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Comparing the Effects of Aquatic and Land-based Exercise on the Physiological Stress Response of Women with Fibromyalgia

Cheryl Kelley and David P. Loy

Abstract

While many studies have suggested various treatment mechanisms for individuals with fibromyalgia (FMS), few have examined the impact of aquatic and land-based exercise on the physiological stress response in women with fibromyalgia. Due to the increased physiological and psychological stress associated with fibromyalgia, additional research examining the physiological responses to stress and interventions addressing stress in the FMS population is warranted. The present study examined salivary cortisol response of women with fibromyalgia during land-based exercise (i.e., walking on a treadmill) and aquatic exercise (i.e., Ai Chi). A single-subject alternating treatment design ($N = 3$) was selected to compare the effectiveness of Ai Chi and treadmill walking on salivary cortisol levels. Cortisol samples were obtained from each participant prior to and immediately following each treatment session to serve as a psycho-physiological marker of stress. Results suggested both aquatic and land-based exercise had a positive influence in reducing salivary cortisol in women with FMS; however, exercising at a moderate pace on a treadmill proved to be the superior treatment intervention. Results of this study may potentially help women with FMS discover an alternate or additional treatment to assist in coping with stress related to chronic illness.

KEYWORDS: *Fibromyalgia, Stress, Cortisol, Land-Based Exercise, Aquatic-Based Exercise, Ai Chi*

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Treating chronic illness is a leading health care concern in the United States. Chronic illness refers to an altered health state that cannot be cured by surgical procedures or medical therapy (Miller, 1992). The way individuals cope with the demands of chronic illness influences the extent and nature of lifelong adjustment and overall quality of life (White, Lemkau, & Clasen, 2001). For individuals dealing with chronic illness, it is not only essential to manage the physical demands of the illness, but also to adjust to the lifestyle changes that accompany illness. While some stressors of chronic illness are temporary and vary in the degree of arousal, disease uncertainty is ever-present (Miller, 1992).

Literature Review

Fibromyalgia

One illness commonly associated with the stress response is fibromyalgia (FMS).

Fibromyalgia is a chronic illness affecting approximately 4.5 million women in the United States (Arthritis Foundation, n.d.). FMS has an unknown etiology and is the second most prevalent condition treated by rheumatologists in the United States (Nicassio, Moxham, Schuman, & Gervirtz, 2002). The condition is often associated with other symptoms that mimic various illnesses, thus making diagnosis difficult and treatment challenging. As a result, millions of dollars are being spent on personal health care, research, and possible treatment interventions to address issues faced by individuals with FMS (Rogers & Maurizio, 2000). Because there are no known cures, individuals with FMS often become frustrated with their illness and the many ways it affects their lives. FMS is a disorder characterized by generalized pain, stiffness, and fatigue, as well as sleep disturbances and multiple tender points at symmetrical locations on the body (Chakrabarty & Zoorob, 2007). FMS is also a condition that affects more females than males, with a female-to-male ratio of 9:1 (Arthritis Foundation). In 1990, the American College of Rheumatology endorsed classification criteria for FMS (Wolfe et al., 1990) to include (a) a history of widespread pain in the neck, shoulders, lower back, hips, and/or knees for a duration of at least 3 months and (b) pain on digital palpation in a minimum of 11 of 18 tender points (White, Hornsby, Briggs, & Hornsby, 2000). The debilitating fatigue, chronic pain, and sleeplessness associated with FMS can often disrupt work performance, interpersonal relationships, the pursuit of personal goals, and generate anxiety (Winfield, 2004), thus exacerbating the stress response.

Stress, Cortisol, and FMS

According to Lazarus and Folkman (1984), stress is a state of anxiety produced when events and responsibilities exceed one's coping ability. Physiological symptoms of stress often include headaches, sweaty palms, cold extremities, ulcers, diarrhea, hypertension, and a decrease in the ability to fight infections (Romas & Sharma, 2004), all of which may be symptoms associated with FMS. The body's physiological stress response system is primarily activated within the autonomic nervous system and the endocrine system. At the onset of a stressor, the body prepares for "battle" provoking the "fight or flight" response (Cannon, 1939). Individuals exhibiting the symptoms of FMS are in a constant internal physiological struggle between the sympathetic nervous system and the parasympathetic nervous system (Crofford, 1998). The sympathetic nervous system of individuals with FMS is often over-stimulated due to the persistent physical and psychological manifestations of the illness (Crofford). The endocrine system responds by releasing stress hormones (i.e., cortisol) into the bloodstream (Vierck, 2006). Cortisol is a glucocorticoid released from the adrenal cortex, via the hypothalamic-pituitary-adrenal axis. Catley, Kaell, Kirschbaum, and Stone (2000) reported higher baseline cortisol levels, as measured in saliva, in individuals with FMS compared to healthy controls. The presence of elevated cortisol levels in healthy individuals has been suggested to be an indicator of increased physiological and/or psychological stress (Catley et al.). Due to the prolonged physiological and psychological distress of individuals with FMS, there are abnormalities in the hypothalamus-pituitary-adrenal axis, the regulatory system of the body responsible for the secretion of cortisol (Bonifazi, Suman, Cambiaggi, Felici, Grasso, Lodi et al., 2006). High cortisol levels increase the body's ability to manage stress for the short-term (Greenberg, 2004); however, the body cannot function in "overdrive" (i.e., over-production of cortisol) for long periods of time. If chronic stress becomes habituated, as in the case with FMS, a state of adrenal exhaustion may occur (Heim, Ehlert, & Hellmanner, 2000).

Physical Activity and FMS

The symptoms of FMS can be studied at varying levels, such as intensity of pain or fatigue, perceived disability, and the physical and psychological distress of the illness. Since no known cure exists, some researchers are focusing their efforts on self-management of symptoms, promotion of health, and improvement in physical function (Mannerkorpi, Nyberg, Ahlmen, & Ekdahl, 2000). Studies focusing on physical activity have shown improved aerobic fitness, increased grip strength, increased work capacity, decreased depressive symptoms, and improved sleep habits (Chakrabarty & Zoorob, 2007; Mannerkorpi et al.; Schafer, 2003), thus doctors are more frequently prescribing physical activity to combat the vast symptomology (Winfield, 2004).

Land-based exercise and FMS. There are extensive data investigating the role of land-based aerobic exercise in the management of FMS symptoms. Martin et al. (1996) suggested that because the fitness of individuals with FMS tends to be lower than age and sex matched controls, a low-grade to moderate exercise program, such as a walking program, should be included in the FMS treatment protocol. Several researchers have reported the benefits of a walking program on the FMS population to include improved overall physical function, increased self-efficacy, reduced tender points, decrease in *Fibromyalgia Impact Questionnaire* ratings (*FIQ*; Wolfe et al., 1990), and improved overall aerobic exercise capacity (Buckelew et al., 1998; Meyer & Lemley, 2000; Redondo et al., 2004). Although land exercise does help alleviate symptoms, researchers also report that the FMS population has a low adherence rate for physical activity beyond prescribed exercise directly overseen by a physician/therapist (Oliver & Cronan, 2002), which may suggest that other types of physical activity may be more beneficial.

Aquatic therapy. Another form of physical activity considered for individuals with FMS is aquatic therapy (Mobily & Verberg, 2001). Aquatic therapy incorporates water exercise and swimming to improve one's physical and psychological well-being (Cole & Becker, 2004). Due to the therapeutic properties of water, aquatic therapy has been widely prescribed and administered to individuals with disabilities (Ogden, 2000). While aquatic-based exercise or aquatic therapy is frequently used as a treatment modality for individuals with FMS, there is limited research among the FMS population (Mannerkorpi & Iversen, 2003). Much of the research has focused on aquatic aerobic exercise which has demonstrated positive effects in individuals with FMS, such as decreased levels of fatigue, depression, anxiety, pain and stiffness and improved mood, aerobic endurance, and increased social interaction (Brasure, Cornelius, Miller, & Mutschler, 2001; Gowens et al., 2001; Mannerkorpi et al., 2000). Similarly, Westfall (1999) suggested mixed results when an aquatic exercise group differed significantly from a control group in levels of well-being, depression, and anxiety, but no differences were found between the groups in levels of pain, stiffness, and sleep quality.

One aquatic therapy intervention becoming more widely prescribed in the treatment of FMS is Ai Chi. Ai Chi is a recent aquatic-based intervention "designed to strengthen and balance a person's energy" (Sova & Konno, 1999, p. 25). Ai Chi has been described as an internal Chinese martial art implemented in the water that focuses on slow rhythmic routines that can have dramatic therapeutic effects on participants (Katz, 2003). Ai Chi is a simple water exercise and relaxation program performed using a combination of deep breathing and slow, broad movements of the arms, legs, and torso in flowing continual patterns (Sova & Konno). While there is no documented efficacy-based research on the benefits of Ai Chi, extensive clinical research has been done on numerous other mind-body techniques (e.g., meditation). Sova and Konno suggested possible benefits of Ai Chi are improved cardio-respiratory health (e.g., lowered blood pressure and decreased VO_2), improved physical functioning (e.g., range of motion and decreased pain), hormone regulation (e.g., epinephrine and cortisol), decreased arousal and increased awareness, and the control of other stress-related symptoms. Sova (2002) reports anecdotal evidence to the benefits of Ai Chi in that individuals with FMS are good candidates for Ai Chi because they benefit from reduced stress and anxiety, which often exacerbates their physical symptoms. Because the sympathetic nervous system tends to be over-activated, individuals with FMS may benefit from a balanced parasympathetic nervous system. Sova and Konno suggested an Ai Chi session with individuals with FMS include extensive work on diaphragmatic breathing techniques to promote a relaxed state and a slow pace to prevent the early onset of fatigue and thus regulate the parasympathetic nervous system.

Summary

Researchers suggest both land and aquatic-based exercise have therapeutic effects on reducing physical and psychological symptoms of FMS. Although researchers have suggested numerous treatments for FMS, limited research has examined the relationships between exercise, cortisol, FMS, and the stress response. As such, the need for additional research examining the physiological responses to stress and interventions addressing stress in the FMS population is warranted. The purpose of this research study was to determine the influence of two interventions (i.e., Ai Chi and land-based exercise) on salivary cortisol levels as a physiological indicator of stress in women with FMS.

Research Questions

1. Do exercise programs (i.e., aquatic and land-based) reduce salivary cortisol level in women with FMS?
2. If so, which intervention technique (i.e., aquatic or land-based) is most effective in reducing salivary cortisol levels in women with FMS?

Methodology

Research Design

Often in therapeutic recreation settings, large populations of similarly diagnosed patients are unavailable. Single-subject methodology allows participants to serve as their own controls (Tawney & Gast, 1944), thus researchers are able to compare target behaviors across time and interventions in smaller sample sizes than traditional experimental designs. This study implemented a single-subject alternating treatment design (ATD) conducted across 4 participants. Single-subject research designs provide a mechanism to compare the effects of interventions within individual cases through repeated measures of performance over time (Tawney & Gast). Alternating treatment designs (ATD) are a type of single-subject research design that provide a research method to compare the relative effects of two or more interventions on the same outcome behavior (Dattilo, Gast, Loy, & Malley, 2000). ATDs involve the fast alternation of two or more different interventions or treatments with an individual participant in order to determine their effectiveness (Tawney & Gast). According to Dattilo et al., "interventions are shown to be effective when a functional relationship exists between an environmental change and a change in the target behavior" (p. 254).

Research Setting and Participant Selection

The research study was conducted at a rehabilitation facility and a university exercise lab located in the southeastern United States. The aquatic sessions were conducted at the rehabilitation facility's therapy pool. The land-based exercise intervention was conducted in an exercise room in the university exercise laboratory.

Potential participants were referred from a local pain clinic in the southeastern United States. Participants met the following inclusion criteria: (a) had a physician's diagnosis of FMS, (b) must have had FMS for at least 2 months, (c) were women between the ages of 25-65, (d) had a physician's prescription for exercise and aquatic therapy, (e) must not have taken any steroidal medication for at least 1 week prior to the beginning of the study and anytime during the study, and (f) had no other major medical conditions. Upon selection, each participant was asked to participate in an aquatic and land-exercise program conducted over a 10-week period with treatment sessions conducted on Mondays, Wednesdays, and Fridays. The researcher obtained prior approval from the university's Institutional Review Board. After thorough explanation of the study, each participant signed an informed consent form.

Participant training. Before the study began, each participant was instructed in the proper technique to collect saliva and at what times each sample was due to be collected. Saliva samples were only collected when participants demonstrated to the researcher with 100% accuracy the proper collection procedures according to testing kit protocols. They were also advised to the importance of following collection guidelines.

Intervention Descriptions

Aquatic exercise. Ai Chi is an aquatic exercise program designed to improve balance, coordination, flexibility, and reduce pain and anxiety through diaphragmatic breathing in a series of broad movements of the arms, legs, and torso in flowing continual patterns under the water's surface (Sova & Konno, 1999). Ai Chi sessions were conducted from 10:30-11:15 a.m. on days 2, 4, 8, 12, 15, 16 and 21 of the study. All Ai Chi intervention sessions were randomly assigned to control for possible sequencing effects (i.e., possibility that the *order* of treatments influenced the outcome variables; Tawney & Gast, 1984). Sessions were conducted in the rehabilitation facility's therapy pool with a water temperature between 91 and 96 degrees Fahrenheit. During each session, participants performed the same 45 minute Ai Chi routine in chest deep water under the guidance of a certified Ai Chi instructor, who was also a certified therapeutic recreation specialist (CTRS). To control for consistency of the intervention, all 4 participants received the same intervention at the same time from the same instructor.

Land-based exercise. Treadmill sessions were conducted between 10:30 a.m. and 11:15 a.m. on days 1, 6, 9, 11, 13, 18, and 20 of the study. Similar to procedures with the Ai Chi sessions, all exercise interventions sessions were randomly assigned to control for sequencing effects (i.e., possibility that the *order* of treatments influence the outcome variables). The land-based exercise program consisted of 15 minutes of stretching exercises, 20 minutes of treadmill walking, and 10 minutes of cool down exercises, all conducted and monitored by the primary investigator. During treadmill walking, each participant's heart rate was monitored via digital heart rate monitors. Participants were asked to exercise at a low to moderate heart rate, about 40-69% of their total maximum heart rate, unless their pain significantly increased during exercise. Sub-maximum total heart rate was determined using the following mathematical formula: [208-(age*0.7)] (Tanaka, Monahan, & Seals, 2001).

Data Collection Procedures

Cortisol, a naturally occurring hormone produced by the adrenal cortex, has been linked to the stress response (Mariab, 2004). The onset of physical and/or mental stress triggers the release of cortisol into blood plasma, urine, and saliva. The integration of using salivary testing in behavioral health-related research has recently increased exponentially (Shirtcliff, Granger, Schwartz, & Curran, 2001). "Salivary (cortisol) levels accurately reflect the unbound, biologically active, fraction of many serological markers in the general circulation" (Shirtcliff et al., p. 166). Monitoring cortisol in saliva has very distinct advantages to other collection methods (i.e., urine, blood, or plasma). Saliva sampling is relatively non-invasive, readily available when other methods are not viable, and, due to its ease in collection procedures, may be conducted at the participant's home. Due to these properties, salivary cortisol testing was chosen for this study.

Saliva collection. Saliva was sampled from each participant during designated times throughout the study. Saliva samples were taken immediately prior to, and within 15 minutes of post intervention to determine if there was a change in cortisol levels. Guidelines for collection included: (a) no eating or drinking 30 minutes prior to sample collection, (b) participants rinsed their mouth with water, (c) waited 5 minutes, then (d) expectorated 5-6 milliliters of saliva into a collection vial. Samples were kept frozen at -20°C until sample analysis (DSL, 2000). Samples were prepared and analyzed according to protocols dictated by the DSL-100671000 ACTIVE® Cortisol Enzyme Immunoassay (EIA) Kit [Diagnostic Systems Laboratory (DSL), 2004]. Prior to collection, the primary investigator was trained in collection monitoring and saliva analyses.

In addition to cortisol sampling procedures, participants were given an introduction to the study facilities, equipment, and data collection procedures which included: (a) aquatic facility, (b) aquatic-based exercise (i.e., Ai Chi), (c) exercise room, (d) land-based exercise (i.e., treadmill), (e) determining resting heart-rate and sub-maximum heart-rate, and (f) participant journal requirements.

Comparison phase. Over a 7-week period, days 1-21 of the study, the *no treatment* (i.e., saliva collection at home) protocol condition was randomly counterbalanced with *Ai Chi* and the *treadmill* interventions to obtain seven samples (i.e., one saliva collection per session) from each intervention. Cortisol samples were taken prior to and immediately following each intervention session. To control for possible carryover effects, two additional *probe* cortisol samples were collected at 10:30 a.m. and 11:30 a.m. the day following sessions 1 and 11.

Best treatment phase. Multi-treatment interference is the possibility that the combination of treatments together is having a confounding effect on the dependent variable rather than a single treatment measured. To control for multiple treatment interference, an additional three treatment sessions (Tawney & Gast, 1984) were conducted on days 22 through 24 of the study. For each day, salivary cortisol samples were taken from each participant prior to and immediately following the treatment that resulted in the greater reduction of cortisol levels during the comparison phase. According to Tawney and Gast, if the majority of data points from the best treatment phase fall into the range demonstrated during the comparison phase, there is stronger evidence that the research lacks multi-treatment interference and thus researchers have greater confidence that the treatment alone is influencing results and not a cumulative effect of treatments.

Participant and investigator journals. As a control mechanism for the study, participants were asked to keep a personal journal indicating: (a) any subjective changes in overall health throughout the course of the study, (b) daily medication and dietary consumption on cortisol sampling days, (c) total hours of daytime and evening sleep per day on cortisol sampling days, (d) weekly perceived stress scores as indicted on the Perceived Stress Scale (r = .85; Cohen, Kamarack, & Mermelstein, 1983), and (e) overall daily pain scores [ranging from low (1) to high (10)] for cortisol sampling days.

The researcher made entries into a journal on a daily basis to increase the rigor of the study. Entries included the researcher's subjective observation of participant's level of activity engagement during treatment sessions, participant's heart rate during land-based exercise, and any variations in sampling procedures or research settings. The journal was intended to increase understanding of the effects of aquatic and land-based exercise on salivary cortisol levels in women with FMS.

Procedural Reliability

To ensure that the same procedures implemented for each intervention were used consistently across sessions, checklists were used by a trained secondary observer to determine procedural reliability. Three sessions of each intervention were observed so that a minimum of 20% (Tawney & Gast, 1984) of the sessions received procedural reliability checks. To calculate reliability, the number of procedural steps conducted was divided by the number of steps conducted plus the number of steps omitted during the procedure. Overall procedural reliability was 98% for both the treadmill and Ai Chi interventions and 92% for the cortisol sampling procedures indicating procedural reliability exceeded the 85% criteria (Tawney & Gast).

Social validity. Social validation is the act of comparing the relationship between an intervention and the physical and social environments (Wolf, 1978). Social validity is typically collected in applied behavior analysis to determine the acceptability and social importance of research beyond using participants as mere research *objects* (Foster & Marsh, 1999). In this study, a professional panel of therapists, health care providers, professors and participants evaluated social validity through the examination of the study's goals, significance of procedures, selection of interventions, and outcomes (see Table 1). High responses on the social validity questionnaire indicated the panel determined the study procedures acceptable and socially important.

Results

Description of Participants

Four women with a clinical diagnosis of FMS were chosen to participate in the study. Prior to the study, the following demographic information was obtained: age, race, work status, number of children, martial status, number month/years with FMS, and baseline PSS scores. Pseudonyms were used throughout the study to ensure participant confidentiality.

Participant #1 – Sally. Sally was a white 41 y.o. married female with four children who was receiving long-term disability benefits due to FMS. She had been diagnosed with FMS for 12 years. Prior to this study, Sally received treatments ranging from medication and massage therapy to general exercise but reported unsatisfactory results from each of these prior interventions.

Participant #2 – Fran. Fran was a white 58 y.o. divorced female who had four adult children, and also received long-term disability benefits for FMS. She reported being diagnosed with FMS for the last 15 years. Fran also reported participating in pool therapy and taking medication for pain management prior to this study.

Participant #3 – Val. Val was a white 46 y.o. single female with no children, and in addition to freelance writing and her art business, collected disability benefits for FMS. She had been diagnosed with FMS for 15 years. Val had undergone numerous treatment interventions for her FMS which included high doses of narcotic pain medication, daily walking and stretching programs, massage therapy and FMS support groups.

Participant #4 – Rose. Rose was a Middle Eastern 38 y.o. married female who had two school age children, worked part-time as a data auditor for a large company, but was on short-term disability for FMS during the course of the study. She reported being diagnosed with FMS for only 2 months. After only 3 weeks of participating in the study, Rose discontinued treatment sessions due to increased pain and fatigue and lack of time to participate in weekly interventions and data collection.

Salivary Cortisol Results

Saliva was collected from each participant during two separate times: (a) comparison phase, and (b) best treatment phase. During the comparison phase, level stability, trend direction, and percent overlap was determined for each participant. The inclusion of the best treatment phase provided data to determine the presence or absence of multiple treatment interference by comparing the best treatment results with prior intervention results from the comparison phase.

The researcher used the comparison phase to compare the relative effectiveness of each of the three conditions over a 7-week period. An intervention was considered superior when the change in cortisol from pre-intervention to post-intervention indicated a higher positive therapeutic change (i.e., cortisol levels decreased after intervention). Figures 1, 2, and 3 include a therapeutic change line, whereas, data points above the line indicate a therapeutic change (i.e., a decrease in cortisol levels) and data points below indicate a non-therapeutic change, (i.e., an increase in cortisol levels). Additionally, the following secondary analysis indicators were determined during the comparison phase of the study: (a) level stability, (b) trend direction, and (c) percent overlap. For this study, level stability referred to the magnitude of data as indicated by the change in cortisol level over a 7-week period. Trend direction (i.e., slope) was determined for each intervention using the split-middle technique and was characterized as accelerating, decelerating, or zero celeration. Percent overlap (i.e., the number of data points across each intervention within the same range) was used in the comparison phase to determine the relative strength between Ai Chi, treadmill, and no exercise groups. Table 2 provides a summary analysis of all comparisons among the three conditions (treadmill exercise, Ai Chi, and no exercise).

The best treatment phase was conducted to control for multiple treatment interference. The superior intervention during the comparison phase was conducted an additional three times in isolation of the inferior intervention (Tawney & Gast, 1984). During analysis, trend direction and percent overlap were determined to calculate the relative effectiveness of the superior intervention in isolation when compared to the effectiveness of the superior intervention during the comparison phase.

Comparison phase: Participant #1 – Sally. Based on the higher frequency of positive changes in cortisol, walking on a treadmill appeared to be the "best treatment" when compared to Ai Chi and no exercise (see Figure 1 and Table 2). Specifically, the treadmill resulted in a higher frequency of positive cortisol changes on five occasions and a lower frequency of positive cortisol changes on two occasions. Additionally, the treadmill and no exercise interventions demonstrated an accelerating trend (i.e., a positive reduction in cortisol), while the Ai Chi intervention resulted in a decelerating trend (i.e., an increase in cortisol), which also provides evidence that the treadmill intervention was the "best treatment" inter-

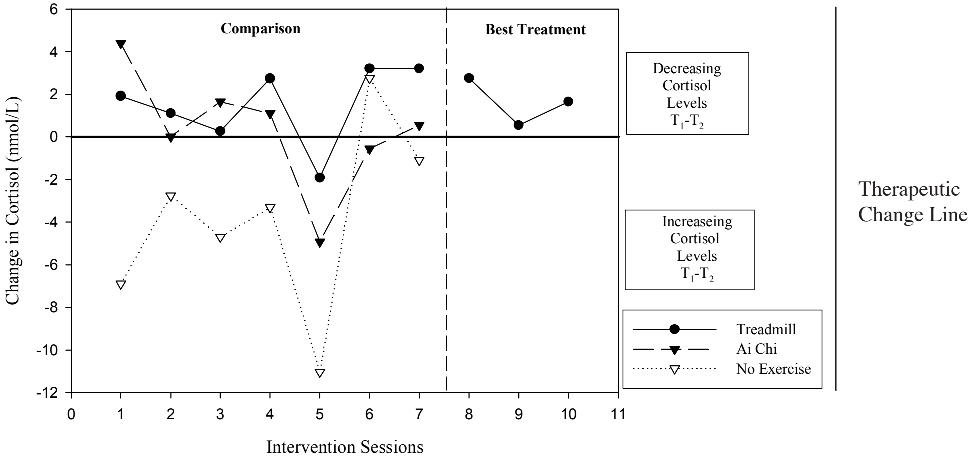

FIGURE 1. CHANGE IN CORTISOL LEVELS DURING TREADMILL, AI CHI, AND NO EXERCISE SESSIONS FOR PARTICIPANT #1 – SALLY.

Note: Data points *above* the "Therapeutic Change Line" indicate values that were in a therapeutic direction (i.e., a reduction in cortisol levels) while data points *below* the line indicate non-therapeutic values (i.e., an increase in cortisol levels)

TABLE 1: SOCIAL VALIDITY OF GOALS, PROCEDURES, INTERVENTIONS, AND OUTCOMES

Goals	Mean Score
Priority of exercising on a consistent and regular basis	9.87
Priority of practicing stress reducing activities on a regular basis	9.32
Procedures	
Appropriateness of Procedures	8.98
Interventions	
Anticipated effectiveness of Ai Chi to reduce physical symptoms of stress	7.87
Anticipated effectiveness of treadmill walking to reduce the physical symptoms of stress	6.89
Outcomes	
Importance of these results for developing effective treatments	7.56
Importance of these results in providing future researcher with information	7.45

Note. Response format was 1 to 10 where 1 = strongly disagree with statement and 10 = strongly agreed with statement.

vention for Sally (see Table 2). Although the treadmill demonstrated superiority during the comparison phase, the percent level stability for each of the three conditions was only 14%, which may suggest the length of the comparison phase was too short to determine any long-term trends in the data. While the percentage of overlap between treadmill and Ai Chi was high (71.4%), the minimal overlap (28.5%) between the treadmill and no exercise provided additional evidence supporting the superiority of the treadmill when compared to no exercise in promoting a positive change in cortisol levels for Sally. Finally, a comparison of Ai Chi and no exercise resulted in Ai Chi being superior to no exercise (71.4 % overlap). Overall, higher frequencies of positive changes in cortisol levels were associated with exercise, with treadmill exercise having the highest degree of positive change (mdn = 1.92nmol/L) with Ai Chi also demonstrating a positive change (mdn = .55nmol/L), when compared to the negative change in cortisol levels of no exercise (mdn = -3.31nmol/L; see Table 2). To further compare the three interventions, the number of data points resulting in a therapeutic change in cortisol levels was examined. A therapeutic change was indicated when a decrease in cortisol levels was noted after the intervention. Figure 1 and Table 2 suggested that both treadmill exercise and Ai Chi resulted in therapeutic change or decreased cortisol levels in 71.4% of sessions (5 out of 7). The no exercise condition was only therapeutic in 14.3% of sessions (or 1 out of 7).

Comparison phase: Participant #2—Fran. Based on the higher frequency of positive changes in cortisol, walking on a treadmill appeared as the "best treatment" when compared to Ai Chi and no exercise (see Figure 2 and Table 2). Specifically, the treadmill resulted in a higher frequency of positive cortisol changes on 4 out of 7 occasions of positive cortisol changes when compared to Ai Chi. When compared to no exercise, treadmill exercise had a higher frequency of positive cortisol changes on 5 out of 7 occasions. Although the treadmill intervention emerged as overall best treatment, secondary analysis of the percent level stability and trend direction during the comparison phase for all three interventions was 28.5% and accelerating (i.e., a therapeutic trend), respectively (see Table 2). Additionally, the high percentage of overlap between treadmill and no exercise (71.4%) and the relatively low percent of overlap between treadmill and Ai Chi (57.1%), may have suggested the length of the comparison phase was too short to effectively determine the overall best treatment for Fran. Furthermore, a comparison of Ai Chi and no exercise resulted in Ai Chi being superior to no exercise (71.4%). Overall, positive therapeutic changes in cortisol levels were associated with all three interventions, with treadmill exercise having the highest degree of positive change (mdn = 3.57nmol/L), followed by no exercise (mdn = 1.93nmol/L) and Ai Chi (mdn = 1.38nmol/L; see Table 2). To further compare the three interventions, the number of data points resulting in a therapeutic change in cortisol levels was also examined. Figure 2 and Table 2 suggest that all three interventions (treadmill exercise, Ai Chi, and no exercise) resulted in therapeutic change or decreased cortisol levels in 71.4% of sessions (5 out of 7).

Comparison phase: Participant #3—Val. Based on the higher frequency of positive changes in cortisol, walking on a treadmill was determined to be the "best treatment" when compared to Ai Chi (see Figure 3 and Table 2); however, upon comparison of the frequency of positive changes in cortisol following the no exercise condition to the positive changes in cortisol after walking on a treadmill, the no exercise condition demonstrated a higher frequency. This finding suggests that the no exercise condition demonstrated an overall "best treatment" when compared across all three intervention protocols. Additionally, the level of stability for both treadmill and Ai Chi was 14% and the no exercise condition exhibited a higher level of stability (28.5%; see Table 2), which may also suggest the length of the comparison phase was too short to effectively determine a clear overall "best treatment". The percentage of overlap for all three interventions during the comparison phase was relatively high which may also indicate the absence of a clear best treatment for Val. When treadmill was compared to Ai Chi and no exercise, the percentages of overlap were 71.4% and 57.1%, respectively. When compared to Ai Chi, the no exercise intervention resulted in an 85.7% overlap. Although both treadmill and no exercise demonstrated accelerating trends during the comparison phase, the median degree of

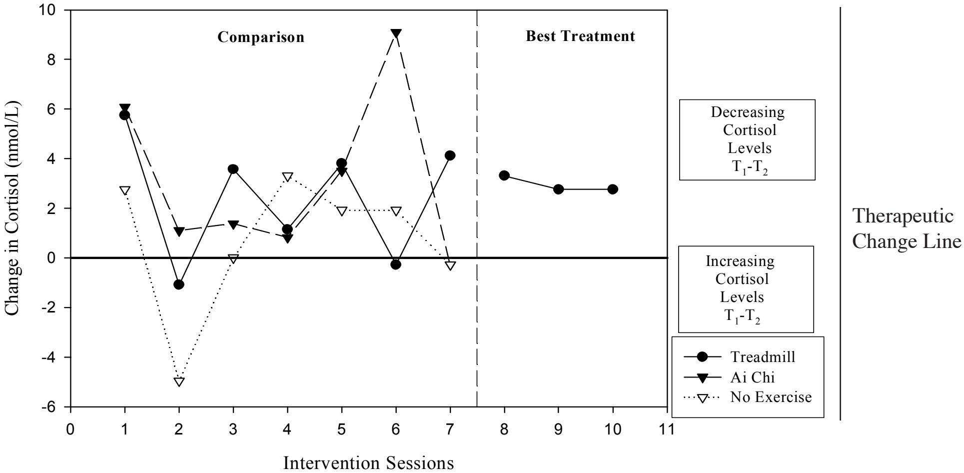

FIGURE 2. CHANGE IN CORTISOL LEVELS DURING TREADMILL, AI CHI, AND NO EXERCISE SESSIONS FOR PARTICIPANT #2 – FRAN.

Note: Data points *above* the "Therapeutic Change Line" indicate values that were in a therapeutic direction (i.e., a reduction in cortisol levels) while data points *below* the line indicate non-therapeutic values (i.e., an increase in cortisol levels)

TABLE 2: ANALYSIS OF CONDITIONS SUMMARY GRID

	Sally (P_1)			Fran (P_2)			Val (P_3)		
Conditions	TM	AC	NE	TM	AC	NE	TM	AC	NE
Degree of change pre-post exercise (nmol/L)	Mdn. 1.92	Mdn. 0.55	Mdn. -3.31	Mdn. 3.57	Mdn. 1.38	Mdn. 1.93	Mdn. 1.09	Mdn. 0.276	Mdn. 0.28
Trend Direction & Effect	/ (+)	\ (-)	/ (+)	/ (+)	/ (+)	/ (+)	/ (+)	\ (-)	/ (+)
Percent Level Stability	14%	14%	14%	28.5%	28.5%	28.5%	14%	14%	28.5%
Percentage Overlap (Best Treat-ment)	(7/7) 100%			(7/7) 100%			(7/7) 100%		
Data Points Above the TCL	5/7 71.4%	5/7 71.4%	1/7 14.2%	5/7 71.4%	5/7 71.4%	5/7 71.4%	3/7 42.9%	4/7 57.1%	5/7 71.4%
Best Treatment	Treadmill			Treadmill			Treadmill		

Key: TM= Treadmill, AC = Ai Chi, NE= No Exercise, TCL = Therapeutic Change Line

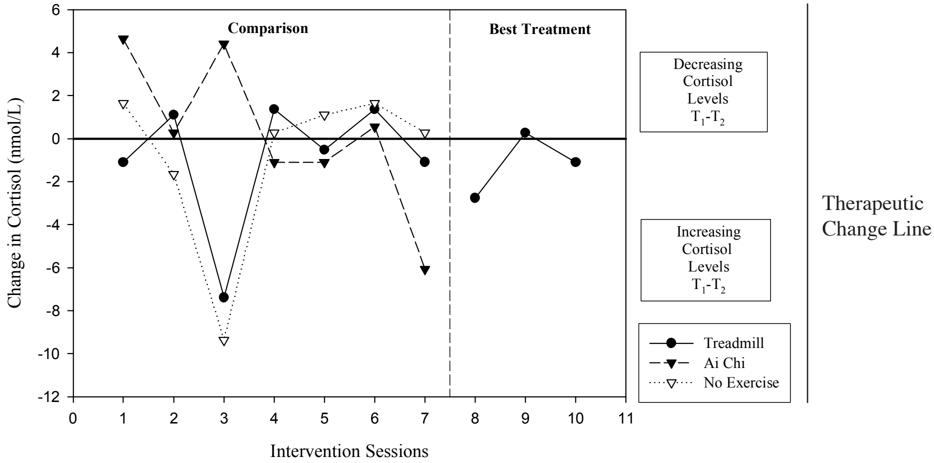

FIGURE 3. CHANGE IN CORTISOL LEVELS DURING TREADMILL, AI CHI, AND NO EXERCISE SESSIONS FOR PARTICIPANT #3 – VAL.

Note: Data points *above* the "Therapeutic Change Line" indicate values that were in a therapeutic direction (i.e., a reduction in cortisol levels) while data points *below* the line indicate non-therapeutic values (i.e., an increase in cortisol levels)

change in cortisol was relatively low. Specifically, the no exercise condition presented the highest degree of positive change in cortisol (mdn = .28nmol/L), while the treadmill intervention demonstrated a negative change in cortisol levels (mdn = -1.09nmol/L; see Table 2). Although Ai Chi demonstrated a decelerating trend in cortisol levels, the degree of positive change in cortisol (mdn = .276nmol/L; see Table 2) was almost equal to the positive change of the no exercise intervention, which may also provide additional evidence to support the lack of a clear best treatment for participant #3 over the 7-week comparison phase of the study. To further compare the three interventions, the number of data points resulting in a therapeutic change in cortisol levels was examined. Figure 3 and Table 2 suggest that the no exercise condition represented the most data points above the therapeutic change line (71.4% or 5 out of 7 sessions), Ai Chi indicated 57.1% (or 4 out of 7 sessions) above the therapeutic change line, and exercise represented a decrease in cortisol 42.7% (or 3 out of 7 sessions).

Based on overall change in median cortisol levels, the slope trend line, and the number of sessions resulting in a decrease cortisol level, treadmill exercise was selected as the most effective intervention in addressing the physiological stress response of women with fibromyalgia. To further analyze the treadmill exercise intervention, a three session best treatment phase was implemented to evaluate the presence of multi-treatment interference and consistency of effects (Tawney & Gast, 1984).

Best treatment phase: Participant #1—Sally. During the best treatment phase, the treadmill exercise displayed a decelerating trend and presented with a percentage of overlap of 100% (i.e., 7 out of 7 data points; see Table 2) with the range of the treadmill data points in the comparison phase (range = -1.92 nmol/L – 3.2 nmol/L) completely overlapping the range of data points in the best treatment phase (range = .55nmol/L – 2.76nmol/L), indicating the absence of multiple treatment interference (see Figure 1). Thus, when the treadmill intervention was conducted separate from the Ai Chi intervention, the treadmill demonstrated superior performance in reducing salivary cortisol levels in Sally.

Best treatment phase: Participant #2 – Fran. During the best treatment phase, treadmill exercise demonstrated a decelerating trend (i.e., increasing cortisol level) and showed a percentage of overlap of 100% (7 out of 7 data points; see Table 2)with the range of the treadmill data points in the comparison phase (range = -1.09nmol/L – 5.75nmol/L) completely overlapping the range of data points in the best treatment phase (range = 2.76nmol/L – 3.31nmol/L), indicating the absence of multiple treatment interference (see Figure 2).

Best treatment phase: Participant #3 – Val. During the best treatment phase, the treadmill exercise displayed an accelerating trend (i.e., decreasing cortisol levels) and presented with a percentage of overlap of 100% (see Table 2) with the range of the treadmill data points in the comparison phase (range = -7.39nmol/L – 1.37nmol/L) completely overlapping the data points in the best treatment phase (range = -2.76nmol/L - .276nmol/L), indicating the absence of multiple treatment interference (see Figure 3).

Discussion

The purpose of this study was to examine the influence of aquatic and land-based exercise on the physiological stress response of women with FMS. Based on the higher frequency of positive changes in cortisol as compared to changes of cortisol concentrations during no exercise days, both treadmill walking and Ai Chi demonstrated a positive influence in reducing salivary cortisol in 2 of the 3 participants. Subsequently, when comparing treadmill walking and Ai Chi, treadmill walking was superior in all 3 participants.

By examining the cortisol response to exercise when compared to days without exercise, the results of this study suggested that treadmill exercise conducted at moderate to low intensities had a positive influence in reducing the salivary cortisol concentrations of these women with FMS, thus possibly leading to a reduction in their perceived or emotional physiological stress response. Although there has been limited research comparing the effects of different exercise modalities on the salivary cortisol levels of individuals with FMS, Gursel et al. (2001) observed significantly lower levels of cortisol after 30-minutes of moderate exercise when compared to their initial levels of cortisol, which supports this study's results. In participant's #1 and #2, both treadmill and Ai Chi demonstrated a positive influence on reducing salivary cortisol levels when compared to the no exercise sessions. Both of these participants continually reported high levels of perceived stress as it pertained to their FMS, thus by participating in the exercise interventions their physiological response to stress may have been suppressed (Borer, 2003).

The superiority of the treadmill intervention may also be explained by the social interaction of the participants while they were exercising. The formation of a social support system though a "shared companionship" in leisure activities may provide a buffer to those experiencing stressful situations (Coleman & Iso-Ahola, 1993). For example, after the completion of one treadmill session during the study, participant #1 stated "We are already done. That was fast. We talked the entire time!" (February 16, 2005). All 3 participants interacted with one another and with the researcher during the treadmill sessions, whereas, during the Ai Chi sessions, participants were concentrating on deep breathing, coordinating movements, maintaining balance, and learning a new skill, which may have increased their stress levels, thus affecting their cortisol levels. This would support research conducted by Schoofs, Bambini, Ronning, Bielak, and Woehl (2004) on the impact of social support networks on the quality of life of individuals with FMS. Additionally, Schoofs et al. found that individuals with FMS lacked high levels of social support, which according to background information on each participant obtained by the researcher, supports this conclusion. Subsequently, Coleman (1993) suggested the social aspects of shared leisure activities may be equally beneficial to promoting physical as well as mental health.

Although treadmill was superior, Ai Chi also demonstrated a positive effect in reducing salivary cortisol in 2 out of 3 participants. One explanation may be due to the therapeutic effects of warm water on the symptoms of FMS (Ogden, 2000). All 3 participants reported in their journals "feeling more relaxed and experiencing less pain and stiffness after Ai Chi sessions" (Participant #2, March 28, 2005). Due to the decrease in the severity of symptoms during Ai Chi, individual physiological stress response may also have been suppressed.

Although results of this study supported research suggesting physical activity decreases cortisol concentrations post intervention (Gursel et al., 2001; Jin, 1989; Pawlow & Jones, 2002), the present study differed from previous research by incorporating a longer duration of exercise (i.e., 7-weeks), repeated measures of cortisol collection over 7 weeks as opposed to one-time sampling (Davies & Few, 1973), and the comparison of an aquatic and land-based exercise program conducted simultaneously. While these results offer additional information on the effects of exercise on the cortisol levels of women with FMS, additional research is needed to determine if land exercise and aquatic relaxation interventions have a significant effect in reducing salivary cortisol concentration in this population as well as other similar diagnostic groups.

Several limitations associated with this study restrict the generalization of results and interpretation of findings. First, while all 3 participant's cortisol levels responded positively to aquatic and land-based exercise, generalizing results beyond the 3 participants in this study is difficult due to the small sample size, the convenience sampling technique, and solely focusing on female research participant's demographics. Secondly, the researcher attempted to control for the time of day of meals and other food and drink consumption on cortisol testing days, but due to participants' changes in daily routines, a portion of the results may have been compromised. Third, every attempt to manage medications effecting salivary cortisol was made, but due to the nature of FMS and participant's daily fluctuating pain and the need for pain medications, participant's medications may have influenced the results. Fourth, because of limited time and funding, the series of results may have been too short to determine long-term trends in the data. Although the treadmill was considered the "best treatment" for all three individuals, a longer duration of the study may have provided further support or a contradiction of these results.

Recommendations for Research

Exercise has been viewed to reduce the severity of symptoms in individuals with FMS (Buckelew et al., 1998; Redondo et al., 2004). Additionally, exercise has also been linked to the reduction in cortisol levels in healthy adults (Davies & Few, 1973), as well as, adults with FMS (Gursel et al., 2001). Results of this study further support the idea that exercise has a positive influence in reducing cortisol levels in individuals with FMS; however, findings in this study highlight the need for future research in several areas.

One possibility for future research may include examining the FMS population's response to long-term exercise. Individuals with FMS have a history of poor exercise adherence (Oliver & Cronan, 2002) and many exercise-based interventions take 3-4 months before many individuals with FMS notice therapeutic effects (Winfield, 2004); therefore, examining cortisol response for short-periods may only provide a snapshot of the overall effectiveness of exercise on reducing cortisol concentrations. Additionally, by increasing the number of participants and expanding the population demographics, a more representative sample of the FMS population may provide future researchers with a better understanding of how exercise and cortisol response impact those individuals who continually battle FMS. Another consideration for future research is the effect of other specific interventions on cortisol and other stress responses in the FMS population and other similar diagnostic groups. Several interventions have been suggested for treating the symptoms and manifestations of FMS, which range from relaxation techniques (Pawlow & Jones, 2002), exercise programs targeting strengthening and stretching (Martin et al., 1996), aerobic exercise (Wigers, Stiles, & Vogel 1996), and aquatic therapy (Mannerkorpi et al., 2000; Brasure et al., 2001). Individuals with FMS exhibited poor exercise adherence, which may be due to increased pain and stiffness after exercising (Oliver & Cronan, 2002), exercising beyond a low to moderate level (Martin et al., 1996), or failure to discover exercise programs of personal interest which may help elevate symptoms (Saltskar Jentoft, Grimstvedt, Valvik, & Mengshoel, 2001). Thus, additional research should be conducted to determine the overall effects of various exercise interventions, both aquatic and land-based, on the physiological stress response of the FMS population.

Finally, although this study did not examine the effect of social support on individuals with FMS, the participant and researcher journals suggested the social interaction between the participants may have influenced their selfperceived stress. Historically, individuals with FMS demonstrate an inadequate social support system (White et al., 2001); however, those individuals with FMS who possess a strong social support system report living a better quality of life (Schoofs et al., 2004). While several studies have examined the influence of social support on individuals with FMS (Dailey, Bishop, Russell, & Fletcher, 1990; Schoofs et al.), the literature lacks specific research investigating the impact of social support on the physiological stress response. As such, examining the impact of social support on the physiological stress response of individuals with FMS may provide researchers and other healthcare providers with alternative programming strategies for treating the FMS syndrome.

Implications for Practice

Results of this study suggested land and aquatic-based exercise had a positive influence in reducing cortisol levels in women with FMS. Such findings provide implications for practitioners such as therapeutic recreation specialists (TRS) and other allied healthcare providers who work with individuals with FMS and other chronic pain related disorders. The following is a discussion of practical implications for TRS and other professionals working with individuals with FMS that include: (a) building social networks through recreation opportunities and (b) promoting exercise adherence to combat FMS symptoms.

The benefits of social support on the quality of life for individuals battling chronic illness or injury have been well documented (Bedini & Henderson, 1993). Social support has specifically been shown to improve the life of individuals with FMS (Daily et al., 1990); therefore, the TRS may want to consider conducting an evaluation of social support of individuals with FMS. Factors to consider may include degree of social inclusion, characteristics of their social network, and quality of social support. Another avenue for improving social networks of individuals with FMS incorporates leisure skill development. More specifically, the TRS should consider providing recreation opportunities that target this population, such as aquatic classes or low impact exercise classes. Finally, individuals with FMS describe their major source of social support as coming from their family and/or spouse (Schoofs et al., 2004). Thus, it makes sense that recreation therapists examine the potential of incorporating the family into any course of treatment.

Several studies have indicated individuals with FMS exhibited poor exercise adherence (Mannerkorpi & Iversen, 2003; Wigers et al., 1996). Consequently, individuals with FMS who report following a routine exercise regime, exhibited longer sleep patterns (Schaefer, 2003), fewer episodes of intense pain (Meyer & Lemley, 2000), lower resting heart-rates, a decrease in perceived stress, and an improvement in overall health and well-being (Oliver & Cronan, 2002). In response, the TRS should examine potential exercise programs that would promote adherence.

One such technique for improving exercise adherence may lie in the intensity and nature of programmed exercises itself. First, the TRS should provide exercise programs which incorporate low to moderate exercise. Low to moderate exercise programs allow individuals with FMS to participate in treatments or other recreation opportunities that are tailored toward their physical level of tolerance (Geel & Robergs, 2002). Second, Oliver and Cronan (2002) suggested individuals with FMS experience a higher exercise self-efficacy when exercising people of similar physical ability, therefore, suggesting the TRS should consider providing social opportunities for exercise, such as exercise groups and community classes. Finally, several exercise programs and treatments have been prescribed for individuals with FMS (Mannerkorpi & Iversen, 2003). The TRS should incorporate various treatment methods when treating individuals with FMS, which may ultimately help to promote adherence to exercise by using innovative techniques such as aquatic therapy, strength training, stretching, yoga, walking, sports, and dance.

Conclusion

Results of this study suggested that both aquatic and land-based exercise had a positive influence in reducing salivary cortisol in women with FMS; however, these results are only applicable to the participant's in this study. The relationship between physiological stress and FMS symptomology is complex and future research is required to further understand the influence of specific treatment modalities on individuals with FMS. This study provides a basis for exploring the relationships between stress, FMS symptoms, and specific courses of treatment for individuals with FMS.

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