PHYSICAL ACTIVITY IN FIBROMYALGIA: ACCELEROMETER VERSUS SELF-REPORT

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ABSTRACT

Fibromyalgia is a multisystem condition that impacts a range of functionality. One function that is particularly impacted is physical movement due to pain. This study examined the relationship between objectively measured and self-reported levels of physical activity (light, moderate, vigorous) among individuals with fibromyalgia. The total sample included 35 participants, 20 participants had Fibromyalgia and 15 participants were in the control group. The method used to collect objective physical activity was accelerometry. Tests used for collecting subjective reports of physical activity included the Rapid Assessment of Physical Activity (RAPA), and the Sedentary Behavior Questionnaire (SBQ). Based on previous research, we hypothesized that the correlation between objective and subjective measures of physical activity would be weaker among participants with fibromyalgia comparted to control participants. The implications of this study were that subjective and objective reports of PA were weaker among those with FM compared to control participants. However, among the sample population of older adults with FM, the difference between groups was not significantly different.

Keywords: Physical Activity, Sedentary Behavior, Validation Studies, Chronic Pain

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CHAPTER 1

INTRODUCTION

Fibromyalgia as a Condition

In the United States, it is estimated that chronic pain affects about 25.3 million people, or about 11.2% of the population (Dowell, Haegerich, & Chou, 2016; Nahin, 2015). Fox (2012) reports that more people are impacted by chronic pain than by heart disease, diabetes, and cancer combined, and world-wide, it is estimated that chronic pain affects roughly 20% of the adult population. Chronic pain is considered one of the most costly and disabling health conditions among industrialized nations (Harstall & Ospina, 2003). Chronic pain involves the persistence of musculoskeletal pain of the head, back, abdomen, and upper and lower extremities lasting for three or more months, in instances where other conditions have been ruled out (Chung, & Wong, 2007). In the past, chronic pain was considered idiopathic due to the absence of a known cause, and upon evaluation of the sensitive muscle tissue, there was a lack of notable damage or inflammation (Clauw, 2009).

Research in some populations has suggested that most individuals experiencing chronic pain do so at more than one location in the body, a condition known as chronic widespread pain (CWP) (Raftery et al., 2011). Globally, approximately four percent of individuals with chronic pain have additionally reported CWP (Lindell, Bergman, Petersson, Jacobsson, & Herrström, 2000). The condition of CWP involves chronic musculoskeletal pain experienced on both the left and right sides of the body, above and below the waist, as well as parts of the axial skeleton for three or more consecutive months (Shipley, 2010).

Among individuals diagnosed with CWP, there is a large subgroup that experiences CWP in addition to other symptoms. Individuals in this subgroup present with a condition called Fibromyalgia (FM). Fibromyalgia is estimated to impact 3.94 million Americans, about 1.2% to 1.75% of the population (Jones et al., 2015; Walitt, Nahin, Katz, Bergman, & Wolfe, 2015). New diagnostic criteria established in 2010, include symptoms (beyond chronic pain) experienced in FM. These further indicators of FM severity include fatigue, cognitive difficulties, unrefreshed sleep, and numerous somatic symptoms such as headache, weakness, bowel problems, nausea, dizziness, numbness/tingling, and hair loss (Jahan, Nanji, Qidwai, & Qasim, 2012; Shipley, 2010; Queiroz, 2013; Wolfe et al., 2010).

Diagnosing Fibromyalgia

Previously, FM diagnoses were made when an individual experienced CWP for three or more months in addition to having 11 of 18 designated tender points on the body, after a physician ruled out any other possible causes of the widespread pain (Shipley, 2010). Designated tender points were established to help physicians diagnose CWP's presence on the body (i.e., on both sides of the body, above and below the waist, and along the axial line). Over time, it has been noted that this methodology of diagnosis incited confusion about the pathophysiology of FM. The provision of tender points inadvertently implied that the pain was localized to the areas used as reference points (Clauw, 2003).

Research from Kravitz and Katz (2015) suggested that FM is a multisystem disorder of polysymptomatic complexity which manifests beyond the musculoskeletal system, extending impact to cognitive functions. Further, FM has been connected to central nervous system over-sensitization (Nielsen & Henriksson, 2007). Hyperalgesia is an enhanced pain response to typical pain inducing stimuli relative to the various tender points on the body (Ablin et al., 2012; Clauw, 2009; Neumann & Buskila, 2003). Clauw (2009) reports allodynia as a pain response to typically non-painful stimuli and suggests that FM is a condition involving a fundamental issue with sensory processing rather than localized body pain. While the etiology of CWP and FM are not clear, the current literature suggests that both are syndromes involving hyper-excitability of the central and peripheral nervous systems wherein there are altered pain perceptions, and shifts in the presumed function of pain receptors (Shipley, 2010). It is not uncommon for blood tests, x-rays, specialized scans and muscle biopsies to be performed when ruling out other diagnoses for those with FM (Jahan et al., 2012).

The original 1990 American College of Rheumatology (ACR) diagnostic criteria of FM was reported to have ceiling effects, which limited the range of individuals acknowledged to have FM by setting high minimum requirements of tender points (Wolfe et al., 2010). Clauw and Crofford (2003) report that the older ACR standards include 20% of individuals with CWP in the classification of FM, while the remaining 80% of individuals with CWP met less than 11 of the 18 tender points, and were non-eligible. Over time, FM has come to be viewed on a spectrum. Current diagnostic criteria for FM established in 2010 replaced the tender points and pressure tests with two new scales. The scales include the Wide Spread Pain Index and the Symptom Severity scale (Clauw & Crofford, 2003).

Wolfe et al. (2010) reported that if there is sufficient chronic widespread body pain present, along with significantly high FM symptom severity (in addition to ruling out other possible diagnoses), FM can be diagnosed. Furthermore, FM is beyond an elevated widespread pain score and should be assessed in a more comprehensive manner. Using the Symptom Severity Scale and Wide Spread Pain Index (created by the ACR in 2010), two new means of FM classification have been established. Diagnostic classification maintains similarities with the previous 1990 ACR criteria, with the exception of a new emphasis on number and severity of common FM symptoms such as fatigue, cognitive problems, unrefreshed sleep, and numerous somatic symptoms. Fibromyalgia classification accepts Wide Spread Pain Index scores that are ≥ 7 in conjunction with a Symptom Severity score ≥ 5, or a Wide Spread Pain Index score between 3 and 6 in conjunction with a Symptom Severity score ≥ 9 (Queiroz, 2013; Wolfe et al., 2010).

Sedentary Behavior

Human activity can be defined in many different ways. It is possible to be sedentary, physically inactive, as well as physically active. It is important to note that physical activity and physical inactivity are mutually exclusive. While sedentary behavior and physical activity category (active and inactive) are not mutually exclusive. This means it is possible to be a sedentary person and be physically active, in the case that someone works a desk job and sits the majority of the day, but accrues enough activity at outside of work during a week. Further, a sedentary person can be physically inactive if high enough levels of activity are not accrued during a week. Sedentary behavior is best characterized as when the body is sitting or lying down while not engaged in sleep (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). Sedentary behavior is typically defined as low energy exertion of less than 1.5 metabolic equivalent of energy METS (Owen, Healy, Matthews, & Dunstan, 2010). A metabolic equivalent of a task (MET) is a physiological measure expressing the energy cost (or calories cost) of physical activities (Hughes, 2012). Observable sedentary behavior may also include standing from a sitting position, or taking a step (Hamilton et al., 2008). Sedentary bouts are periods of time spent in sedentary type behaviors that are uninterrupted. Sedentary behavior can be prolonged (≥ 30 minutes) or non-prolonged (< 30 minutes) (Honda, et al., 2016).

Physical Activity

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that results in energy expenditure and may be classified as light, moderate, vigorous, as well as a combination of moderate and vigorous intensity, based on energy expenditure (Caspersen, Powell, & Christenson, 1985). Physical activity requiring energy expenditure between 1.9 and 2.9 METS is classified as light PA (Owen et al., 2010). The light PA range is defined primarily as standing and can include gentle ambulation as well as a host of activities of daily living. Moderate and vigorous PA requires greater energy expenditure, generally falling between 4 and 6 METS (moderate) and > 6 METS (vigorous), although this may vary to a small degree depending upon an individual's level of physical fitness (Garber et al., 2011).

A simple test to roughly distinguish between moderate and vigorous PA is called the Talk test. When engaging in moderate level PA, generally an individual will be able to speak without undue shortness of breath but not sing during the activity, while during vigorous level PA, individuals are unable to say more than a few words without pausing to take a breath (Center for Disease Control and Prevention, 2015). According to the Center for Disease Control and Prevention (CDC) moderate PA can include, but is not limited to: engaging in water aerobics, brisk walking, bicycling slower than 10 miles per hour, or general gardening. The CDC lists vigorous PA examples such as: running, swimming laps, aerobic dancing, bicycling over 10 miles per hour, or uphill climbing with a heavy item for ≥ 10 minutes at a time (Center for Disease Control and Prevention, 2015; Garber et al., 2011). Adults are considered physically active if they engage in either moderate-intensity PA for ≥ 150 minutes per week, ≥ 75 minutes of vigorous-intensity PA per week, or an equivalent combination of moderate-and vigorous-intensity PA per week, where bouts of PA are in 10 minute episodes (Office of Disease Prevention and Health Promotion, 2017). Adults are considered inactive if they do not meet the minimum of 150 minutes of moderate or vigorous PA in a week (Haskell et al., 2007).

Multiple factors are known to impact PA among humans. Buchan, Ollis, Thomas, and Baker (2012) report the socio-ecological model of PA as particularly effective in understanding the variation and complexity of human PA. Physical activity naturally varies and research pertaining to PA uses several theoretical models to address factors of PA engagement (Buchan, Ollis, Thomas & Baker, 2012). The socio-ecological model of PA encompasses external factors that impact PA relating to the: the individual, social environment, physical environment, and factors of policy. Individual factors can be reduced to demographic and biological constructs such as age, gender, level of education, employment status, physical abilities or disabilities, as well as psychological constructs including self-efficacy, knowledge, attitudes, and beliefs (Giles-Corti, Timperio, Bull & Pikora, 2005). The current literature on determinants of PA suggest that males tend to engage in more PA than females, and that younger individuals engage in more PA than their elders (Fan, 2014; Troiano et al., 2008). Social-environmental factors are typically considered to be the presence of support or influence toward PA by family members, a partner, or peers, in addition to community organizations. Additional social means of benefit to PA are community norms, cultural background, and the influence of health professionals within the community (Essiet, Baharom, Shahar, & Uzochukwu, 2017; Giles-Corti, Timperio, Bull & Pikora, 2005). Physical environmental factors involve weather, geography, density of housing, availability of parks, playgrounds, facilities for sports, and gymnasiums. The safety of the physical environment (local crime rates and traffic speed) may encourage or discourage PA engagement as well (Giles-Corti, Timperio, Bull & Pikora, 2005). Fan (2014) suggests that where an individual lives (urban, micropolitan, metropolitan or rural environments) can impact level of PA. Policy impacts PA in many ways too; such as urban planning, active transport planning, education policies, workplace policies, as well as overall unique environmental policies, funding, and health policy interest (Giles-Corti, Timperio, Bull & Pikora, 2005).

Physical activity among individuals with FM has not been evaluated extensively with the simultaneous use of subjective and objective measures (McLoughlin, Colbert, Stegner, Cook, 2011). The use of subjective and objective methods to quantify PA reflects a more accurate depiction of overall activity. Acknowledgment of the importance for accurate PA measurement among those with FM has grown with the literature that suggest lower PA levels are linked to other health concerns (Segura-Jiménez et al., 2015).

Lack of PA is associated with numerous health conditions, including depression and anxiety, immune system dysfunction, heart disease, decreased bone health, cancer incidence, sexual dysfunction, and obesity (Gomes & Florida-James, 2016; Landro, 2010; Miles, 2007; Paluska & Schwenk, 2000; Penedo & Dahn, 2005; Soares-Miranda, Siscovick, Psaty, Longstreth & Mozaffarian, 2016). As chronic pain is common among those with FM and tends to create a cycle of inactivity due to increased feelings of pain, this population is at a greater risk for declines in PA and health impairment (Nijs et al., 2013).

Subjective Measurement in Individuals with Fibromyalgia

A key diagnostic symptom of FM previously noted is cognitive difficulty. The co-occurrence of cognitive difficulties within FM has become important enough to be included in the new ACR diagnostic criteria. Many recent studies have found cognitive difficulties in memory, attention, and information processing speed among individuals with FM (Bar-On Kalfon, Gal, Shorer, & Ablin, 2016; Glass, 2009). Kravitz and Katz (2015) have reported that those diagnosed with FM have been found to underperform on scales that involve semantic memory, executive functioning, attention, and working memory. Specifically, semantic memory difficulties of those diagnosed with FM can impact many types of self-report (subjective) measures.

Self-report measures have been an important component in evaluating overall health, psychological traits, and PA among those with FM. Subjective measures have provided valuable perceptions about quality of life and physical function of individuals with CWP that further enhance treatment. There are limitations to subjective reports, however, and within self-report research it has been noted on several occasions that more reliable measures, such as objective measures should accompany subjective assessment (Sallis & Saelens, 2000). Objective measures refer to standardized means of measurement that collect information about a participant based on performance, thus reducing bias in the data. Past research examining the agreement between subjective and objective reports from individuals with FM involving treatment adherence, cognitive function, and sleep quality did not always demonstrate high levels of concurrence (Etnier et al., 2009; Gelonch, Garolera, Valls, Rosselló & Pifarré, 2016).

Subjective and objective assessments of PA in individuals with FM have shown greater concurrence in previous research (Kop et al., 2005; Korszun et al., 2002). In a nationally-representative health survey of 6,329 individuals, Troiano et al. (2008) reported moderate associations between the self-reported and objective assessments of PA in respective gender and age groups. Other research suggests that among subsets of the population there is a lack of consistency among self-report and objective assessments of PA (Ekelund et al., 2006; Hagströmer, Oja, & Sjöström, 2007). Prince et al. (2008) speculated that the use of different self-report questionnaires can create discrepancies between subjective and objective reports of PA. The metric used by one assessment is not necessarily consistent with the metric of alternative measures. However, self-report instruments of PA provide information about the context of PA whereas a limitation of most objective measures, including accelerometry, is that they cannot provide such contextual information. In a study comparing subjective and objective assessments of PA at moderate and vigorous levels, adults and youth were found to have different patterns of PA engagement (LeBlanc & Janssen, 2010). LeBlanc and Janssen noted that while adults engage in PA during distinguishable bouts throughout a day (during a workout, travel time, or housework), youth tend to engage in PA sporadically over the course of a day. The sporadic nature of accumulated PA among youth complicates recollection of total activity because bouts may vary in length. The LeBlanc and Janssen study indicates that questions about duration of time in PA were more appropriate for adult populations, while the youth appeared underactive or overactive in reports. The effectiveness of PA assessment in measuring activity among a tested population is important (Sylvia, Bernstein, Hubbard, Keating & Anderson, 2014). Variability between subjective and objective reports of PA among individuals with FM also creates uncertainty in measurement reliability from past research (McLoughlin, 2011).

Objective Measurement of Physical Activity

Current PA research has utilized accelerometers as an objective measurement tool to distinguish between levels of PA. Accelerometers work by detecting acceleration from physical movement of the body, which is converted to absolute activity count values for a predetermined time period (seconds or minutes) by accompanying accelerometer software (Fitzhugh, 2015). The count is linearly related to the intensity of an individual's PA during the specified duration of time (Tech. Variable GT3X). Device-specific accelerometer count cut-points have been established allowing for the minute by minute (or second by second) classification of movement as sedentary, low, moderate, and vigorous intensity activity (Fitzhugh, 2015). This allows for the objective assessment of PA frequency, duration, intensity and activity patterns, as well as sedentary behaviors. Although accelerometer counts are based on proprietary algorithms and are device-specific, cut-points have been established for several sub-populations, including children, older adults, and women, allowing researchers to choose appropriate cut-points for their study populations and facilitating the comparison of findings between studies (Actigraph, 2017). To our knowledge, cut-points specific to individuals with FM have not yet been established, thus, most studies in this area have used non-specific adult population cut-points to encompass the variation of PA (Freedson, Melanson, & Sirard, 1998).

<u>Physical Inactivity among Adults with and without Fibromyalgia</u>

The prevalence of physical inactivity among adults can range considerably (between 17% and 43% depending on the country), indicating that some regions have more physical inactivity than others (Althoff, Hicks, King, Delp, & Leskovec, 2017; Hallal et al., 2012). As previously discussed with the socio-ecological model, many factors impact PA and inactivity among adults (Buchan, Ollis, Thomas, and Baker, 2012). Fibromyalgia is an individual factor that impacts physical inactivity, as chronic pain has been reported to be one of the most disabling conditions among industrial countries (Harstall & Ospina, 2003). According to Segura-Jiménez et al. (2015) in a study of 433 female subjects with FM and 196 female control subjects from southern Spain, females with FM spent longer amounts of time than the control subjects engaging in sedentary behaviors (minutes/day estimated mean, FM 279 (270-288); Non-FM 247 (233-260); $p < .001$), took fewer steps per day (no./day estimated mean, FM 7, 468 (718-7,748); Non-FM 9,349 (8,928-9,769); $p < .001$). Participants with FM also engaged less in PA of light (minutes per day estimated mean, FM 425 (417-433); Non-FM 446 (434-457); $p < .05$), moderate (minutes per day estimated mean, FM 45 (42-48); Non-FM 62 (58-67); $p <.05$), and moderate-to-vigorous (minutes per day estimated mean, FM 45 (42-48); Non-FM 64 (59-68); $p <.05$) intensities compared to controls on every day of the week. Segura- Jimenez et al. further discussed the risk that is associated with time spent in sedentary behaviors, as they suspect that the length of a sedentary bout could also be related to worsening health conditions.

Previous research surveying the PA of FM patients has indicated somewhat conflicting results. Two studies conducted with wrist mounted accelerometers have reported that those with FM had comparable PA to healthy controls (Kop et al., 2005; Korszun et al., 2002). Kop (2005) demonstrated that FM participants were similar to controls at average activity levels (mean ± SEM, FM 1,525 ± 63; Non-FM 1,602 ± 89). Korszun (2002) reported similar daytime activity levels among participants with FM and controls (mean ± S.E., FM 191.44 ± 8.53; Non-FM 192.38 ± 4.27). Alternatively, McLoughlin, Colbert, Stegner, and Cook (2011) reported that FM participants overall had significantly lower PA compared to controls. The 26 FM participant's subjective and objective ratings at any level of PA associations were low and weak (light, $r = 0.17$, $p > .05$; moderate, $r = -0.04$, $p > .05$; vigorous, $\rho = 0.28$, $p > .05$), whereas the 26 controls were found to have significant correlations between subjective and objective ratings of PA at all levels with stronger relationships (light, $r = 0.41$, $p < .05$; moderate, $r = 0.51$, $p < .01$; vigorous, $\rho = 0.41$, $p < .05$). McLoughlin et al. noted that their accelerometer placement at the hip may be partially responsible for the difference in findings. Hip placement of the accelerometer provides a location on the trunk of the body close to the center of gravity, which increases accuracy of measurement of body movement (Trost, McIver, & Pate, 2005; Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005).

A few factors that impact the findings of McLoughlin (2011) are subjective and objective tests selected for PA measurement. The McLoughlin study included two subjective PA measures, the International Physical Activity Questionnaire (IPAQ) long form and the Fibromyalgia Impact Questionnaire (FIQ). The IPAQ long form is additionally reported to have less sensitivity to measuring low levels of PA (Ekelund et al., 2006). This is a concern as individuals with FM tend to exhibit lower levels of PA, similar to older adults, who also average less PA (HagstrÖmer et al., 2007; Kop et al., 2005; Segura-Jiménez et al., 2015). The concern with selecting subjective tests for assessing a subpopulation is that questionnaires may lack the range of response items necessary to accurately reflect group characteristics. Subjective questionnaires administered in this way provide circumstances for forced responses, which can produce misleading results. For instance, if an individual with FM engages in PA in short bursts, a measure that assesses activity in bouts of ≥10 minute increments may not document this individual's activity.

In the US, individuals diagnosed with FM are high users of healthcare and have been found to have annual healthcare costs that are up to three times higher than the average American (Berger, Dukes, Martin, Edelsberg, & Oster, 2007; Lacasse, Bourgault, & Choinière, 2016). In the interest of establishing more efficient treatment outcomes, it has become important for medical professionals to understand whether there is variability in the manner of self-reported PA provided by those with FM. It is important to expand on previous research that evaluates the association between self-report and PA among those with FM to establish more accurate estimates of PA and sedentary behavior in this population. Improved estimates of PA and sedentary behavior common among the population further improve the quality of public health interventions provided, which in turn impact PA and sedentary behavior through more effective chronic disease management strategies.

The present study evaluated the variability of subjective and objective responses about PA levels among individuals with FM compared to healthy controls. Our first hypothesis is that the relationship between subjective and objective ratings at all PA levels would be weaker among FM participants compared to healthy controls. Our second hypothesis is there would be a weak positive relationship between self-reported and objectively measured sedentary behavior in individuals with FM.

CHAPTER 2

METHODS

This study is a secondary, cross-sectional analysis of data collected in the 2016 (5^{th}) wave of a larger longitudinal study research of functional ability among adults 50+ with and without fibromyalgia (Jones et al., 2015). The fifth wave of this study included 71 older adults, 38 with FM, and 33 without FM. The participants for the study were recruited from the Fibromyalgia Research and Education Center at California State University Fullerton, by telephone calls and emails. Participants with FM were required to bring signed documentation from a rheumatologist confirming diagnosis of FM (as per the 1990 American College of Rheumatology criteria). Screening for inclusion and exclusion was conducted via telephone calls. Prior to the study, participants were mailed questionnaires to complete an informed consent form. The day preceding assessments participants received a phone call reminder and were additionally asked to wear comfortable clothing and shoes, refrain from heavy exertion, substance use, and to take normal medications for the 24 hour period preceding the appointment time. A reminder telephone call additionally requested participants have a light meal about an hour before the appointment, and that those with FM reschedule their appointment in the event that they experienced onset of severe symptoms.

Participants

The data for the present study were drawn from a sub sample of volunteers from the 2016 wave who consented to objective monitoring of their PA over a one week period of time. In total, the study sample included 35 participants (80% Female, 20% Male) aged 50 years and older with and without FM (57.1% FM; 42.9% non-FM). Within the FM group there were 19 females and one male, and within the control group there were nine females and six males.

Materials

Subjective Measures of Physical Activity

Rapid assessment of physical activity. The Rapid Assessment of Physical Activity (RAPA) is a questionnaire that assesses engagement in aerobic PA separately from strength and flexibility activities (Follick, 2015). For the purposes of the present study, only the aerobic activity section of the instrument was considered. The RAPA examines PA participation over the past month, and references the Talk test to aid participants in distinguishing between PA intensity levels (light, moderate, and vigorous) in completing the questionnaire (Follick, 2015). The aerobic activity section of the RAPA includes seven questions asking participants to confirm their participation (yes/no) in physical activities of differing intensities. Sample questions include "I do moderate physical activities every week, but less than 30 minutes a day or 5 days a week" and "I do vigorous physical activities every week, but less than 20 minutes a day or 3 days a week". The RAPA is scored from 1 to 7, with increasing scores corresponding to higher reported PA. Scores below six are considered a suboptimal PA level (see Appendix A). This scale was normalized on adults older than 50 years of age and has a high sensitivity and predictive value of energy and caloric expenditure among this population (Patrick, Williams, Walwick, & Patrick, 2006).

Sedentary behavior questionnaire. The Sedentary Behavior Questionnaire (SBQ) includes two scales, each including the same set of nine questions pertaining to sedentary tasks (i.e., watching television, playing video games, sitting, and reading) completed on a typical weekday and weekend day. The weekday scale begins with a statement that asks about time expenditure on a typical weekday that an individual spends doing sedentary tasks, between waking and going to sleep, and the tasks are then listed. An example item from the SBQ list asks about time "doing paper work or computer work (office work, emails, paying bills, etc.)". There are nine response options available: none, 15 minutes or less, 30 minutes, one hour, two hours, three hours, four hours, five hours, or six or more hours. The average of the weekday and weekend time responses were calculated for each participant. For both the weekday and weekend measure, the highest response time that could potentially be reported is 168 hours (the number of hours in a week as this scale is open ended) and the lowest time response that can be reported is zero. A higher overall score on this measure indicates more time spent doing sedentary behaviors, a lower overall score indicates less time spent in sedentary behaviors. The reliability and validity of the SBQ is reported to be acceptable with reliability of $\rho = 0.52$, and validity of $\rho = 0.30$ compared to accelerometer measured inactivity, and sitting time reported with the International Physical Activity Questionnaire (IPAQ) (Healy et al., 2011). Healy (2011) examined the reliability and validity of the SBQ among older adults and suggests that this measure is suitable for use among this population (see Appendix B).

Objective Measures of Physical Activity

Physical activity was measured objectively using two different but compatible models of tri-axial accelerometer (Actigraph WGT3X, and WGT3X-BT; ActiGraph, Penssacola, FL, USA). The primary difference between the monitors is that the WGT3X-BT monitors have Bluetooth capability. Both accelerometer models were similarly calibrated to 60 second epochs. Activity data was processed using Actigraph software (Actilife 6).The selection of cut points to delineate sedentary, light, and moderate to vigorous PA was made based upon previous research in FM patients (HagstrÖmer et al., 2007; Ruiz et al., 2013). In the present study, accelerometer counts lower than 100 CPM were classified as sedentary behavior, light activity was defined as 100- 759 CPM, moderate activity was defined as 760-5724CPM, and vigorous activity included any activity at 5724 CPM or higher. These cut points were selected to maintain sensitivity in observation of PA levels among the FM population. Participants with fewer than three weekdays and one weekend day of valid data (<10 hours of wear time daily) were removed from the analysis. A continuous bout of activity was defined as at least 10 consecutive minutes of accelerometry counts above the 100 CPM threshold. Bouts of activity that were less than 10 minutes in length were labeled as sporadic activity. Periods of 90 minutes or more of consecutive zero CPM were considered to be non-wear time. The average number of minutes spent daily in each of light, moderate and vigorous PA as well as the total daily step counts (all normalized to the number of valid days) were determined for each participant's entire monitoring period. Normalization was carried out by dividing PA activity range, or the daily step counts by the number of valid accelerometer days for each participant.

Procedures

Data collection was performed in either the morning or afternoon. Upon participant arrival at the assessment, research assistants initially reviewed informed consent and questionnaires, and answered any questions. Participants then assembled in a common room and met with the lead investigator who reviewed the study purpose and procedures. Participants were provided additional opportunity to ask questions before they received instructions for and completed the 18-item Everyday Problems Test and the RAPA. Following the group assessment, half of the participants were assigned to cognitive testing first while the other half of the participants were assigned to physical performance measures first. Trained research assistants administered a battery of neuropsychological tests to each individual in an assigned testing room during cognitive assessment. The task order for the neuropsychological tests was consistent for all participants: MMSE, CERAD immediate recall trials 1-3, Stroop Color/Word test, Digit Span Forward and Backward, trails A and B, CERAD delayed recall and recognition, naming animals, and Digit Symbol Substitution Coding. Cognitive testing took about 30 to 60 minutes to complete based on individual differences (Cherry et al., 2012). Participants also had measurements taken of their blood pressure, height, weight, and waist circumference.

Following the completion of cognitive and physical assessment, participants met briefly with the lead investigator to address any concerns and to be thanked for their participation. During this time, participants were asked if they were interested in further participation in the week-long accelerometer study. Participants who consented were notified that they could opt out of participation at any time during the accelerometer study. Participants were provided a demonstration of how to wear the accelerometer correctly. The accelerometer was worn on the right hip and secured using an elastic, adjustable band. Participants were asked to wear the accelerometer each day during their daily activities and were instructed to remove the accelerometer before entering water, and before bed each night. Participants were additionally provided with a log, and were asked to put an entry in the log each time that they took the accelerometer off and put it back on. Stamped and addressed envelopes to return the accelerometer after seven days of activity monitoring were discussed and provided.

Statistical Analyses

This is a cross-sectional study with two groups, participants diagnosed with fibromyalgia (by the 1990 diagnostic criteria) and control participants. The dependent variables of interest were the RAPA score, SBQ score, and data from PA monitoring (time in sedentary bouts, MVPA categorized as: inactivity, insufficient activity, and active). Data from eleven participants were excluded due to accelerometer malfunction.

Data Cleaning

Prior to an exploratory analysis of the data set, frequency statistics were run for all demographic variables and the independent and dependent variables of interest. The frequency statistics provided information about missing values, accuracy of data entry, fit of each distribution, as well as assumptions of multivariate analysis. Normality and univariate outliers among the variables were assessed using z scores, skewness values, QQ, box and whisker plots, as well as histograms. There was no missing data in any variables, with the exception of race (which was missing one case). Data appeared to be within appropriate range for all continuous variables. Mean and standard deviations appeared plausible for all variables with the exception of variables BMI, race, and vigorous PA. All descriptive plots considered, the variables appeared to have univariate normality (with the exception of race, and vigorous PA). The variable BMI had a positive skew that was slightly leptokurtic. Vigorous PA was severely positively skewed and so was log transformed and the transformed variable was used in all analyses.

Participant Characteristics

Physical and demographic variables were examined using frequencies and proportions or means and standard deviations for categorical and continuous variables, respectively. Differences between the FM and control groups in participant characteristics and among physical variables were analyzed using independent sample *t* tests.

Organization of Subjective and Objective Variable Levels for PA

Participants were classified into one of three activity groups based on their RAPA score (1-7). Participants with RAPA scores of two or below were classified as inactive, scores between two and five were classified as insufficiently active, and scores of six and seven were classified as active. For our purposes, objectively measured moderate and vigorous PA data were combined into a single variable [moderate-vigorous PA (MVPA)] and Individuals with MVPA scores of ≥150 minutes per week were categorized as active. Participants with MVPA scores between 49 and 149 minutes per week were categorized as insufficiently active, while those with scores ≤ 48 minutes per week were categorized as inactive. The inactive category was established based upon the lowest MVPA score reported that could be divided by seven weekdays and provide a product that is less than

10 minutes (as 10 minutes is the lowest amount of minutes required to count as a bout of MVPA within the study criteria).

A comparison of subjective and objective PA was examined using Fisher's Exact Tests. Fisher's Exact tests were performed to examine the independence of categorical classification of subjective and objective PA. The tau b test was used to further assess the relationship between subjective and objective reports of activity levels (the tau b test was used as categorical variables were ordinal).

Organization of Subjective and Objective Variables for SB

The average of time spent in sedentary behavior was calculated by summing the total minutes within sedentary bouts over the total wear time. The total time spent in sedentary bouts was compared to the weekly average of the reported sedentary time in the SBQ. The SBQ week-day and weekend scales were averaged together to create a weekly average amount of time spent in sedentary bouts (in minutes). The total amount of minutes spent in sedentary bouts for each participant was averaged by the number of valid wear days.

A comparison of subjective and objective sedentary behavior was examined with Pearson bivariate correlation. Pearson bivariate correlation was used to evaluate the relationship between measured minutes in sedentary bouts and SBQ reports among FM participants. Separately, a Pearson bivariate correlation was used to evaluate the relationship between self-reported SBQ scores and objectively measured sedentary bouts for control participants.

CHAPTER 3

RESULTS

Participant Characteristics

Participant characteristics are summarized in Table 1. Physical characteristics, and race between groups did not differ. A greater proportion of control participants were older in age, retired, and were married less often than those participants in the FM group. A greater proportion of FM participants completed some college or technical school compared to control participants, and a greater proportion of FM participants graduated with postgraduate degrees than controls. A greater proportion of the control group was male compared to the FM group (40% vs. 5%, CO vs. FM respectively); however, both groups were predominantly female (60% vs 95%, CO vs. FM respectively). Independent samples *t* tests were used to compare physical characteristics between groups. Variable age was significantly independent between the control and FM group, $t(33) = -3.38$, $p = .002$. The variable gender was also found to be significantly independent between the control and FM group ($p < .001$).

Table 1. Physical and Demographic Information among FM and Control Participants

	FM (*n* = 20)	CO (*n* = 15)	*p*
Age (yr), mean ± SD	63.6 ± 7.40	72.5 ± 8.17	0.002**
Height (in), mean ± SD	64.6 ± 3.63	65.6 ± 4.18	0.44
Weight (lbs), mean ± SD	170.6 ± 46.28	173 ± 40.24	0.874
Body mass Index (lbs·ft), mean ± SD	28.7 ± 7.79	28.4 ± 7.56	0.911
Gender	0.05 ± .224	0.40 ± .507	0.009**
Education mean n (%)			
Less than high school	0 (0)	0 (0)	
High school Diploma	0 (0)	0 (0)	
Some college/Technical school	8 (40)	4 (26.7)	
College graduate	6 (30)	8 (53.3)	
Postgraduate degree	6 (30)	3 (20)	
Employment status n (%)			
Retired	6 (30)	11 (73.3)	
Working Full-time	6 (30)	2 (13.3)	
Working Part-time	3 (15)	1 (6.7)	
Permanently Disabled	2 (10)	0 (0)	
Keeping House	2 (10)	1 (6.7)	
Marital status mean n (%)			
Never Married	0 (0)	2 (13.3)	
Divorced/ Separated	5 (25)	4 (26.7)	
Widowed	3 (15)	2 (13.3)	
Married	12 (60)	7 (46.7)	
Race, *n* (%)			
White, not Hispanic	17 (85)	12 (80)	
White, Hispanic	2 (10)	0 (0)	
Asian	1 (5)	2 (13.3)	
Not reported	0 (0)	1 (5)	

Measures are mean ± SD expressed as counts and minutes per day

Note: * significant at α = 0.05, ** significant at α = 0.01, *** significant at α = 0.001 after an independent *t* test

Subjective Physical Activity and Sedentary Behavior Measures

The RAPA reports that at levels insufficiently active and active, the FM and control group did not differ. In concordance with previous research (Mcloughlin, 2011) a greater percentage of participants with FM reported inactive behavior compared to control participants. Results from the RAPA are shown in Table 2. Descriptive statistics were conducted to calculate the mean and standard deviations for the FM and control groups on the SBQ as well. These results conversely indicated that the control group reported a larger amount of time as inactive compared to the FM group. These results are not completely unexpected as the control group has a larger number of older adults. An independent sample *t* test was used to examine subjective reports on the SBQ between groups. The SBQ scores were reported as not significantly different from one another, t(33) = -1.80, p = .08. Results from the SBQ are shown in Table 2.

Table 2. Self-reported Physical Activity in FM and Control Participants

	FM (n = 20)	CO (n = 15)	p
SBQ (minutes per day) mean ± *SD*	68 ± 18	78 ± 16	0.081
RAPA Scale One n (%)			
Inactive	3 (15)	1 (6.7)	
Insufficiently active	12 (60)	10 (66.7)	
Active	5 (25)	4 (26.7)	

Measures are mean ± *SD* expressed as counts and minutes per day

Note: * significant at α = 0.05, ** significant at α = 0.01, *** significant at α = 0.001 after an independent *t* test

Objective Measures

Of the initial 26 FM and 20 control participants who received accelerometers, data from 20 FM participants and 15 controls met criteria for inclusion in the analyses.

Six FM participants and five controls were excluded from analyses because the accelerometer did not record any data during their wear time, or the participant did not meet the criteria for valid wear time.

Means and frequencies were examined to compare relationships between measured PA and participant groups. Daily counts were lower among the FM group than the control group. However, the time spent in light PA, vigorous PA, and total time in PA was not significantly different between groups. Time spent in moderate PA and the combined MVPA were not markedly different between groups. Control participants had larger amounts of time in sedentary bouts per week compared to those in the FM group. An independent sample *t* test found that time spent in sedentary bouts per week was significantly different between the FM and control groups, $t(33) = -3.96$, $p \leq .001$. Results from the physical activity measurements are shown in Table 3.

Table 3. Objectively Measured Activity in FM and Control Participants

	FM (n = 20)	CO (n = 15)	*p*
Daily Minutes	899 ± 82	888 ± 69	0.685
Daily Counts	6241 ± 3569	6490 ± 4537	0.443
Minutes Sedentary	238 ± 66	335 ± 78	≤0.001***
Minutes light	160 ± 63	165 ± 51	0.799
Minutes moderate	27 ± 23	20 ± 12	0.273
Minutes vigorous	1 ± 1	1 ± 2	0.632
Minutes moderate and vigorous	28 ± 24	21 ± 13	0.301
Minutes total in PA	192 ± 75	179 ± 59	0.605

Measures are mean ± *SD* expressed as counts and minutes per day

Sedentary = <100 counts per minute, light = 100-2019 counts per minute, moderate = 2020-5998 counts per minute, vigorous = > 5999 counts per minute.

Note: * significant at α = 0.05, ** significant at α = 0.01, *** significant at α ≤ 0.001 after an independent *t* test

Subjective and Objective Report Agreement

Physical Activity Comparison

Crosstabulation analysis of the control group indicated that 25% of the subjective and objective reports of inactivity were related. Crosstabulation among the control group indicated that 75% of the subjective and objective reports at an insufficient activity level were related. Crosstabulation among the control group indicated that 42.9% of the subjective and objective reports at an active level were related. Participants in the control group had the highest agreement between subjective and objective reports in category insufficient activity (75%). Results are shown in Table 4.

Crosstabulation analysis of the FM group indicated that 50% of the subjective and objective reports of inactivity were related. Crosstabulation indicated that among the FM group 62.5% of the subjective and objective reports at an insufficiently active level were related. Crosstabulation indicated that among the FM group 30% of the subjective and objective reports at an active level were related. Participants in the FM group had the highest agreement in the category insufficiently activity (62.5%). Results are shown in Table 4.

Table 4. Crosstabulation Analysis between Subjective and Objective Reports of Activity Categories between Groups

		Subjective Measure (RAPA)			
Control		Inactive	Insufficiently active	Active	Total
Objective Measure (Acceler-ometry)	Inactive	1	3	0	4
	% within	25%	75%	0%	100%
	Insufficiently active	0	3	1	4
	% within	0%	75%	25%	100%
	Active	0	4	3	7
	%within	0%	57.10%	42.90%	100%
	Total	1	10	4	15
	% within	6.70%	66.70%	26.70%	100%
FM					
Objective Measure (Acceler-ometry)	Inactive	1	1	0	2
	% within	50%	50%	0%	100%
	Insufficiently active	1	5	2	8
	% within	12.50%	62.50%	25%	100%
	Active	1	6	3	10
	% within	10%	60%	30%	100%
	Total	3	12	15	20
	% within	15%	60%	25%	100%

Further examination with the Fisher's exact two-sided test indicated that comparisons of subjective and objective PA for both groups were not statistically significant ((n = 15) = 4.08, $p > 0.05$; (n = 20) = 2.52, $p > 0.05$). The results indicate that objectively measured activity and subjectively reported activity are independent of one another among both FM and control participants.

Examination of the Kendall's tau-b correlation coefficient among FM participants indicated a weak positive relationship between subjective and objective reports of activity at each level. Examination of Kendall's tau-b rank correlation coefficient for control participants indicated a positive moderate strength relationship between subjective and objective reports of activity at each level.

Sedentary Behavior Comparison

Pearson bivariate correlational analysis indicated that there was no significant relationship between SBQ report and measured time in sedentary bouts among either participant groups (all $p > 0.05$). Pearson correlation indicated that there was a weak negative correlation between subjective and objective measures of sedentary behavior [$r\,(20) = -0.13$] in the FM group, where there was no correlation between the two measures in the control group [$r\,(15) = 0.00$].

CHAPTER 4

DISCUSSION

One implication of this study is that the relationship between subjective and objective ratings at all PA levels were weaker among FM participants compared to healthy controls. Second, there was not a weak positive relationship between self-reported and objectively measured sedentary behavior in individuals with FM.

Group comparisons

Previous studies such as Korszun et al. (2002) and Kop et al. (2005) reported no differences in total physical activity between FM and control groups, while McLoughlin et al. (2011) reported that overall, individuals with FM had lower activity than controls. Among this sample population of older adults, participants with FM were not less physically active than control participants. The present study's findings are demonstrated in both the self-report (RAPA) and objective measurement (accelerometry). A few study characteristics might account for the discrepant results between this study and earlier reports of activity between groups. The present study was focused on quantifying and examining the association between subjective and objective reports of PA and sedentary behavior between those with and without FM, while both the Kop et al. (2005) and Korszun et al. (2002) studies intended to measure sleep quality. Kop (2005) and Korszun (2002) additionally had accelerometers placed at the wrist, as opposed to placement at the hip, as was done in this study and the Mcloughlin et al (2011) study. The wrist worn accelerometer has been reported by Swartz et al. (2000) to record upper body movements about 2.6% more effectively than the hip worn accelerometer. As previously mentioned, hip worn accelerometers tend to measure total PA more comprehensively than wrist mounted accelerometers (Trost, McIver, & Pate, 2005; Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). For the purposes of our study, the small percent of data to be gained by enhanced upper body measurement did not justify the loss of accuracy of whole body measurement, which the accelerometer placed at the hip could provide. The Mcloughlin study included female participants only, while the current study examined both male and female participants. Possible effects of gender on activity levels were considered as males tend to engage in more PA then females (Fan, 2014). Although conversely, the majority of male participants (6) were in the control group, which had lower total PA levels. Another explanation may be differences in body composition, however, an independent *t* test indicated that BMI was not significantly different between the FM and control groups, $t(33)= .112$, $p = .911$. BMI's in the present study (FM, 28.74 ± 7.79; Controls 28.44 ± 7.56) were similar to those observed in the previous McLoughlin (2011) study as well (BMI = 26.6 $kg \cdot m^{-2}$). The potential impact that employment status may have on PA levels was considered as well. A larger amount of the control group were retired, and had less fixed schedules of PA. This allows for the control group more opportunity to engage in different levels of PA compared to those in the FM group. Age is another factor that may explain our results as the participants in this study were older than those in all earlier studies (FM, 63.60 ± 7.40; Controls, 72.53 ± 8.17), and as previously discussed, PA is lower among older individuals (Troiano et al., 2008). Independent sample *t* tests previously discussed in the present study indicated that there were significant differences in age between the FM and control groups. Furthermore, the discrepancy in age between the FM and CO groups has potential to create a masking effect for other factors impacting levels of PA in our control sample.

<u>Contingency between Self-Reported and Objectively Measured PA</u>

A few interesting findings were observed when subjective measures of sedentary behavior and PA (the SBQ and RAPA, respectively) were compared with accelerometer measures of sedentary behavior and PA. First, the association between the RAPA and accelerometer measures, across all intensities of PA, was very weak and non-significant, indicating that the RAPA may not adequately measure different intensities of PA. This is further supported by results that indicate control participants were documented as having moderate level associations between the RAPA (at inactive, insufficiently active, and active levels) compared to objective reports at each level.

The results of the Pearson bivariate correlation do not support the third hypothesis that predicted a weak positive correlation between the SBQ and objectively measured sedentary activity among the FM participants. The association between the SBQ and objectively measured sedentary time was weak and inverse, particularly in the control group where there was no association found between the two measures. This suggests that the SBQ is not an adequate measure of sedentary behavior when compared to objectively measured sedentary behavior. Healy (2011) expressed that the SBQ was suitable for older adults, although, it is not a measure that is intended for sedentary behavior assessment among older adults. Further, the objectively measured time in sedentary behavior was assessed based upon cut points that are typical among older adults. This finding also supports previous suggestions that individuals with FM have greater variability among subjective report in relation to objective reports.

Therefore, these findings support hypothesis one, that FM participants would have weaker relationships between objective and subjective reports of activity at each level compared to control participants. These results do not support hypothesis two, that control participants would have a strong positive correlation at each activity level.

Limitations and Directions for Future Research

A further limitation of this study is related to the small sample size (n =35) as this may have resulted in insufficient statistical power. The crosstabulation analysis may have yielded clearer results with a larger number of participants present within each group. Additionally, the associations involving the subjective activity measures should be taken with caution as these may have a restricted range of possible responses. Further, the criteria used to classify participants into PA groups based on objectively measured total PA was not supported by the literature. This is a limitation to our study as the separation of time (between insufficiently active and inactive behavior within MVPA) is not supported by previous research. Different subjective tests of activity measurement such as the International Physical Activity Questionnaire (IPAQ) would be suggested for future analysis, as both the RAPA and SBQ have limited response categories in relation to overall PA.

This study demonstrates the importance of simultaneous use of subjective and objective measures upon examination of PA and sedentary behavior among individuals with FM, as subjective measurement alone may not adequately report PA or sedentary behavior. Individuals who plan to implement public health interventions should be alerted to these findings as they may strengthen strategies of effective chronic disease management. Improvements to chronic disease management strategies allow for better treatment adherence among the FM population as well as opportunity for an enhanced quality of life.

APPENDIX A

RAPID ASSESSMENT OF PHYSICAL ACTIVITY (RAPA)

How Physically Active Are You?

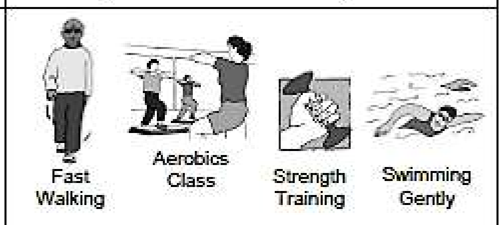
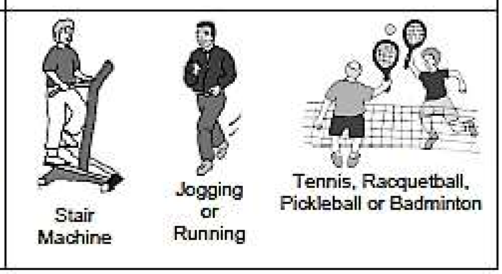
An assessment of level and intensity of physical activity

Rapid Assessment of Physical Activity

Physical Activities are activities where you move and increase your heart rate above its resting rate, whether you do them for pleasure, work, or transportation.

The following questions ask about the amount and intensity of physical activity you usually do. The intensity of the activity is related to the amount of energy you use to do these activities.

Examples of physical activity intensity levels:

Light activities • your heart beats slightly faster than normal • you can talk and sing	
Moderate activities • your heart beats faster than normal • you can talk but not sing	
Vigorous activities • your heart rate increases a lot • you can't talk or your talking is broken up by large breaths	

How physically active are you? *(Check one answer on each line)*

			Does this accurately describe you?	
RAPA 1	1	I rarely or never do any physical activities.	Yes ☐	No ☐
	2	I do some **light** or **moderate** physical activities, but not every week.	Yes ☐	No ☐
	3	I do some **light** physical activity every week.	Yes ☐	No ☐
	4	I do **moderate** physical activities every week, but less than 30 minutes a day or 5 days a week.	Yes ☐	No ☐
	5	I do **vigorous** physical activities every week, but less than 20 minutes a day or 3 days a week.	Yes ☐	No ☐
	6	I do 30 minutes or more a day of **moderate** physical activities, 5 or more days a week.	Yes ☐	No ☐
	7	I do 20 minutes or more a day of **vigorous** physical activities, 3 or more days a week.	Yes ☐	No ☐
RAPA 2 (3 = Both 1 & 2)	1	I do activities to increase muscle **strength**, such as lifting weights or calisthenics, once a week or more.	Yes ☐	No ☐
	2	I do activities to improve **flexibility**, such as stretching or yoga, once a week or more.	Yes ☐	No ☐

ID # ______________________________

Today's Date ______________________

Scoring Instructions

RAPA 1: Aerobic

To score, choose the question with the highest score with an affirmative response. Any number less than 6 is suboptimal.

For scoring or summarizing categorically:

Score as sedentary:

1. I rarely or never do any physical activities.

Score as under-active:

2. I do some light or moderate physical activities, but not every week.

Score as under-active regular – light activities:

3. I do some light physical activity every week.

Score as under-active regular:

4. I do moderate physical activities every week, but less than 30 minutes a day or 5 days a week.
5. I do vigorous physical activities every week, but less than 20 minutes a day or 3 days a week.

Score as active:

6. I do 30 minutes or more a day of moderate physical activities, 5 or more days a week.
7. I do 20 minutes or more a day of vigorous physical activities, 3 or more days a week.

APPENDIX B

SEDENTAR BEHAVIOR QUESTIOINAIRE (SBQ)

SEDENTARY BEHAVIOR: Weekday									
On a typical WEEKDAY, how much time do you spend (from when you wake up until you go to bed) doing the following?									
	None	15 min. or less	30 min.	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs or more
1. Watching television (including videos on VCR/DVD).	O	O	O	O	O	O	O	O	O
2. Playing computer or video games.	O	O	O	O	O	O	O	O	O
3. Sitting listening to music on the radio, tapes, or CDs.	O	O	O	O	O	O	O	O	O
4. Sitting and talking on the phone.	O	O	O	O	O	O	O	O	O
5. Doing paperwork or computer work (office work, emails, paying bills, etc.)	O	O	O	O	O	O	O	O	O
6. Sitting reading a book or magazine.	O	O	O	O	O	O	O	O	O
7. Playing a musical instrument.	O	O	O	O	O	O	O	O	O
8. Doing artwork or crafts.	O	O	O	O	O	O	O	O	O
9. Sitting and driving in a car, bus, or train.	O	O	O	O	O	O	O	O	O

SEDENTARY BEHAVIOR: Weekend Day									
On a typical WEEKEND DAY, how much time do you spend (from when you wake up until you go to bed) doing the following?									
	None	15 min. or less	30 min	1 hr	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs or more
1. Watching television (including videos on VCR/DVD).	O	O	O	O	O	O	O	O	O
2. Playing computer or video games.	O	O	O	O	O	O	O	O	O
3. Sitting listening to music on the radio, tapes, or CDs.	O	O	O	O	O	O	O	O	O
4. Sitting and talking on the phone.	O	O	O	O	O	O	O	O	O
5. Doing paperwork or computer work (office work, emails, paying bills, etc.)	O	O	O	O	O	O	O	O	O
6. Sitting reading a book or magazine.	O	O	O	O	O	O	O	O	O
7. Playing a musical instrument.	O	O	O	O	O	O	O	O	O
8. Doing artwork or crafts.	O	O	O	O	O	O	O	O	O
9. Sitting and driving in a car, bus, or train.	O	O	O	O	O	O	O	O	O

APPENDIX C

FIGURES

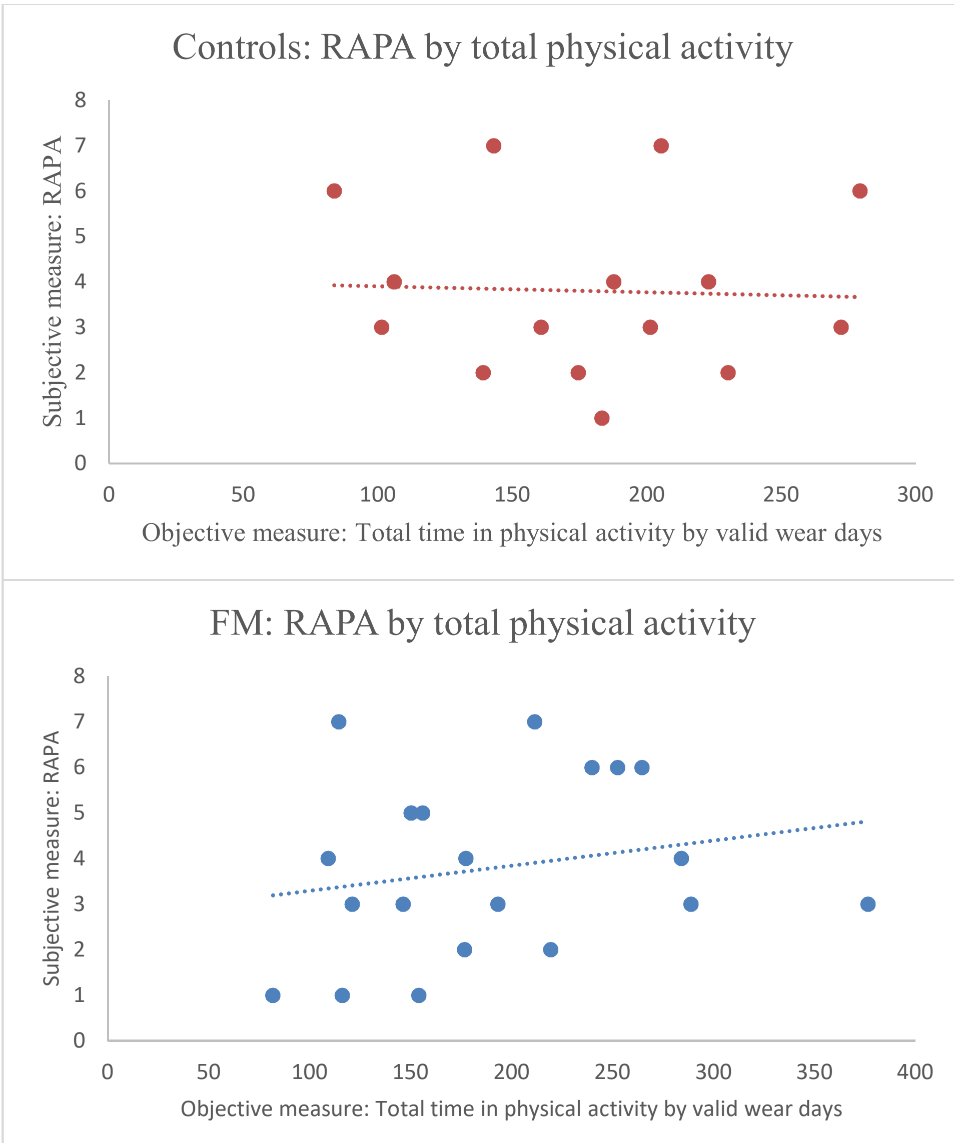


Figure 1. Relationship between objectively measured PA (total physical activity by valid ware days) and self-reported activity (total reported PA on the RAPA part one scale) among control (*above*; *n* = 15) and FM (*below*; *n* = 20) participants.

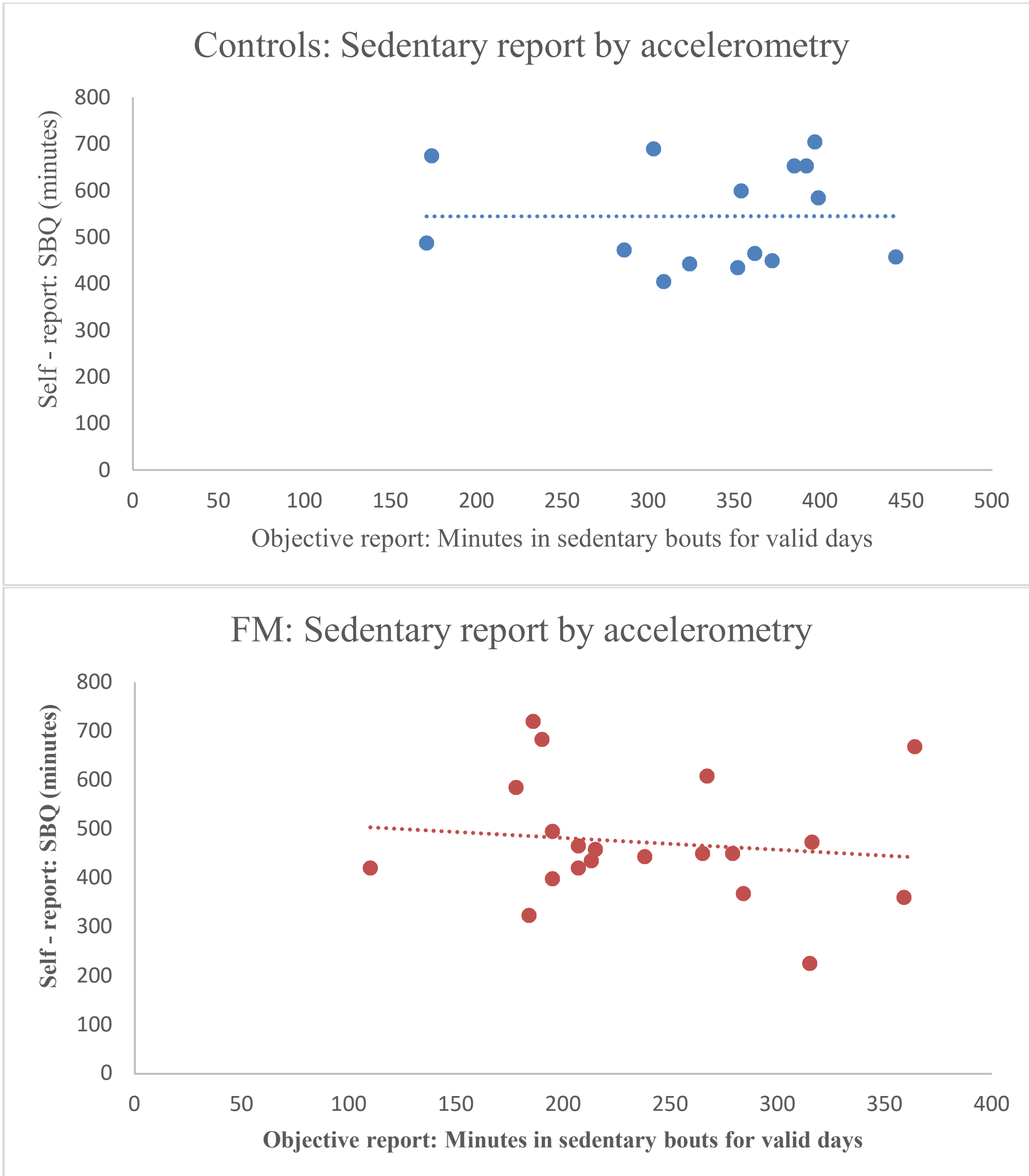


Figure 2. Relationship between total objectively measured sedentary behavior and total subjectively reported sedentary behavior among both control (top) and FM (bottom) groups.

REFERENCES

Ablin, J. N., Oren, A., Cohen, S., Aloush, V., Buskila, D., Elkayam, O., . . . Berman, M. (2012). Prevalence of fibromyalgia in the Israeli population: a population-based study to estimate the prevalence of fibromyalgia in the Israeli population using the London Fibromyalgia Epidemiology Study Screening Questionnaire (LFESSQ). *Clinical Experimental Rheumatology*, *30*(6 Suppl 74), 39-43.

Actigraph (2017). What's the difference among the cut points available in ActiLife. *Support Center*. Retrieved from

https://actigraph.desk.com/customer/en/portal/articles/2515803-what-s-the-difference-among-the-cut-points-available-in-actilife-

Althoff, T., Hicks, J. L., King, A. C., Delp, S. L., & Leskovec, J. (2017). Large-scale physical activity data reveal worldwide activity inequality. *Nature*, *547*(7663), 336-339.

Bar-On Kalfon, T., Gal, G., Shorer, R., & Ablin, J. (2016). Cognitive functioning in fibromyalgia: The central role of effort. *Journal of Psychosomatic Research*, *87*, 30-36.

Berger, A., Dukes, E., Martin, S., Edelsberg, J., & Oster, G. (2007). Characteristics and healthcare costs of patients with fibromyalgia syndrome. *International Journal of Clinical Practice*, *61*(9), 1498-1508.

Buchan, D. S., Ollis, S., Thomas, N. E., & Baker, J. S. (2012). Physical activity behaviour: an overview of current and emergent theoretical practices. *Journal of Obesity*, *2012*.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126–131.

Centers for Disease Control and Prevention (CDC) (2015, June 04). Measuring Physical Activity Intensity. *Physical Activity*. Retrieved September 25, 2017, from https://www.cdc.gov/physicalactivity/basics/measuring/index.html

Centers for Disease Control and Prevention (CDC) (2015, June 04). Physical Activity and Health. *Physical Activity*. Retrieved November 12, 2017, from https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm

Cherry, B. J., Zettel-Watson, L., Shimizu, R., Roberson, I., Rutledge, D. N., & Jones, C. J. (2012). Cognitive performance in women aged 50 years and older with and without fibromyalgia. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *69*(2), 199-208.

Chung, J. W., & Wong, T. K. (2007). Prevalence of pain in a community population. *Pain Medicine*, *8*(3), 235-242.

Clauw, D. J., & Crofford, L. J. (2003). Chronic widespread pain and fibromyalgia: What we know, and what we need to know. *Best Practice & Research Clinical Rheumatology*, *17*(4), 685-701.

Clauw, D. J. (2009). Fibromyalgia: an overview. *The American Journal of Medicine*, *122*(12), S3-S13.

Dowell, D., Haegerich, T. M., & Chou, R. (2016). CDC guideline for prescribing opioids for chronic pain—United States, 2016. *Jama*, *315*(15), 1624-1645.

Ekelund, U., Sepp, H., Brage, S., Becker, W., Jakes, R., Hennings, M., & Wareham, N. J. (2006). Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. *Public Health Nutrition*, *9*(02), 258-265.

Essiet, I. A., Baharom, A., Shahar, H. K., & Uzochukwu, B. (2017). Application of the Socio-Ecological Model to predict physical activity behaviour among Nigerian University students. *The Pan African Medical Journal*, *26*.

Etnier, J. L., Karper, W. B., Gapin, J. I., Barella, L. A., Chang, Y. K., & Murphy, K. J. (2009). Exercise, fibromyalgia, and fibrofog: a pilot study. *Journal of Physical Activity and Health*, *6*(2), 239-246.

Fan, J. X. (2014). Rural–urban differences in objective and subjective measures of physical activity: findings from the National Health and Nutrition Examination Survey (NHANES) 2003–2006. *Preventing Chronic Disease*, *11*.

Fitzhugh, E. C. (2015). Methods to measure physical activity behaviors in health education research. *American Journal of Health Education*, *46*(1), 1-6.

Fox, M. (2012). Towards A Multidisciplinary Team Approach in Chronic Pain Management. In *DOCPLAYER*. Retrieved December 4, 2016.

Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the Computer Science and Applications, Inc. accelerometer. *Medicine and Science in Sports and Exercise*, *30*(5), 777-781.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., . . . & Swain, D. P. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Medicine & Science in Sports & Exercise*, *43*(7), 1334-1359.

Gelonch, O., Garolera, M., Valls, J., Rosselló, L., & Pifarré, J. (2016). Executive function in fibromyalgia: Comparing subjective and objective measures. *Comprehensive Psychiatry*, *66*, 113-122.

Giles-Corti, B., Timperio, A., Bull, F., & Pikora, T. (2005). Understanding physical activity environmental correlates: increased specificity for ecological models. *Exercise and Sport Sciences Reviews*, *33*(4), 175-181.

Glass, J. M. (2009). Review of cognitive dysfunction in fibromyalgia: a convergence on working memory and attentional control impairments. *Rheumatic Disease Clinics of North America*, *35*(2), 299-311.

Gomes, E. C., & Florida-James, G. (2016). Exercise and the Immune System. In *Environmental Influences on the Immune System* (pp. 127-152). Springer Vienna.

Hagströmer, M., Oja, P., & Sjöström, M. (2007). Physical activity and inactivity in an adult population assessed by accelerometry. *Medicine and Science in Sports and Exercise*, *39*(9), 1502-1508.

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet*, *380* (9838), 247-257.

Hamilton, M. T., Healy, G. N., Dunstan, D. W., Zderic, T. W., & Owen, N. (2008). Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior. *Current Cardiovascular Risk Reports*, *2*(4), 292-298.

Harstall, C., & Ospina, M. (2003). How prevalent is chronic pain. *Pain Clinical Updates*, *11*(2), 1-4.

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., . . . & Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*, *116*(9), 1081.

Healy, G. N., Clark, B. K., Winkler, E. A., Gardiner, P. A., Brown, W. J., & Matthews, C. E. (2011). Measurement of adults' sedentary time in population-based studies. *American Journal of Preventive Medicine*, *41*(2), 216-227.

Honda, T., Chen, S., Yonemoto, K., Kishimoto, H., Chen, T., Narazaki, K., . . . & Kumagai, S. (2016). Sedentary bout durations and metabolic syndrome among working adults: a prospective cohort study. *BMC Public Health*, *16*(1), 888.

Hughes, K., MEd. (2012). MET minutes: A simple common value to track exercise progress. *Cooper Institute*. Retrieved November 16, 2017, from https://www.cooperinstitute.org/2012/04/met-minutes-a-simple-common-value-to-track-exercise-progress/

Jahan, F., Nanji, K., Qidwai, W., & Qasim, R. (2012). Fibromyalgia syndrome: an overview of pathophysiology, diagnosis and management. *Oman Medical Journal*, *27*(3), 192-195.

Jones, G. T., Atzeni, F., Beasley, M., Flüß, E., Sarzi-Puttini, P., & Macfarlane, G. J. (2015). The prevalence of fibromyalgia in the general population: a comparison of the American College of Rheumatology 1990, 2010, and modified 2010 classification criteria. *Arthritis & Rheumatology*, *67*(2), 568-575.

Kop, W. J., Lyden, A., Berlin, A. A., Ambrose, K., Olsen, C., Gracely, R. H., . . . &

Clauw, D. J. (2005). Ambulatory monitoring of physical activity and symptoms in fibromyalgia and chronic fatigue syndrome. *Arthritis & Rheumatology*, *52*(1), 296-303.

Korszun, A., Young, E. A., Engleberg, N. C., Brucksch, C. B., Greden, J. F., & Crofford, L. A. (2002). Use of actigraphy for monitoring sleep and activity levels in patients with fibromyalgia and depression. *Journal of Psychosomatic Research*, *52*(6), 439-443.

Kravitz, H. M., & Katz, R. S. (2015). Fibrofog and fibromyalgia: a narrative review and implications for clinical practice. *Rheumatology International*, *35*(7), 1115-1125.

Lacasse, A., Bourgault, P., & Choinière, M. (2016). Fibromyalgia-related costs and loss of productivity: a substantial societal burden. *BMC Musculoskeletal Disorders*, *17*(1), 168.

Landro, L. (2010). The Informed Patient: The Hidden Benefits of Exercise --- Even Moderate Physical Activity Can Boost the Immune System and Protect Against Chronic Diseases. *Wall Street Journal*, p. D.1.

LeBlanc, A. G., & Janssen, I. (2010). Difference between self-reported and accelerometer measured moderate-to-vigorous physical activity in youth. *Pediatric Exercise Science*, *22*(4), 523-534.

Lindell, L., Bergman, S., Petersson, I., Jacobsson, L., & Herrström, P. (2000). Prevalence of fibromyalgia and chronic widespread pain. *Scandinavian Journal of Primary Health Care*, *18*(3), 149-153.

McLoughlin, M. J., Colbert, L. H., Stegner, A. J., & Cook, D. B. (2011). Are women with fibromyalgia less physically active than healthy women? *Medicine and Science in Sports and Exercise*, *43*(5), 905.

Miles, L. (2007). Physical activity and health. *Nutrition Bulletin*, *32*(4), 314-363.

Nahin, R. L. (2015). Estimates of pain prevalence and severity in adults: United States, 2012. *The Journal of Pain*, *16*(8), 769-780.

Nielsen, L. A., & Henriksson, K. G. (2007). Pathophysiological mechanisms in chronic musculoskeletal pain (fibromyalgia): the role of central and peripheral sensitization and pain disinhibition. *Best Practice & Research Clinical Rheumatology*, *21*(3), 465-480.

Nijs, J., Roussel, N., Van Oosterwijck, J., De Kooning, M., Ickmans, K., Struyf, F., . . . & Lundberg, M. (2013). Fear of movement and avoidance behaviour toward physical activity in chronic-fatigue syndrome and fibromyalgia: state of the art and implications for clinical practice. *Clinical Rheumatology*, *32*(8), 1121-1129.

Neumann, L., & Buskila, D. (2003). Epidemiology of fibromyalgia. *Current Pain and Headache Reports*, *7*(5), 362-368.

Office of Disease Prevention and Health Promotion (2017). Chapter 4: Active Adults. *Physical Activity Guidelines*. Retrieved November 20, 2017, from https://health.gov/paguidelines/guidelines/chapter4.aspx

Owen, N., Healy, G., Matthews, C., & Dunstan, D. (2010). Too much sitting: The population health science of sedentary behavior. *Exercise and Sport Sciences Reviews*, 38(3), 105-13.

Paluska, S., & Schwenk, T. (2000). Physical activity and mental health - Current concepts. *Sports Medicine*, 29(3), 167-180.

Patrick, D. L., Williams, B., Walwick, J., & Patrick, M. B. (2006). The rapid assessment of physical activity (RAPA) among older adults.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, *18*(2), 189-193.

Prince, S. A., Adamo, K. B., Hamel, M. E., Hardt, J., Gorber, S. C., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *5*(1), 56.

Queiroz, L. P. (2013). Worldwide epidemiology of fibromyalgia. *Current Pain and Headache Reports*, *17*(8), 356.

Raftery, M. N., Sarma, K. W., Murphy, A. E., De la Harpe, D., Normand, C., & McGuire, B. (2011). Chronic pain in the Republic of Ireland—Community prevalence, psychosocial profile and predictors of pain-related disability: Results from the Prevalence, Impact and Cost of Chronic Pain (PRIME) study, Part 1. *Pain, 152*(5), 1096-1103.

Ruiz, J. R., Segura-Jiménez, V., Ortega, F. B., Álvarez-Gallardo, I. C., Camiletti-Moirón, D., Aparicio, V. A., & Delgado-Fernández, M. (2013). Objectively measured sedentary time and physical activity in women with fibromyalgia: a cross-sectional study. *BMJ Open*, *3*(6).

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: status, limitations, and future directions. *Research Quarterly for Exercise and Sport*, *71*(sup2), 1 14.

Segura-Jiménez, V., Álvarez-Gallardo, I. C., Estévez-López, F., Soriano-Maldonado, A., Delgado-Fernández, M., Ortega, F. B., & Ruiz, J. R. (2015). Differences in Sedentary Time and Physical Activity Between Female Patients with Fibromyalgia and Healthy Controls: The al-Ándalus Project. *Arthritis & Rheumatology*, *67*(11), 3047-3057.

Shipley, M. (2010). Chronic widespread pain and fibromyalgia syndrome. *Medicine*, *38*(4), 202-204.

Soares-Miranda, L. S., Siscovick, D. M., Psaty, B. T., Longstreth, W., & Mozaffarian, D. (2016). Physical Activity and Risk of Coronary Heart Disease and Stroke in Older Adults: The Cardiovascular Health Study. *Circulation*, 133(2), 147-155.

Swartz, A. M., Strath, S. J., Bassett, D. R., O'brien, W. L., King, G. A., & Ainsworth, B. E. (2000). Estimation of energy expenditure using CSA accelerometers at hip and wrist sites. *Medicine & Science in Sports & Exercise*, *32*(9), S450-S456.

Sylvia, L. G., Bernstein, E. E., Hubbard, J. L., Keating, L., & Anderson, E. J. (2014). Practical Guide to Measuring Physical Activity. *Journal of the Academy of Nutrition and Dietetics*, *2*(114), 199-208.

Troiano, R. P., Berrigan, D., Dodd, K. W., Mâsse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise*, *40*(1), 181.

Trost, S. G., McIver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Medicine and Science in Sports and Exercise*, *37*(11), S531.

Walitt, B., Nahin, R. L., Katz, R. S., Bergman, M. J., & Wolfe, F. (2015). The prevalence and characteristics of fibromyalgia in the 2012 National Health Interview Survey. *PloS One*, *10*(9), e0138024.

Ward, D. S., Evenson, K. R., Vaughn, A., Rodgers, A. B., & Troiano, R. P. (2005). Accelerometer use in physical activity: best practices and research recommendations. *Medicine and Science in Sports and Exercise*, *37*(11 Suppl), S582-8.

Wolfe, F., Clauw, D. J., Fitzcharles, M. A., Goldenberg, D. L., Katz, R. S., Mease, P., . . . & Yunus, M. B. (2010). The American College of Rheumatology preliminary diagnostic criteria for fibromyalgia and measurement of symptom severity. *Arthritis Care & Research*, *62*(5), 600-610.