR. Participants were given the option of exercising individually or in a group setting. However, participants were encouraged to exercise together. Participants kept a headache diary in which they recorded the frequency, intensity, and duration of their headache activity pre-treatment, each month during treatment, and one month follow-up. Statistically significant decreases in the headache index were found between baseline and one month into treatment. From baseline to the last month of treatment 6 out of 7 participants experienced a decrease in the headache index. From baseline to follow-up 4 out of 7 participants experienced decreases in the headache index, but these were not at the statistically significant level. The small sample size, the group setting serving as social support, and the lack of a control group all serve as limitations in this study. However, due to the fact that all exercise sessions were supervised compliance rates can be verified, eliminating this as a possible confound.

Peters et al. (1996) also utilized a within-subjects design in which 7 female participants diagnosed with tension headache or combined tension and migraine headache participated in 150 minutes of aerobic exercise weekly (50 minutes three time a week) for 6 weeks. Participants were asked to attend group exercise sessions taught by a certified aerobics instructor. However, if they were unable to attend these, they were asked to exercise at home. Participants kept a headache diary 2 weeks pre-treatment and post-treatment. No improvements were found in headache activity post-intervention. The small sample size, lack of a control group to account for maturation, difficulty verifying compliance rates when participants exercised independently, and the group exercise sessions serving as social support, are all factors that need to be considered as possible limitations in this study.
In contrast to the two previous studies discussed, S Osun Narin et al., (2003) utilized a mixed subjects design. In this study, 40 female participants diagnosed with migraine headache without aura (according to the IHS criteria) were divided into two groups. The intervention group participated in 180 minutes of aerobic exercise weekly (60 minutes three times a week) over 8 weeks and also received medication treatment. In contrast, the control group received only medication treatment. Each group was evaluated pre-treatment and post-treatment through the use of a visual analogue scale to rate headache intensity as well as the Pain Disability Index, which was utilized to measure how the pain interfered with participants' daily functioning. All exercise sessions were supervised by a physiotherapist. Similar measurements were found between the two groups at pre-treatment measurements. At post-intervention measurements, the control group and intervention group reported significant decreases in the intensity, frequency, and duration of pain. The intervention group reported greater improvement in pain relief, and quality of life than the control group. The researchers cited that the intervention time, 8 weeks, might not have been long enough to demonstrate significant changes. The use of a physiotherapist to supervise all exercise sessions eliminated the concern over verification of exercise compliance. Additionally, the use of the control group is another strength of the research design employed by the researchers.

**Follow-up effect sizes**

In three of the six studies included in this meta-analysis, researchers reported follow-up data. Information necessary for the calculation of effect sizes was only available in two of the studies. A small effect size was found when comparing the within-subjects data (headache index) pre-intervention and follow-up intervention.
Summary of Findings Across Studies

When comparing the studies by the type of effect size obtained (large, small, and negligible) there were no patterns found in the research designs employed in terms of accounting for in the differences in outcomes of each study. After an examination of each study included in this meta-analytic review it is evident that there are a number of limitations that exist across the studies, even in the studies in which large effect sizes were found.

One limitation common to a number of the studies was a lack of control group. As a result of this, changes that occur overtime, such as maturation, could not be accounted for. In addition, in some of the studies where a control group was utilized, the participants in the control group received abortive medication treatment, while the intervention group received preventative treatment through aerobic exercise. This mixing of treatment paradigms contributes to the difficulty in drawing conclusions from the findings of these studies. In the studies where a group treatment setting was employed, social support, acting as a protective factor against stress, could have produced the effects, rather than the intervention of aerobic exercise. In contrast, in the studies where an individual treatment method was employed, exercise compliance rates could not be verified. A number of the researchers also postulated that the intervention time was not long enough to produce the desired results. The researchers also failed to evaluate the intensity level of exercise for each participant at the physiological level. As a result, it is possible that not only was the intervention time not long enough, but that the daily intervention time was either too intense, creating stress on the body, or not intense enough, limiting the possible benefits of aerobic exercise. All of the studies had relatively small sample sizes. It is possible that the low number of participants contributed to low statistical power,
increasing the likelihood of a Type II error. For example, only one of the researchers, Witucki (1993), mentioned the calculation of a power analysis, and in this example many more participants were needed in order to obtain statistically significant results. Finally, the participants included in this meta-analysis primarily consisted of adult, Caucasian, women. Thus, the participants included in this review might not be an accurate representation of the overall migraine population. As a result, the generalizability of the results might be limited. However, it is important to note that adult, Caucasian, women report the highest prevalence rates for migraine headaches as well as have the highest rates for seeking treatment. As the result, the use of this sample could also be considered a strength of the studies. It is important to be mindful of the limitations of each of the studies included in this meta-analytic review, because these limitations might impact the results of the current study.

Limitations

Just as it is important to be mindful of the limitations of each study included in the meta-analysis, it is also important to be aware of the limitations of the current meta-analysis, which include: problems with Orwin's fail safe n, internal validity, and missing data. After reviewing Orwin's fail safe n it was evident that a small number of null studies would negate the effect size presented in the current meta-analysis; meaning the effect size reported in this analysis may not be representative of the true effect size. Internal validity is another limitation to consider. The internal validity of the current meta-analysis is dependent on the internal validity of each study included in the review. Some of the studies lacked random selection, random assignment, and control groups, which prevents one from knowing if maturation accounted for the observed changes. In addition, some of the researchers chose to have the participants engage in exercise...
individually, at their home, or on their own time. This is problematic because it is unclear if a standardized protocol was followed and compliance rates cannot be verified. In most of the studies, participants recorded the medication they consumed in their headache diaries. However, any other treatments they may have been using were not reported. If they were using other treatments, the effect size reported for aerobic exercise would not be entirely accounted for by aerobic exercise. Finally missing data, including the possibility that some relevant studies were not located through the search methods employed in the current meta-analysis is another limitation to consider.

**Directions for Future Research**

The variety of possible limitations and the lack of consistent findings when comparing the studies by the type of effect size obtained create a new research question. Perhaps it is not the treatment methods employed that is important to study, but the participant variables that explain why some individuals demonstrate improvements and others do not. In fact, some headache researchers argue that treatment outcomes are affected more by patient variables than by the treatment modality that is utilized (Bogaards, & ter Kuile, 1994; Lemstra, Stewart, & Olszynski, 2002). It is possible that the differences in effect sizes found among the studies included in this meta-analytic review are actually due to participant variables, such as demographic characteristics (e.g. age, gender, and socio-economic status), migraine severity/treatment history, personality characteristics, coping resources, as well as physical and psychological functioning, rather than the intervention employed. Individual differences, especially when sample sizes are small, can impact the findings.

The importance placed on individual differences has produced a recent trend of an individualized approach to migraine headache treatment. Included in this trend is the use
of multi-component treatment methods, in which treatment entails matching a variety of therapeutic interventions from different disciplines to the unique needs of the individual. While aerobic exercise for the treatment of migraine headaches appears to have an overall negligible effect size, exercise might have a beneficial role in the treatment of migraine headaches if included in a multi-component treatment.

Multi-component treatment methods have been shown to be effective in treating other types of chronic pain. For example, researchers assigned 96 individuals suffering from chronic back pain to four different groups: (1) a group receiving behavior therapy and aerobic exercise treatment, (2) a group receiving only behavior therapy, (3) a group receiving only aerobic exercise, and (4) a group receiving no treatment, serving as a waitlist control. Prior to treatment, following treatment, and at 6 and 12 month follow-ups, participants rated themselves on a number of self-report measures, and were also directly observed and rated by significant others. Participants in the combined behavior therapy and aerobic exercise group demonstrated significant improvements when compared to all other groups’ pre-treatment and post-treatment (Turner, Clancy, McQuade, & Cardenas, 1991). In a more recent study, a multi-component treatment was examined with 32 patients suffering from fibromyalgia. In this study, participants were randomly assigned to three groups: (1) a group receiving a multi-component treatment, consisting of aerobic exercise, psycho-education, and biofeedback, (2) a group receiving aerobic exercise only, and (3) a group receiving no treatment serving as a control. After the 10 week intervention period Groups 1 and 2 demonstrated significant improvements in functioning, fitness level, and pain level. However, only the group receiving the multi-component treatment reported an additional significant improvement in sleep functioning (Beltran, 2003). Finally, Kitahro, Kojima, and Akito, (2006) conducted a study in which
99 patients suffering from non-cancerous chronic pain received an interdisciplinary treatment consisting of psycho-education, aerobic exercise and stretching, cognitive behavioral therapy, and medication management for 8-12 sessions, depending on the needs of the patient. Patient progress was measured by comparing pre-treatment scores to scores 2 and 4 weeks post-treatment. Significant decreases were found in reported pain level and significant increases were found in daily functioning post-treatment.

Multi-component treatment methods that include exercise have also been examined for the treatment of migraine headaches. Specifically, researchers have reported that multi-component treatments can be effective in improving functioning, quality of life, as well as decreasing pain and symptoms of depression for individuals suffering from migraine headaches (Saper, Lake, Madden, & Kreeger, 1999). In addition, a group of researchers assigned 80 participants diagnosed with migraine into two groups: (1) a group receiving a multi-component treatment consisting of sessions with a neurologist, physical therapy sessions, 18 supervised exercise sessions, two group lectures on relaxation and stress management, and three massage therapy sessions, (2) a group receiving care from a primary care physician. The group that received the multi-component intervention reported experiencing significant improvements in functional status and quality of life, as well as significant decreases in pain frequency, intensity, and duration. These changes were maintained at 3 month follow-up measures. There were no significant changes found for medication consumption or work status. Similar changes were not reported by the group receiving care from the primary care physician (Lemstra, et al., 2002). In both of the studies discussed above, the researchers commented on the positive health outcomes that can be created through the use of the multi-component treatments as well as the cost effectiveness of such treatments (Lemstra et al., 2002;
Saper et al., 1999). For example Saper et al., (1999) reported the positive health outcomes resulted from a mean of 3.5 doctors’ visits in a 2 year period. Multi-component treatment methods are considered cost effective, because compared to traditional treatment methods, both direct and indirect costs for migraine headaches are usually lower. For example, with multi-component treatment methods, typically fewer annual doctors’ visits are required. Also, because of the individualized approach to treatment in which an individual has a number of treatment options available from different disciplines, work productivity may be less affected than with traditional treatment methods in which limited options are available. Additionally, some researchers have reported treatment outcomes to be affected more by the patient outcomes than the treatment modality, arguing for individualized treatment based on the needs of the patient (Bogaards, & ter Kuile, 1994; Lemstra et al., 2002). In sum, current research supports individualized approach to treatment that is based on the specific needs of the patient, in which exercise is part of a multi-component treatment plan.

Migraine headaches have significant effects on both the sufferer and the larger society. The aim of this meta-analysis was to investigate effective treatment options for this disorder. As more research is conducted on multi-component treatments, the contribution of each part of the treatment should be investigated in order to determine the most efficacious and cost effective methods of treatment. Additionally, researchers should conduct treatment research using a cross-section of individuals from different demographic groups, including age, ethnicity, and socioeconomic status, in order to improve the generalizability of research findings, determine participant variables that might influence treatment outcomes, and to utilize the effective treatment modalities based on individual variables. For example, in the United States individuals from lower
socio-economic groups have been found to have high prevalence rates for migraine headaches. It would be helpful for future researchers to participate in outreach activities targeting this group, as well as other groups who typically do not have access to healthcare, in order to establish effective treatment options.

Finally, another way to study individual variables in order to utilize effective treatment modalities is through the use of single case design methodologies. When using this method, a number of the limitations previously discussed are eliminated. For example, individuals serve as their own controls, and large numbers of participants are not required in order to determine if results are significant. Additionally, individual differences are not masked. This approach allows for treatment to be tailored to the specific needs, and abilities of the individual while still utilizing the scientific method to evaluate treatment. While traditional A-B-A-B single case designs might be helpful, it is likely that single case, multiple baseline design might be more helpful because with multiple baseline designs, more variables can be controlled for, allowing for increased generalizability of results. When using multiple baseline designs, both the length of time of the initial baseline, as well as the amount of specific treatment can vary. This can help to determine if the treatment is effective, as well as the amount of treatment that is needed in order to be effective. As a result, this method can be utilized to inform both clinical and research decisions regarding the most helpful practices for migraine treatment.
REFERENCES


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* Indicates the studies that were included in the current meta-analysis.
<table>
<thead>
<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>1</td>
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<tr>
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<td>Type of publication</td>
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<tr>
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<td>Year (full four digits)</td>
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<td>4</td>
<td>Research Design</td>
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<td>Research Methodology</td>
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<tr>
<td>6</td>
<td>Mean Age of Sample</td>
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<tr>
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<td>Predominant sex of the sample</td>
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<tr>
<td>7.1</td>
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<td>8</td>
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<tr>
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</tr>
<tr>
<td>8.2</td>
<td>Group</td>
</tr>
<tr>
<td>8.3</td>
<td>Both Individual and Group</td>
</tr>
<tr>
<td>8.4</td>
<td>Other</td>
</tr>
</tbody>
</table>
9. Duration of treatment in weeks; Amount of treatment in minutes per week

10. Method of participant recruitment
   1 advertisement
   2 referred by physician
   3 both advertisement and physician referral
   4 Other

11. Number of participants who completed treatment

12. Percentage of participants who dropped out

13. Type of outcome measure
   1 Headache Diary
   2 Other methods

14. Concurrent treatment
   1 Yes
   2 Not mentioned

15. Pharmacological treatment
   1 Yes
   2 Not mentioned

16. Biofeedback training
   1 Yes
   2 Not mentioned

17. Relaxation training
   1 Yes
   2 Not mentioned

18. Coping Skills/Stress Management/Psychotherapy
   1 Yes
   2 Not mentioned
19. Acupuncture
   1 Yes
   2 No

20. Hypnosis
   1 Yes
   2 No

21. Physical therapy
   1 Yes
   2 Not mentioned

22. Massage therapy
   1 Yes
   2 Not mentioned

23. Dietary Consultation
   1 Yes
   2 Not mentioned

24. Follow-up time (in weeks)

25. Findings
   1 In support of aerobic exercise

   2 Not in support of aerobic exercise