5-2011

The Effect of Walking Poles on Gait Characteristics and Fear of Falling in Community Dwelling, Four-Wheel Walker Dependent and Non-Assistive Device Dependent Older Adults

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May 2011

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ABSTRACT

BACKGROUND AND PURPOSE: Walking poles are advertised as a beneficial gait device for individuals of all ages. Claims that they help increase confidence, balance, posture, and stride quality have led to their growth in popularity. However, to date there is no published evidence showing the impact of walking poles on gait parameters or fear of falling in the older adult population. The purpose of this study was to analyze gait speed, stride length, double-limb support, base of support, fear of falling, and change in perceived walking quality in four-wheel walker (4WW) and non-assistive device (NAD) dependent older adults, comparing the differences between walking pole and usual assistive device usage.

METHODS: Using a two-group repeated measures design, twenty-one community dwelling older adults (mean age = 85.4 ± 5.1, 7 male, 14 female) participated in this study. Eight subjects were 4WW dependent and 13 were NAD dependent for mobility. Participants completed walking trials with their usual assistive device and with walking poles. Gait characteristics were measured using the GAITRite® system. Fear of falling was measured on a visual analog scale and a global rating of change scale was used for perceived gait quality. Statistical significance was determined with $p<0.05$ using paired and two-sample t-tests. Pearson and Spearman correlation coefficients were used to analyze relationships between measures.

RESULTS: Significant differences ($p<0.05$) were found within the 4WW dependent group for gait speed, double-limb support, base of support, and fear of falling in trials with walking poles compared to usual assistive device. Within the NAD dependent group, significant differences were found in gait speed, double-limb support, and fear of falling in trials with walking poles compared to trials without. Between groups, significant differences were found in stride length and base of support. Strong correlations between gait speed and double-limb support time were discovered with use of usual assistive device compared to use of walking poles.

CONCLUSION: With minimal training on walking pole usage, both 4WW dependent and NAD dependent older adults displayed decreased gait speed, increased double-limb support time, and increased fear of falling when using walking poles. Additionally, 4WW dependent adults displayed decreased stride length and increased base of support.

ACKNOWLEDGEMENTS

We would like to acknowledge the individuals who assisted with this research project. Thank you to our participants at St. Therese Home in New Hope, MN for their willingness to volunteer and participate. Also, we are grateful to the staff at St. Therese Home for allowing access to the facility and helping to recruit subjects.

We are grateful to our research advisor, Deborah Madanayake, PT, JD, GCS, for her support and guidance during the research process. Thank you to Laura Gilchrist, PT, PhD for her time and assistance with data collection. Also, special thanks to Children's Hospital for allowing us to use the GAITRite® walkway. We want to extend appreciation to John Schmitt, PT, PhD for his time and assistance with analyzing data during the research process. Finally, we appreciate the support we received from our family, friends, and classmates throughout this process.

The undersigned certifies that she has read and recommended approval of the research project entitled:

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CHAPTER I: INTRODUCTION

The geriatric population continues to grow in number, with an estimated 39.5 million older adults currently living in the United States.[1] The older adult population puts great value on independence and mobility, and seeks out ways to preserve these aspects of life. As the body ages there are musculoskeletal changes that occur leading to muscular weakness and balance deficits; these changes may eventually lead an individual to depend on an assistive device for ambulation. In 2009, the Centers for Disease Control reported that over 2 million unintentional falls resulting in non-fatal injuries occurred in adults over 65 years of age.[2] Options for gait devices are limited to canes or walkers, and therefore, may be underutilized given the social stigmas associated with use of such devices. As the geriatric population continues to live longer, gait devices may become increasingly important to preserve quality of life and safety.

Walking poles are advertised as a beneficial gait device for individuals of all ages. In recent years, walking poles have increased in popularity for use during exercise. Research with walking poles has shown that they may reduce forces on the body and alter gait mechanics in young to middle age adults.[3] Advertisements purport that these devices can be a beneficial assistive device for older individuals. Specifically, advertising claims state that walking poles increase confidence, balance, breathing, posture, and stride quality.[4] However, to date there is no evidence to support these claims in the older adult population. As marketing claims go unsupported in the literature and walking poles are readily available on the market, there is the potential for older adults to use these devices without knowledge of how walking poles may impact their gait or potential for falls. Therefore, it is necessary to investigate the implications of walking poles use in the geriatric population.

The purpose of this study was to analyze gait speed, stride length, double-limb support, base of support, fear of falling, and change in perceived walking quality in four-wheel walker (4WW) and non-assistive device (NAD) dependent older adults, comparing the differences between walking pole and usual assistive device usage. Current evidence shows possible correlations between gait parameters and fear of falling.[5,6] Since there is the potential that an older adult may purchase walking poles and begin using them without instruction, this study also looks at the impact of each subject's subjective report of fear of falling using a visual analog scale, and perceived change of gait quality with the global rating of change scale. It was hypothesized that gait quality and fear of falling would change when using walking poles compared to usual assistive device. The results of the study offer insight about whether or not walking poles provide the benefits that are advertised in the media.

CHAPTER II: LITERATURE REVIEW

Walking Poles

To our knowledge there is no evidence supporting the use of walking poles as an alternative gait assistive device for older adults. However, there is a body of research showing the benefits of using walking poles for exercise. They have been shown to improve cardiovascular fitness, lessen load forces on the lower extremities, and alter gait mechanics. Walking poles have also been shown to be beneficial for use in specific patient populations, including those with cardiovascular disease, Parkinson's disease, and stroke.

The use of walking poles for exercise appears to be the most researched aspect of use. A number of studies support the use of walking poles to supplement exercise. A study by Willson et al examined the effects of walking poles on gait mechanics.[3] Specifically, loading of the knee and gait kinematics were measured with a variety of pole handling techniques. The subjects in this small trial of young healthy adults ambulated with the poles in four conditions to determine how gait mechanics were altered. The conditions included: walking without poles at a self-selected pace, walking with poles at a self-selected pace with minimal instruction, controlled velocity with additional instruction, and controlled velocity with poles angled forward. A three-dimensional motion analysis system and a force platform were utilized for data collection. Results showed that there were statistically significant increases in gait speed, stride length, and stance time between the conditions where no instruction was given compared to the other three conditions. This may indicate that formal instruction may be necessary prior to beginning walking pole use to promote maximum benefit. Furthermore, ground reaction force braking, average vertical ground force reaction, and compressive knee joint reaction forces decreased in all conditions compared to no pole use. It was determined that the use of walking poles during ambulation produced equal or decreased loading of the lower extremities despite increasing gait velocity. It was concluded that walking poles can be beneficial for exercise, and the reduction of lower extremity loading may provide a less harmful form of exercise training.[3]

Another study by Porcari et al examined the potential exercise benefits of walking poles.[7] In this study, subjects' use of walking poles elicited a greater physiologic response to exercise compared to walking without poles. Variables of oxygen consumption, heart rate, caloric expenditure, respiratory exchange ratio, and rate of perceived exertion were monitored during sub-maximal walking trials with and without poles. In all variables measured, physiological response with walking poles was significantly greater than without poles. The largest overall increases in responses were seen in maximal oxygen consumption measured by VO_2 max and caloric expenditure, which had 23 percent and 22 percent increases, respectively. Authors concluded that using walking poles during exercise can allow individuals to exercise at a lower intensity while eliciting similar physiological benefits as those seen when exercising at a higher intensity.[7]

In contrast to research conducted in healthy populations, a number of studies have examined the use of walking poles in individuals with chronic conditions. Two studies examining individuals with intermittent claudication secondary to peripheral arterial disease show promising functional gains with the use of walking poles.[8,9] In a study of male patients, Oakley et al examined differences in maximum distance walked and distance walked before onset of claudication pain with and without poles over a treadmill.[9] While using walking poles, patients walked significantly further before onset of claudication. Maximum ambulation distance also increased. Cardiopulmonary variables were also monitored, and showed that VO_2, volume air expired, and peak oxygen pulse also increased significantly. This study yet again shows the potential for poles to evoke greater cardiopulmonary work, even in a diseased population. It was suggested that walking poles may be a useful method for improving cardiovascular fitness in individuals suffering from claudication pain, especially since this population may otherwise be unable to ambulate a sufficient distance to gain fitness benefits.[9]

A randomized control trial followed a similar group of subjects over more long-term use of walking poles for exercise.[8] In this study, subjects followed a walking pole exercise program consisting of supervised training for 24 weeks, compared to a control group who received bi-weekly checkups to measure ankle brachial index without exercise intervention. Within four weeks the exercise group showed a statistically significant increase in exercise duration, measured by both symptom-limited and constant-work treadmill tests. Walking pole use was also shown to significantly increase oxygen consumption in the exercise group by week 16.[8]

Other uses for walking poles in patients with cardiovascular issues include using poles in cardiac rehabilitation. In examining males recovering from an acute coronary incident, a randomized control trial by Kocur et al showed that exercise with walking poles improved the subjects' functional outcomes following a three week long program compared to a standard rehabilitation program and a walking program without poles.[10] Outcome measures included: energy expenditure based on heart rate and belt accelerometer, exercise capacity measured by VO_2Max on a treadmill, and Fullerton Functional Fitness Test (FFT), which includes components of the Timed Up and Go, 30-second chair stand, and 6 Minute Walk Test. Scores on the FFT improved significantly in all subjects in both walking groups. Furthermore, the walking pole group performed statistically better on the chair stand and up and go components of the FFT compared to the control and walking groups, indicating that the use of walking poles may produce higher functional benefits to patients. The use of walking poles was found to improve exercise capacity and endurance in subjects participating in cardiopulmonary rehabilitation.[10]

In addition to research in cardiovascular patients, subjects using walking poles have been examined to determine usefulness in those with neurologic pathologies. Two studies examining the use of walking poles in individuals with Parkinson's disease show benefits to health and well-being.[11,12] In a study of elderly individuals with early Parkinson's disease, van Eijkeren et al found that exercise with walking poles increased walking speed, timed walking distance, Timed Up and Go score, and quality of life with no evidence of adverse training effects.[12] The 19 subjects in this study received six weeks of an exercise program with poles twice weekly. Walking poles were shown to be a safe and effective device to lessen inactivity and reduce debilitating effects of this progressive motor disease. Similarly, Baatale et al found that exercising with walking poles for eight weeks in patients with stage 1-3 Parkinson's disease increased quality of life and scores on the Unified Parkinson's Disease Rating Scale, which is a measure of disease severity.[11] However, the number of participants in the study was very low (n=6).

It also appears that walking poles are used as an assistive device in the rehabilitation setting with little apparent validation. Allet et al examined the usefulness of walking poles in early rehabilitation with subjects with hemiparesis post-stroke.[13] In this study, gait parameters, Six-Minute Walk, and subjective report of usefulness of assisted device were evaluated comparing the use of different assistive devices. The devices included: single-end cane, quad cane, and single walking pole navigated with the unaffected upper extremity. Results showed that the walking pole elicited similar gait symmetry and step length compared to the other assistive devices. However, subjective reports indicated that subjects preferred either cane over the walking pole. Nonetheless, authors concluded that a walking pole seemed to be a viable assistive device, but is not necessarily the best device to use in the acute stroke population.[13]

Research has examined the effect that walking pole use can have on chronic low back pain. A randomized control trial by Hartvigsen et al recruited subjects with low back and/or leg pain from an outpatient clinic.[14] The 136 patients were randomized into three groups: supervised nordic walking twice each week, one-hour instruction on nordic walking and advice to perform at home at patient discretion, or oral advice to remain active. Although statistical improvements were seen in all groups on the Low Back Pain Rating Scale and the Patient Specific Function Scale, there were no statistically significant differences between the groups. Nonethelss, the authors suggested that nordic walking may potentially be a beneficial form of exercise for those with chronic back pain.[14]

Gait Characteristics

Several studies have been conducted comparing gait characteristics in the elderly population. Gait characteristics such as slow gait speed and short stride length have been correlated with fear of falling and falls. However, it is still unknown whether these characteristics are present before a fall or are a result of a fall. The following three studies attempt to address this question.

In a prospective cohort study conducted by Maki, gait changes were compared in 75 older adults in order to see if these changes correlated with predictors of falls or indicators of fear.[6] It was hypothesized that gait changes that are thought to increase stability (decreased stride length and speed and increased stride width and double support time) would be associated with pre-existing fear of falling, but not be independently associated with future falls. The gait component of the assessment was videotaped and then scored later. Each subject wore their own footwear, along with a slipper with three custom made footswitches, in order to record temporal parameters. These footswitches were glued in three places across the width of the sole: under the toes, metatarsal heads, and heel. Three felt pads, saturated with ink, were glued to each footswitch to record spatial parameters. Logistic regressions were used to compare the dependent variables of future falling or pre-existing fear of falling with each of the 11 gait measures (10 spatial-temporal measures and the gait assessment score). The 10 spatial-temporal gait measures included: initiation of gait, step length, step height, step width, step symmetry, step continuity, straightness of path, trunk sway, ability to turn around, and the ability to pick up speed. The conclusion of this study supported their hypothesis. It was found that shorter stride length, slower velocity, and longer double support time were associated with fear of falling, but were not predictive of future falls.[6]

In another study by Wolfson et al., a group of 49 nursing home residents was observed, including 27 with a recent fall history and 22 controls.[15] Their gait was assessed using the Gait Abnormality Rating Scale (GARS) and compared with gait velocity and stride length. Participants were videotaped in order for their gait to be analyzed for velocity and stride length and also by the GARS. Significant differences were found between fallers and controls for both gait velocity (fallers 0.37 m/s, controls 0.64 m/s, $p < .001$) and stride length (fallers 0.53m, controls 0.82m, $p < .001$). In terms of the GARS, fallers were consistently found to have more impairments compared to the control group. Mean GARS scores were significantly higher, which indicated more gait impairments. Based upon their findings, the authors concluded that the nursing home residents with a history of falls had slower gait velocity, shorter stride length, and poorer gait quality compared to the control group.[15]

Gait characteristics among hospitalized people were examined by Guimaraes and Isaacs.[16] The individuals in this study included both older and younger individuals who were hospitalized for falls or other reasons. The gait characteristics studied were velocity, step frequency, step length, and stride width. Gait velocity and step frequency were recorded using a stopwatch. Step length and stride width were recorded by applying ink soaked, absorbent material to the heels of each shoe, and observing the imprint created on the mat. The results showed that people who were in the hospital due to a fall walked significantly slower than those who were hospitalized not due to a fall. Both of these groups walked slower than the controls as well as the non-hospitalized fallers. In terms of step length, the hospitalized elderly had the shortest step length, followed by the non-hospitalized elderly, and then the controls. There was no significant difference in step length between the hospitalized elderly, whether they were fallers or non-fallers. The conclusion of this study was that the people who had sustained a fall and were subsequently admitted to the hospital had slow gait speed, short step length, narrow stride width, a wide range of frequency, a wide degree of variability of step length, and variability increased with frequency. This study suggested that longitudinal studies be conducted to determine if these gait abnormalities precede or succeed a fall.[16]

Fear of Falling

Fear of falling in older adults has been extensively researched and is an established risk factor for incidence of falls.[5,17,18] According to Walker and Howland, older individuals rank fear of falling as their biggest fear when weighed against other common fears experienced by older adults, including robbery and financial difficulties.[5,19] Fear of falling is associated with increased frailty in older adults due to reduction in physical activity, leading to decreased strength, which further increases the older individual's risk for experiencing a fall.[5,20] In addition to being a risk factor for falls, studies have demonstrated changes in spatial and temporal gait parameters in older individuals who fear falling. Changes in gait parameters such as decreased stride length, reduced gait speed, and increased double-limb support time are significantly associated with a pre-existing fear of falling.[5,6] According to Chamberlin et al, gait deviations further impact an individual's ability to move about safely, and thus increase the probability of falling.[5]

Due to the prevalence of fear of falling in older individuals, Kressig et al conducted a study to determine whether associations between demographic, functional, and behavioral characteristics, and fear of falling exist in older adults.[18] This cohort study included 287 subjects aged 70 years and older who had reported a fall in the previous year. Data was collected regarding subject demographics, medical status, behavioral characteristics, and functional abilities. Fear of falling was measured using the Falls Efficacy Scale (FES) and Activities-Specific Balance Confidence Scale (ABC). Functional tests included a timed 360^{o} turn, functional reach, and timed 10-meter walk. Results of the study showed that approximately half of the participants (50.1% for the FES and 48.1% for the ABC) expressed apprehension regarding falling according to the tasks described in the FES and ABC. Using a multivariable logistic regression model, individuals who were fearful of falling were more likely to be depressed, use an assistive device, and display reduced gait speed. Age was not found to have an association with fear of falling.[18] This result is contradictory to outcomes from another study by Friedman et al that indicated age does predict fear of falling.[17]

A cohort study by Friedman et al was conducted with the aim of establishing the temporal relationship between fear of falling and falls.[17] A second objective of this study was to assess whether fear of falling and falls share predictive factors. The 2,212 community-dwelling participants ages 65 to 84 were assessed using a home-based questionnaire and clinic evaluation both at baseline and 20 months later. Comorbidities and pain were established by self-report. Neuropsychiatric status was determined using the Mini-Mental State Examination and the General Health Questionnaire, a screening tool that includes questions regarding depression, anxiety and other mental health conditions. Physical performance testing included knee extensor and hip flexor strength measurements, vibratory sensation, gait speed, and balance. Fear of falling was established by asking the following question: "Apart from being in a high place, in the past 12 months have you been worried or afraid that you might fall?" If the participant answered "yes" to this question, the individual was then asked, "Do you ever limit your activities, for example, what you do or where you go, because you are afraid of falling?" After utilization of step-wise logistic regression analyses, the results of the study indicated that falls at baseline were a predictor of fearing falling 20 months later, and that fearing falling at baseline predicted falling at follow-up.[17] These results demonstrate the inter-connected nature of fear of falling and incidence of falls.

Two studies, one by Chamberlin et al and one by Maki, examined whether fear of falling was associated with changes in gait parameters in older adults.[5,6] Chamberlin et al utilized a sample of 95 community-dwelling adults aged 60 to 97 years and separated the subjects into "fearful" and "fearless" groups based on scores on the Modified Falls Efficacy Scale (MFES).[5] Subjects scoring eight and lower on the MFES were placed into the fearful group and subjects scoring greater than eight on the MFES were placed in the fearless group. Spatial and temporal gait parameters including speed, stride length, step width and double-limb support time were measured using the GAITRite® system, a portable, electronic mat that assesses footfall patterns and calculates measurements. Results of the study showed that participants in the fearful group demonstrated significantly slower gait speed, shorter stride length, longer stride width, and longer double-limb support time than the fearless group (all p values $\leq .05$).[5]

In the previously mentioned study conducted by Maki, fear of falling was assessed by asking the question, "Are you afraid of falling?"[6] After taking baseline measurements, subjects were then contacted weekly for one year to determine if any falls had occurred. Results of the study indicate that subjects with pre-existing fear of falling demonstrated significantly decreased stride length and velocity, and increased double-limb support time.[6] These findings are consistent with the study conducted by Chamberlin et al.[5] In addition, Maki found that participants who feared falling scored lower on the gait quality assessment.[6] In their discussion of this result, Chamberlin et al hypothesize that the measurement technique of ink prints utilized by Maki, as opposed to the GAITRite® system utilized by Chamberlin et al, may have influenced the lack of significant increase in stride width found in the Maki study.[5,6]

One randomized, single-blind study conducted by Kressig et al examined whether demographics, functional ability, and behavioral characteristics were associated with fear of falling in older adults transitioning to frailty.[18] This study involved 17 men and 270 women, all aged 70 or older, from 20 different independent living facilities. It compared the effects of intense Tai Chi training with education on the occurrence of falls and specific behavioral, functional, and biomechanical measures. Subjects were followed for one year. For each individual, demographic, medical, functional, and behavioral data were collected. Then a functional assessment was conducted including single limb standing, 360 degree turning balance, picking up an object, three chair stands, 10-meter walk, and a functional reach test. The Falls Efficacy Scale was used to assess fear of falling. It was determined that there were indeed associations between fear of falling and demographic, functional, and behavioral measurements.[18]

Considerable variation exists in the literature regarding techniques for measurement of fear of falling. Fear of falling has been determined by asking research participants "yes" or "no" questions such as, "Have you been worried or afraid that you might fall?"[17] Balance confidence scales such as the Falls Efficacy Scale and Activities-Specific Balance Confidence Scale have been used to measure participants' fear of falling.[18] Additionally, a visual analog scale (VAS) has been employed as a tool to objectively measure research subjects' fear of falling.[21,22,23] When measured in millimeters, the VAS has 101 response levels, providing greater potential for detecting small increments of change.

Although a large amount of research supports the validity and reliability of the VAS in measurement of self-reported pain intensity, the VAS has not been validated as a measurement of other subjective states, including fear of falling. Proponents of the VAS emphasize that while the VAS is easy to administer, the scale must be described carefully in order to decrease participant error.[24]

GAITRite®

The GAITRite® walkway system is a widely recognized and commonly used system to measure gait parameters such as speed, cadence, and step length. Several studies have been conducted that show this instrument to be a valid tool to use in various patient populations.

A study by Bilney et al was conducted to determine the validity of the GAITRite® walkway system.[25] The results from the GAITRite® were compared to the Clinical Stride Analyser (CSA), an accepted tool with which to judge reliability and criterion validity of other tools. The study consisted of 25 adults who were told to perform three walking trials at a slow speed, three trials at normal speed, and three at a fast speed. Spatial and temporal measures of gait were collected using both the GAITRite® and the CSA. It was determined that the GAITRite® measures of speed, cadence, and stride length had good concurrent validity.[25]

Another study conducted by Webster et al, examined the psychometric properties of the GAITRite® walkway system for the measurement of averaged individual step parameters of gait.[26] There were 10 subjects, all who had undergone knee replacement at least 12 months prior to study. Subjects were asked to walk at comfortable and fast speeds. Four trials were performed at each speed. Measurements were compared with the Vicon Workstation software to examine the reliability. The Vicon software involves a three-dimensional motion analysis system that records the motion of reflective markers placed on the subjects' shoes. The measurements of velocity, cadence, step length, and step time were recorded. Paired t-tests confirmed that there were no significant differences in step length and step time between the GAITRite® and the Vicon systems.

Intraclass correlation coefficients demonstrated excellent agreement between the two systems. The data showed good concurrent validity of the GAITRite® for speed, cadence, and step length. It also showed concurrent validity for measuring individual footstep data.[26]

Mini Mental State Exam

The Mini Mental State Exam (MMSE) is widely used to assess cognitive status. Although the MMSE cannot replace a complete examination of cognition to diagnose conditions, it can be helpful for identifying individuals who are having cognitive difficulties. The tool examines cognition through items addressing orientation, attention, recall, command following, and language.

In a review analysis, Tombaugh and McIntyre concluded that the MMSE fulfills its role as a brief screening tool to quantify cognitive impairments, but cautions that it cannot be used to diagnose dementia.[27] The authors suggest that a score of 24/30 indicates no cognitive impairment. Similar findings were confirmed by Crum et al, who reports that MMSE scores are related to education level and age as well.[28] Specifically, an inverse relationship between age and scores exists, and the authors also provide reference of median scores for individuals based on years of education.

A study by Folstein et al examined validity and reliability of the MMSE in persons with cognitive syndromes versus normal senior subjects.[29] The MMSE was shown to depict changes over time in patients with improving cognition. In addition, the exam was determined to have good intra and inter-rater reliability of 0.887. Overall, the

MMSE is a valid test of cognitive function since it can separate those with cognitive dysfunction from those without.[29]

Snellen Eye Chart

The Snellen chart is an assessment tool that is used to measure visual acuity. A score of 20/40 or better is considered normal; whereas, a score of 20/50 or worse in the better-seeing eye is considered as visual impairment.[30,31,32] Although the Snellen assessment is quick and easy, the sensitivity of this tool has been questioned.[31,33] The Snellen assessment is performed in good lighting and high contrast which is optimal for vision functioning. However, many daily activities take place in environments with less than optimal lighting.[34] Despite the fact that the sensitivity of the Snellen assessment is weak, it has been accepted as a useful tool to assess vision in the elderly population.[33]

Global Rating of Change

Global rating of change scales are used most commonly to measure patient satisfaction with treatment outcomes in the field of low back pain.[24,35] Evidence suggests that global rating of change scales are a valid and responsive means of measuring participants' perceived benefit of treatment.[24] Despite its extensive use in the field of low back pain, the global rating of change scale has not been employed commonly to assess participants' perceived change in walking quality.

CHAPTER III: METHODS

Approval for this study was received from the St. Catherine University Institutional Review Board (IRB) prior to recruitment of subjects. The assisted living complex at St. Therese Home in New Hope was our community partner for this study.

Design

The design of this research study was a two-group repeated measures.

Subject Population

Twenty-one subjects (7 male; 14 female) volunteered and met inclusion criteria to participate in this study. Participants in this study were community dwelling adults age 60 and older (mean age = 85.4 ± 5.1 yr). Other inclusion criteria included demonstrating better than 20/50 vision through use of the Snellen chart, hearing conversational level verbal directions, moving upper extremities in a pain free and unrestricted motion as required for walking pole use, and scoring at least 24/30 on the Mini Mental State Examination (MMSE) indicating the ability to provide informed consent to participate.

Besides not meeting the above, other exclusion criteria included having a prior history of walking pole training or use, inability to grip walking poles with one or both hands, or the presentation of a gait pattern with asymmetrical strides or asymmetrical lower extremity weight bearing when using the subject's usual assistive device.

There were eight subjects who were screened that did not meet the above criteria and therefore were excluded from this study, most of whom were excluded due to low scores on the MMSE. In addition, there were five subjects who completed the study but were later excluded from data reporting since their usual assistive device was a single end cane (n=3) or two-wheel walked (n=2). These assistive devices were excluded from data reporting because the sample size was too small.

Recruitment Process

Prior to recruitment of subjects and data analysis, the researchers provided an information session to residents of the St. Therese Home. The session lasted approximately thirty minutes and involved a description of the study and methods procedure. Following this information session, community members interested in participating signed up for potential inclusion in the study. The consent form and screening process to determine eligibility took place the day before and the morning of data collection. This process followed the request of the facility administrator who preferred that there not be a posted advertisement.

Screening

Researchers described the research study to the potential subjects, reviewed the consent form, and obtained written consent before proceeding. Following consent, the subject participated in the following screens to determine eligibility:

Vision screen: Researchers used a Snellen chart to screen visual acuity.[30,31,32,33] For this research study a score of 20/50 on the Snellen chart indicates the ability to safely see the GAITRite® mat during data collection. Subjects stood 10 feet from the chart held by the researcher at chest height. Subjects' right and left eyes were tested simultaneously. In order to be eligible to participate, subjects had to correctly read the appropriate line of letters indicating better than 20/50 vision. Subjects were permitted to use corrective eyeglasses.

Hearing screen: Subjects were asked to repeat a spoken sentence, in the context of the MMSE, which was stated using conversational level volume to ensure ability to hear the researcher's voice during the data gathering session. This was primarily a safety precaution.

Upper extremity range of motion screen: Subjects were asked to swing their arms forward and backward to ensure pain-free, unrestricted range of motion for walking pole manipulation.

Memory screen: The Mini Mental State Examination (MMSE) was administered according to test protocol. A score of at least 24/30 was required for participation in this study.[27,28] This was primarily a safety precaution to ensure the subjects had the cognitive capacity to give consent for participation, as well as the capacity to remember the directions provided during the data gathering session. Evidence indicates that a score below 24/30 is indicative of potential cognitive impairment.[28] Researchers solicited feedback regarding the subjects' understanding throughout the data gathering process. If there was any doubt about a subject's understanding, the study was terminated, in a gentle fashion, for that particular subject.

Gait screen: Subjects were asked to verify that they had not previously had experience or training with walking poles. Gait with their usual assistive device was observed to rule out gait asymmetries. Subjects were not required to have used an assistive device in order to participate in this study.

Procedures

Each subject completed three trials of three ambulation sequences for a total of nine walks on the GAITRite® mat. To quantify gait parameters, the GAITRite® walkway system was used. This system consisted of a walkway, a thin mat that was two feet in width and twelve feet in length with a one meter acceleration/deceleration space at each end.

Subjects began by ambulating on the mat with their usual assistive device. After completing the first trial of three ambulation sequences on the mat with their usual device, walking poles were administered off of the GAITRite® mat. During the second trial, subjects completed three walks with the walking poles on the mat. For the third trial, subjects again completed three walks with their usual assistive device on the mat.

To begin the ambulation sequences with the walking poles, subjects were instructed on walking pole use per guidelines set by the manufacturer, and were told to ambulate at a self-selected speed. The following instructions were individually verbalized to familiarize the subjects with walking pole usage: "The initial contact of the walking pole should occur at the same time as contact of opposite foot." In accordance with the study conducted by Willson et al, researchers also demonstrated how the walking poles are properly used.[3] Subjects were given an opportunity to practice using the walking poles until they stated readiness to begin walking on the GAITRite® mat with the walking poles. Subjects were not left alone at any time while using the walking poles. The same style pole was used for each subject. Per manufacturer guidelines, the height of the poles was determined by the subject's height by having the subject stand with his/her elbows flexed to 90 degrees and the tip of the pole on the floor at mid-foot position.[3,4]

Ambulation began and ended at a marked tape line positioned one meter on each end of the GAITRite® walkway. A transfer belt was worn at all times for safety. A researcher provided standby assistance, guarding to the side and slightly behind as the subject ambulated along the GAITRite® walkway. A chair was placed at each end of the walkway to allow subjects to sit and rest as needed. Subjects were encouraged to wear their normal walking shoes. To ensure confidentiality, subjects' identities were concealed by using a coded identification.

Subjects' fear of falling was assessed three times, once following each set of trials with his/her usual assistive device and again following trials with the walking poles. Following the completion of each sequence of trials, subjects were asked to rate fear of falling using a visual analog scale on a piece of white paper with 18 point font (refer to Appendix C). This was measured by having each subject draw a line on the paper somewhere between the ends of the scale labeled “no fear of falling” and “very afraid of falling.”

In addition to fear of falling, global rating of change was verbally assessed after the second trial was completed, in which subjects rated the difference in fear associated with using their usual assistive device as compared to walking poles. The following questions were used to assess global rating of change: “How would you say your quality of walking changed when using the walking poles compared to when you used your usual walker/cane/no device. Was it the same, better, worse?” If subjects noted a change, they rated the amount of change on a seven point scale ranging from “no change” to “a great deal worse”. Subjects were then asked “If your walking did change, how important would you say the change was?” They then rated the importance of the change on a seven point scale ranging from “a tiny bit” to “a great deal” (refer to Appendix D).

Data analysis

The GAITRite® walkway recorded each footfall and registered this data into the corresponding computer program. From the recorded trials, the gait parameters were averaged. Specifically, the gait parameters of velocity, stride length, double stance time, base of support, and percent gait cycle were included for data analysis.

Fear of falling was analyzed by measuring the length, in millimeters, from the start of the line to the subject’s marked line. From the compiled measurements, averages were figured.

The Number Cruncher Statistical Software (NCSS) 2004 statistical analysis program was used. Differences in gait speed, stride length, base of support, double stance time, fear of falling, and global rating of change were analyzed using a two-sample t-test to determine differences between groups. The same variables were analyzed using a paired t-test to determine differences within groups. The confidence level, using alpha, was set at 0.05. To determine normality of data, the Omnibus Normality Test was used. In the cases where the data was normal, the t-test was used to determine significance. In the cases where the data was not normal, the Mann-Whitney U test was used to determine significance.

CHAPTER IV: RESULTS

Gait Speed

Figure 1 shows mean gait speed for each assistive device compared with use of walking poles. Within the four-wheel walker group, the mean gait speed with use of the four-wheel walker was 56.47 cm/s while the mean gait speed with use of the walking poles was 36.28 cm/s. On average, gait speed decreased by 35.7% within the four-wheel walker group when walking poles were used. Results of a paired t-test revealed a statistically significant decrease in gait speed with use of the walking poles within the four-wheel walker dependent group ($p = 0.0300$).

Within the non-assistive device dependent group, the mean gait speed when walking with no assistive device was 86.09 cm/s whereas the mean gait speed with use of the walking poles was 66.60 cm/s. The average decrease in gait speed for the non-assistive device dependent group was 22.6%. Upon interpretation of a paired t-test, a statistically significant decrease in gait speed ($p = 0.0005$) was found with use of the walking poles compared to walking with no assistive device in the non-assistive device dependent group.

Although both the four-wheel walker dependent and non-assistive device dependent groups demonstrated statistically significant decreases in gait speed within each group with use of walking poles, results of a two-sample t-test revealed no statistically significant differences between the four-wheel walker and non-assistive device dependent groups for gait speed.

Stride Length

Figure 2 depicts mean stride length for each assistive device compared with use of walking poles. In walking trials with the usual assistive device, the mean stride length was 79.76 cm for the four-wheel walker dependent group. The mean stride length decreased to 71.80 cm for the four-wheel walker dependent group during the trials with walking poles. The average reduction in stride length with use of walking poles was 9.98%. No significant decrease in stride length was found with use of a paired t-test when comparing walking trials with four-wheel walkers to trials with walking poles (p= 0.1822).

Within the non-assistive device dependent group, the mean stride length when walking with no assistive device was 99.18 cm whereas the mean stride length with use of walking poles was 103.34 cm. The average increase in stride length for the non-assistive device dependent group was 4.19%. Upon interpretation of a paired t-test, no statistically significant change in stride length was found with use of the walking poles compared to walking with no assistive device in the non-assistive device dependent group.

Results of a two-sample t-test revealed a statistically significant difference (p= 0.0448) between the four-wheel walker and non-assistive device dependent groups for stride length, with the non-assistive device dependent group demonstrating an increased mean stride length when using the walking poles compared to the four-wheel walker group.

Double-Limb Support

Figure 3 displays mean percentage of gait cycle spent in double-limb support for each assistive device compared with use of walking poles. On average, the percentage of the gait cycle spent in double-limb support was 41.43% for the four-wheel walker dependent group during walking trials with the usual assistive device. With use of walking poles, the percentage of the gait cycle spent in double-limb support increased to an average of 51.31% for the four-wheel walker dependent group. The paired t-test showed a statistically significant increase in the percentage of the gait cycle spent in double-limb support ($p= 0.0209$) within the four-wheel walker dependent group with use of the walking poles.

For the non-assistive device dependent group, the average percentage of the gait cycle spent in double-limb support during walking trials prior to use of the walking poles was 33.25%. With use of the walking poles, the percentage of the gait cycle spent in double-limb support increased to 37.35% on average for the non-assistive device dependent group. The paired t-test showed no statistically significant change in the percentage of the gait cycle spent in double-limb support for the non-assistive device group when using the walking poles.

In comparing the four-wheel walker group to the non-assistive device dependent group, a two-sample t-test showed no significant difference for the change in percentage of the gait cycle spent in double-limb support between the groups when using walking poles compared to the usual assistive device, although a trend toward significance was noted ($p= 0.0760$).

Base of Support

Figure 4 illustrates mean base of support for each assistive device compared with use of walking poles. Within the four-wheel walker dependent group, the mean base of support measurement was 7.73 cm during walking trials with use of four-wheel walkers. With use of walking poles, the mean base of support measured 15.21 cm for the four-wheel walker dependent group. The paired t-test demonstrated a statistically significant increase in base of support of 96.8% (p= 0.0054) with use of the walking poles for the four-wheel walker dependent group.

For the non-assistive device dependent group, the mean base of support measurement was 11.13 cm during walking trials without use of an assistive device. With use of the walking poles, the mean base of support measurement decreased to 10.20 cm. A paired t-test showed no statistically significant change in base of support within the non-assistive device dependent group when using the walking poles (p= 0.9443).

In comparing the four-wheel walker group to the non-assistive device dependent group, a two-sample t-test revealed a statistically significant difference in base of support (p= 0.0015) between the groups when using walking poles compared to the usual assistive device. On average, the base of support for the four-wheel walker group was wider than the average base of support for the non-assistive device dependent group.

Fear of Falling

Figure 5 exhibits mean fear of falling for each assistive device compared with use of walking poles. The mean fear of falling score for the four-wheel walker dependent group was 11.0 mm, as measured with a visual analog scale, during walking trials using four-wheel walkers. After walking trials with use of the walking poles, the mean fear of falling score was 50.5 mm for the four-wheel walker dependent group. A paired t-test showed a statistically significant increase in fear of falling (p= 0.0324) within the four-wheel walker dependent group when walking poles were used.

Within the non-assistive device group, the mean fear of falling score was 3.7 mm for walking trials prior to use of the walking poles. With the walking poles, the mean fear of falling score increased to 18.54 mm for the non-assistive device dependent group. A statistically significant increase in fear of falling (p= 0.0023) was found with use of a paired t-test within the non-assistive device dependent group when using the walking poles.

Analyzed individually, each group demonstrated an increased fear of falling with use of the walking poles compared to the usual assistive device. However, a two-sample t-test revealed no statistically significant differences between the four-wheel walker dependent and non-assistive device dependent groups for fear of falling (p= 0.103).

Correlations

Figures 6 through 20 depict correlations between independent variables. For all participants, Pearson Product Correlations showed moderate, statistically significant correlations between changes in stride length and changes in gait speed (r= 0.682), fear of falling and gait speed (r= -0.573), stride length and percentage of the gait cycle spent in double-limb support (r= -0.728), base of support and stride length (r= -0.565), stride length and fear of falling (r= -0.557), percentage of the gait cycle spent in double-limb support and fear of falling (r= 0.539), Global Rating of Change and percentage of the gait cycle spent in double-limb support (r= -0.543), and Global Rating of Change and fear of falling (r= -0.507).

Pearson Product Correlations displayed good, statistically significant correlations between changes in gait speed and changes in percentage of the gait cycle spent in double-limb support (r= -0.769).

CHAPTER V: DISCUSSION

In this study, subjects' gait characteristics and fear of falling changed when walking poles were used compared to ambulation with usual assistive device. The relationship between fear of falling and gait parameters, as well as their relationship to fall risk, has been and continues to be unclear. Fear of falling is a risk factor for falls, but no direct link between fear of falling and actual incidents of falls has been established.[5] For this reason, we cannot take the results of this study to mean that the change in gait parameters also signified a change in fall risk.

Nonetheless, the results of this study show statistically significant correlations between fear of falling and the gait characteristics of stride length, gait speed, and percentage of gait cycle spent in double-limb support with use of walking poles compared to usual assistive device. Fear of falling increased significantly in both groups when using walking poles. This increased fear of falling may have influenced the subjects' gait characteristics. This partially supports Chamberlin et al who found that fear of falling led to gait changes in older adults, including decreased gait speed, decreased stride length, increased base of support, and increased double-limb support time.[5] However, our walking poles study found no statistically significant correlation between fear of falling and base of support.

In one study, Maki concluded that a wider base of support, or stride width, does not increase stability; rather, this wider base seems to predict an increased likelihood of experiencing falls.[6] Interestingly, in examining the four-wheel walker dependent and non-assistive device dependent groups separately in relation to base of support, the four-wheel walker group showed a statistically significant increase in base of support with walking poles, whereas the non-assistive device dependent group did not. Although definite conclusions cannot be generated to account for these differences between groups, it is speculated that this difference could be attributed to the potential differences in balance between subjects who rely on an assistive device and those who do not. Specifically, it is speculated that someone who relies on an assistive device for ambulation has poorer balance than an individual who ambulates without an assistive device. This speculation is supported by Kressig et al who determined that individuals who are more fearful have an increased likelihood of using an assistive device.[18]

Walking poles have been shown in the literature to positively influence gait characteristics in the young, healthy adult population. Previous research by Willson et al showed that gait speed, stride length, and stance time increased when walking poles were used with minimal training.[3] These results were not supported by either group in our study. However, the subjects who were not dependent upon an assistive device for ambulation demonstrated increased stride length with use of walking poles. This finding of increased stride length in the non-assistive device dependent older adults was consistent with that of the young, active adult population.

Similar to the improvements noted in the Willson study, a study examining older adults with Parkinson's disease by van Eijkeren found improvements in outcomes measuring gait velocity, balance, and endurance after six weeks of formal training with walking poles.[12] Although this study had a closer age range to our study, it raised questions about a potential walking poles training effect. The differences in research findings may potentially be attributed to the minimal training given to subjects in our study, especially considering that the use of walking poles and the GAITRite® were novel experiences.

There were limitations in this study. One limitation was our subject population. The sample size was relatively small. The subject population consisted of only older adults, and therefore the results may not apply to a younger population. Subjects used either a four-wheel walker or no assistive device, thereby limiting the application of results to older adults who use other assistive devices. Secondly, since multiple researchers provided instructions on walking pole use, feedback varied slightly. Another limitation of this study is that, despite the fact that the Global Rating of Change Scale is a validated outcome measure, several of the participants showed difficulty understanding the scale. This may have affected the results of this measure. Lastly, this study did not formally examine balance in conjunction with fear of falling and gait characteristics.

CHAPTER VI: CONCLUSION

The use of walking poles in comparison to usual assistive device use in both four-wheel walker dependent and non-assistive device dependent older adults led to changes in gait characteristics and an increased fear of falling. It is unclear whether or not the demonstrated changes in gait characteristics and the increased fear of falling actually put the subjects at increased risk for falls. Further research is needed to explore the relationship between walking pole use and fall risk in older adults.

Further studies are also needed to determine what type, intensity, and frequency of walking pole training may lead to improved gait characteristics in older adults. In addition, further research may give insight into the long term impact of walking pole use on gait in the older adult population.

REFERENCES

1. U.S. Census Bureau. Population Estimates. http://www.census.gov/popest/national/asrh/NC-EST2009-sa.html. Updated December 7, 2010. Accessed December 7, 2010.

2. Centers for Disease Control and Prevention. http://www.cdc.gov/. Updated December 7, 2010. Accessed December 7, 2010

3. Willson J, Torry M, Decker M, Kernozek T, Steadman J. Effects of walking poles on lower extremity gait mechanics. *Medicine And Science In Sports And Exercise*. 2001;33(1):142-147.

4. Exerstrider. http://www.walkingpoles.com. Updated December 7, 2010. Accessed December 7, 2010.

5. Chamberlin M, Fulwider B, Sanders S, Medeiros J. Does fear of falling influence spatial and temporal gait parameters in elderly persons beyond changes associated with normal aging?. *The Journals Of Gerontology. Series A, Biological Sciences And Medical Sciences*. 2005;60(9):1163-1167.

6. Maki B. Gait changes in older adults: predictors of falls or indicators of fear. *Journal Of The American Geriatrics Society*. 1997;45(3):313-320.

7. Porcari J, Hendrickson T, Walter P, Terry L, Walsko G. The physiological responses to walking with and without Power Poles on treadmill exercise. *Research Quarterly For Exercise And Sport*. 1997;68(2):161-166.

8. Langbein, E, Collins E, Orebaugh C, at al. Increasing exercise tolerance of persons limited by claudication pain using polestriding. *Journal of Vascular Surgery*. 2002; 35:887-893.

9. Oakley C, Zwierska I, Tew G, Beard J, Saxton J. Nordic poles immediately improve walking distance in patients with intermittent claudication. *European Journal Of Vascular And Endovascular Surgery: The Official Journal Of The European Society For Vascular Surgery*. 2008;36(6):689-694.

10. Kocur P, Deskur-Smielecka E, Wilk M, Dylewicz P. Effects of Nordic Walking training on exercise capacity and fitness in men participating in early, short-term inpatient cardiac rehabilitation after an acute coronary syndrome -- a controlled trial. *Clinical Rehabilitation.* 2009;23(11):995-1004.

11. Baatile J, Langbein W, Weaver F, Maloney C, Jost M. Effect of exercise on perceived quality of life of individuals with Parkinson's disease. *Journal Of Rehabilitation Research And Development*. 2000;37(5):529-534.

12. Van Eijkeren F, Reijmers R, Kleinveld M, Minten A, Bruggen J, Bloem B. Nordic walking improves mobility in Parkinson's disease. *Movement Disorders: Official Journal Of The Movement Disorder Society*. 2008;23(15):2239-2243.

13. Allet L, Leemann B, Guyen E, et al. Effect of different walking aids on walking capacity of patients with poststroke hemiparesis. *Archives Of Physical Medicine And Rehabilitation*. 2009;90(8):1408-1413.

14. Hartvigsen J, Morso L, Bendix T, Manniche C. Supervised and non-supervised Nordic walking in the treatment of chronic low back pain: a single blind randomized clinical trial. *BMC Musculoskeletal Disorders.* 2010; 11:30.

15. Wolfson L, Whipple R, Amerman P, Tobin J. Gait assessment in the elderly: a gait abnormality rating scale and its relation to falls. *Journal Of Gerontology*. 1990;45(1):M12-M19.

16. Guimaraes R, Isaacs B. Characteristics of the gait in old people who fall. *International Rehabilitation Medicine*. 1980;2(4):177-180.

17. Friedman S, Munoz B, West S, Rubin G, Fried L. Falls and fear of falling: which comes first? A longitudinal prediction model suggests strategies for primary and secondary prevention. *Journal Of The American Geriatrics Society*. 2002;50(8):1329-1335.

18. Kressig R, Wolf S, Sattin R, et al. Associations of demographic, functional, and behavioral characteristics with activity-related fear of falling among older adults transitioning to frailty. *Journal Of The American Geriatrics Society*. 2001;49(11):1456-1462.

19. Walker J, Howland J. Falls and fear of falling among elderly persons living in the community: occupational therapy interventions. *The American Journal Of Occupational Therapy.: Official Publication Of The American Occupational Therapy Association* [serial online]. February 1991;45(2):119-122.

20. Walston

21. Donat H. Comparison of the effectiveness of two programmes on older adults at risk of falling: unsupervised home exercise and supervised group exercise. *Clin Rehabil*. 2007;21:273-283.

22. Lin MR, Wolf SL, Hwang HF, Gong SY, Chen CY. A randomized, controlled trial of fall prevention programs and quality of life in older fallers. *J Am Geriatr Soc.* 2007;55(4):499-506.

23. Wolf B, Feys H, Weerdt WD. Effect of a physical therapeutic intervention for balance problems in the elderly: a single-blind, randomized, controlled multicentre trial. *Clin Rehabil*. 2001;15:624-636.

24. Ostelo RW, de Vet HC. Clinically important outcomes in low back pain. *Best Pract Res Clin Rheumatol.* 2005 19(4):593-607.

25. Bilney B, Morris M, Webster K. Concurrent related validity of the GAITRite walkway system for quantification of the spatial and temporal parameters of gait. *Gait & Posture*. 2003;17(1):68-74.

26. Webster K, Wittwer J, Feller J. Validity of the GAITRite walkway system for the measurement of averaged and individual step parameters of gait. *Gait & Posture*. 2005;22(4):317-321.

27. Tombaugh T, McIntyre N. The mini-mental state examination: a comprehensive review. *JAGS*. 1992; 40: 922-935.

28. Crum R, Anthony J, Bassett S, Folstein M. Population-based norms for the mini-mental state examination by age and educational level. *JAMA*. 1993; 269: 2386-2391.

29. Folstein M, Folstein S, McHugh P. Mini-mental state. *J Psychiat Res.* 1975; 12: 29-198.

30. Whiteside MM, Wallhagen MI, et al. Sensory impairment in older adults: part 2. Vision loss. Am J Nurs 2006;106:52-61.

31. Kalinowski M. "Eye" dentifying vision impairment in the geriatric patient. *Geriatric Nursing (New York, N.Y.)*. 2008;29(2):125-132.

32. Vitale S, Cotch M, Sperduto R. Prevalence of visual impairment in the United States. *JAMA: The Journal Of The American Medical Association*. 2006;295(18):2158-2163.

33. Squirrell DM, Kenny J, Mawer N, et al. Screening for visual impairment in elderly patients with hip fracture: validating a simple bedside test. Eye 2005;19:55-9.

34. West CG, Gildengorin G, Haegerstrom-Portnoy G, et al. Is vision function related to physical functional ability in older adults? JAGS 2002;50:136-45.

35. Fritz JM, Hebert J, Koppenhaver S, Parent E. Beyond minimally important change: defining a successful outcome of physical therapy for patients with low back pain. *Spine.* 2009;34(25):2803-2809.

FIGURES

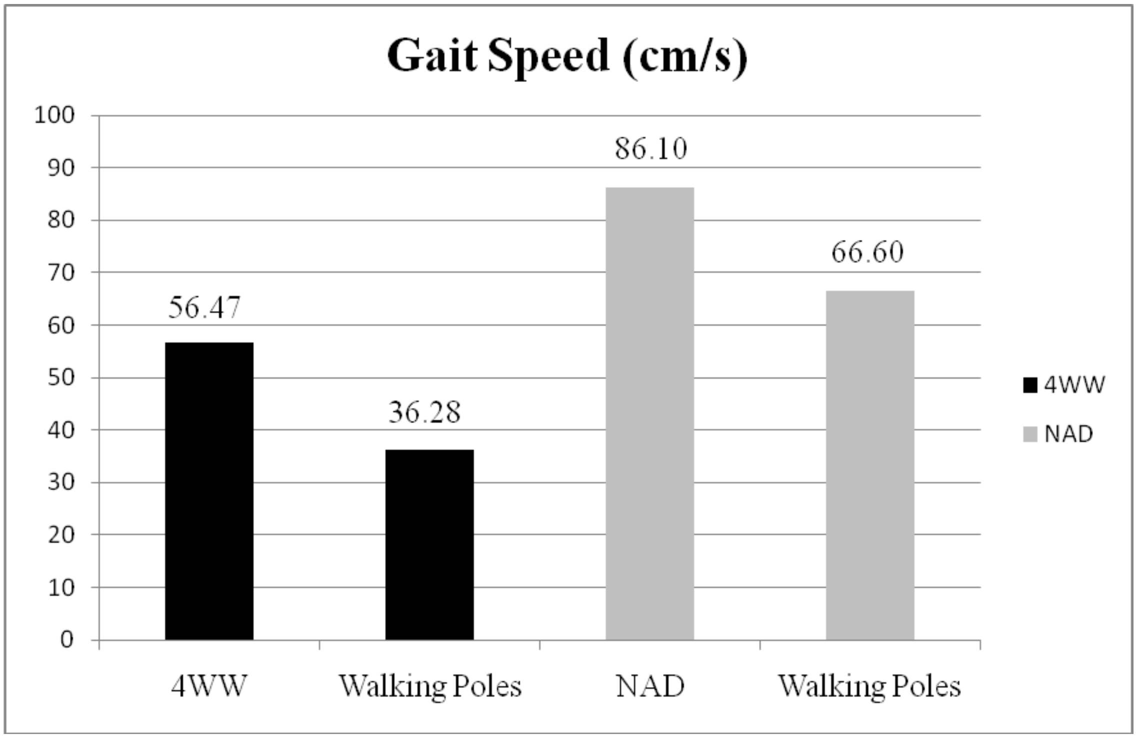

Figure 1. Mean gait speed (cm/s) for each assistive device. Data for the four-wheel walker dependent group is shown in black and data for the non-assistive device dependent group is shown in gray. A statistically significant decrease in gait speed of 35.7% ($p= 0.030$) was found within the four-wheel walker dependent group and a statistically significant decrease in gait speed of 22.6% ($p= 0.0005$) was found within the non-assistive device dependent group when using the walking poles. In comparing the four-wheel walker group to the non-assistive device dependent group, no significant difference for gait speed was found between the groups when using walking poles compared to the usual assistive device.

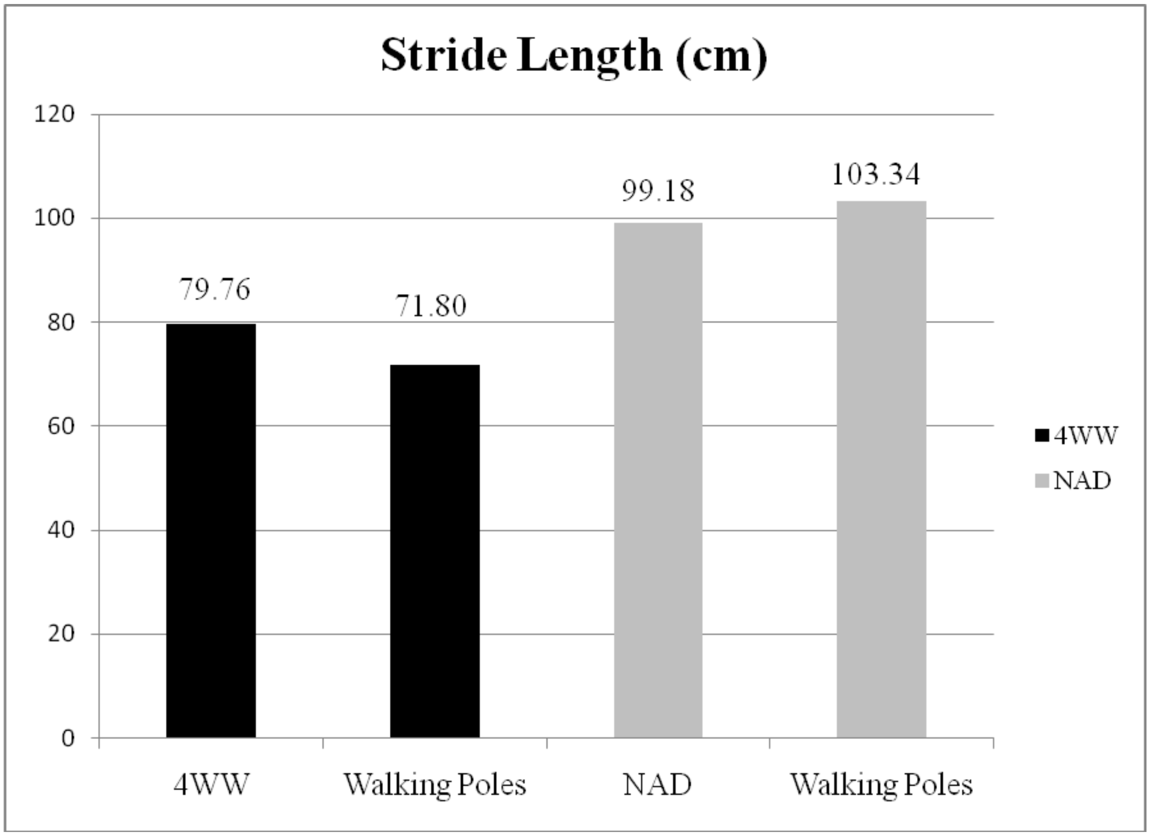

Figure 2. Mean stride length (cm) for each assistive device. Data for the four-wheel walker dependent group is shown in black and data for the non-assistive device dependent group is shown in gray. No significant decrease in stride length was found within the four-wheel walker dependent group when using the walking poles versus the four-wheel walker (p= 0.1822). No significant change in stride length was found within the non-assistive device dependent group (p= 0.1867). However, a statistically significant difference (p= 0.0448)was found between the four-wheel walker and non-assistive device dependent groups for stride length, with the non-assistive device dependent group demonstrating an increased mean stride length when using the walking poles compared to the four-wheel walker group.

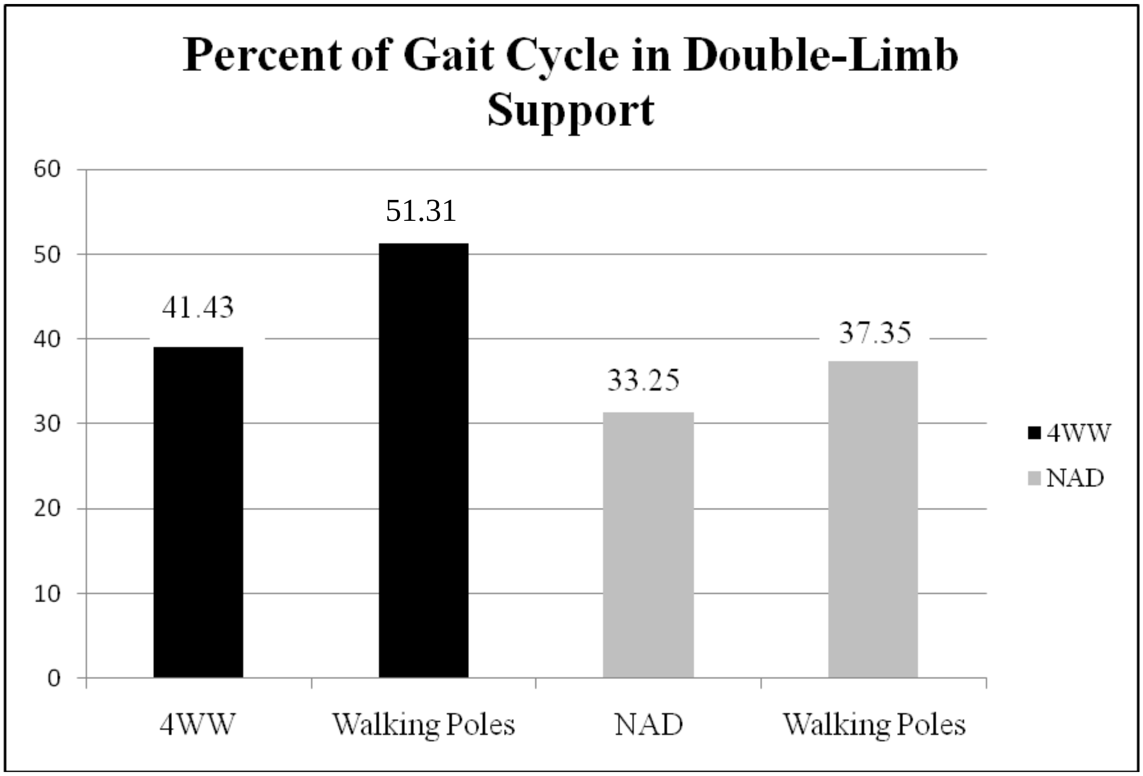

Figure 3. Mean percentage of gait cycle in double-limb support for each assistive device. Data for the four-wheel walker dependent group is shown in black and data for the non-assistive device dependent group is shown in gray. A statistically significant increase in percentage of gait cycle spent in double-limb support of 23.8% (p= 0.0209) was found within the four-wheel walker dependent group. No significant increase in double support was found within the non-assistive device dependent group when using the walking poles (p= 0.0935). In comparing the four-wheel walker group to the non-assistive device dependent group, no significant difference for double limb support was found between the groups when using walking poles compared to the usual assistive device, although a trend toward significance was noted (p= 0.0760).

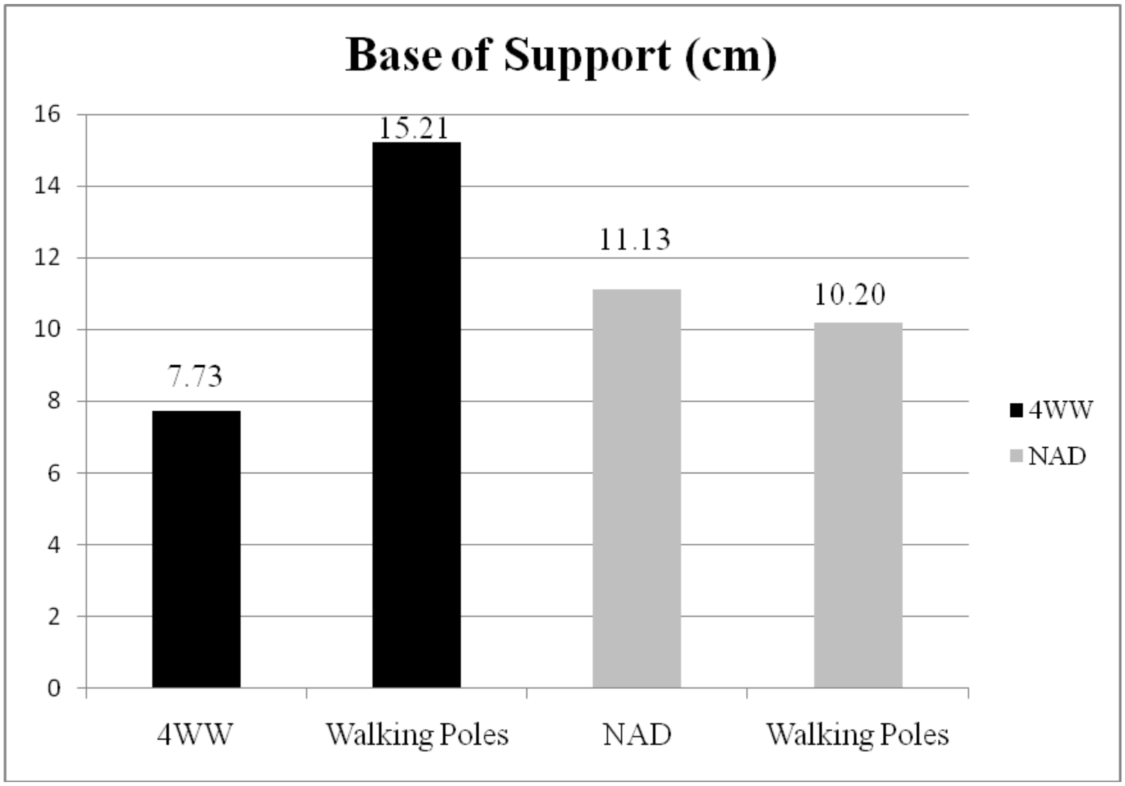

Figure 4. Mean base of support (cm) for each assistive device. Data for the four-wheel walker dependent group is shown in black and data for the non-assistive device dependent group is shown in gray. A statistically significant increase in base of support of 96.8% (p= 0.0054) was found within the four-wheel walker dependent group when using the walking poles compared to the four-wheel walker. No statistically significant change in base of support was detected within the non-assistive device dependent group when using the walking poles. In comparing the four-wheel walker group to the non-assistive device dependent group, a statistically significant difference in base of support (p= 0.0015) was found between the groups when using walking poles compared to the usual assistive device. On average, the base of support for the four-wheel walker group was wider than the average base of support for the non-assistive device dependent group.

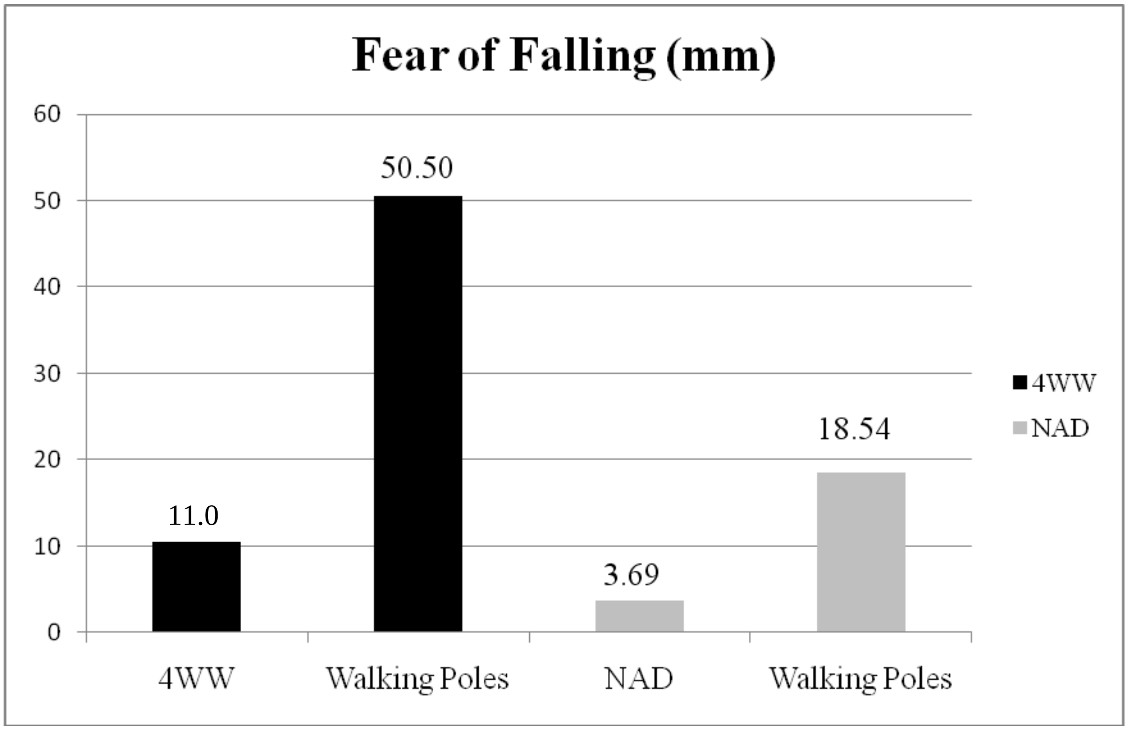

Figure 5. Fear of falling score determined by visual analog scale (mm) for each assistive device. Data for the four-wheel walker dependent group is shown in black and data for the non-assistive device dependent group is shown in gray. A statistically significant increase in fear of falling (p= 0.0324) was found within the four-wheel walker dependent group and a statistically significant increase in fear of falling (p= 0.0023) was found within the non-assistive device dependent group when using the walking poles. In comparing the four-wheel walker group to the non-assistive device dependent group, no significant difference in fear of falling was found between the groups when using walking poles compared to the usual assistive device.

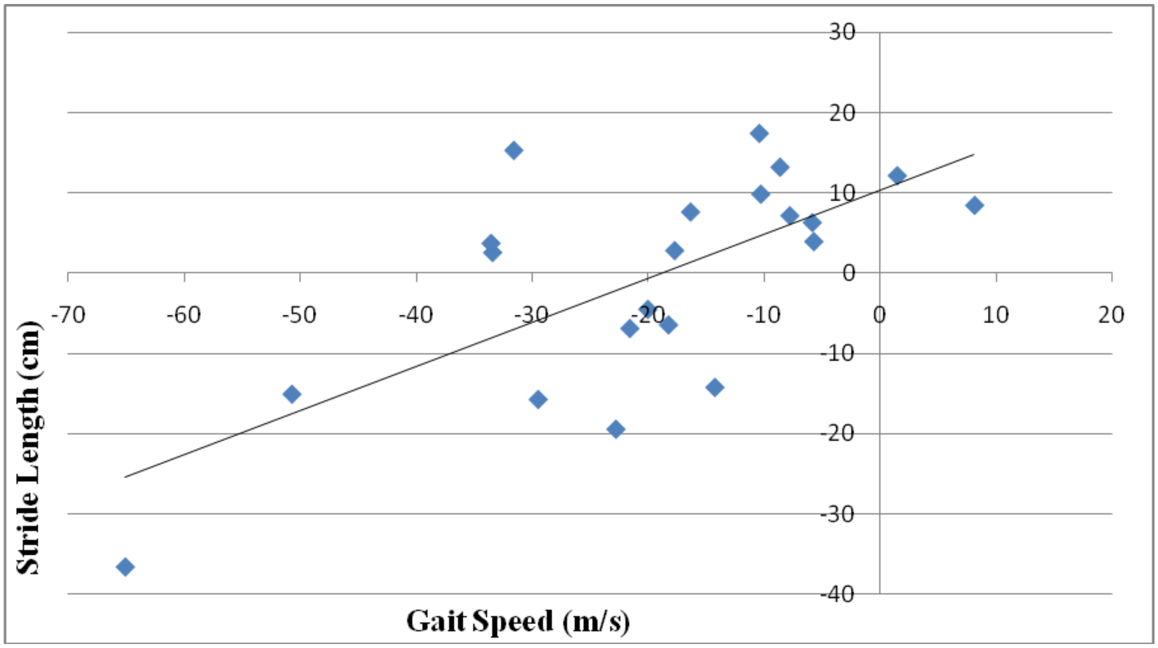

Figure 6. A statistically significant relationship between gait speed and stride length with the use of usual assistive device compared to use of walking poles (r= 0.681702, p= 0.000666).

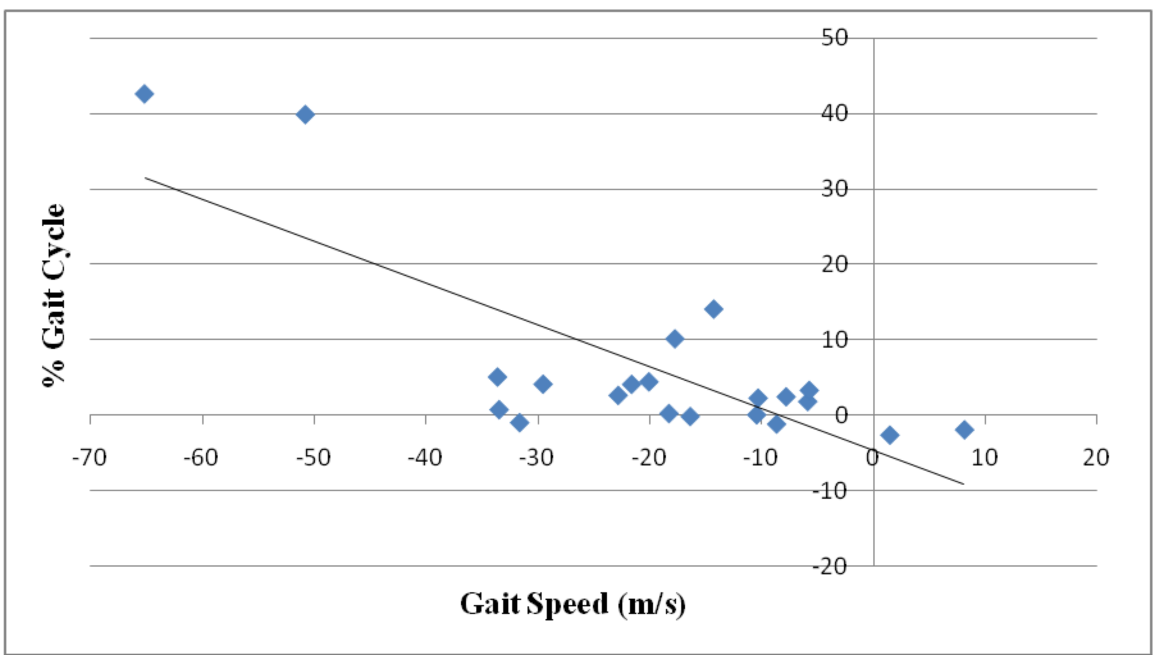

Figure 7. A statistically significant relationship between gait speed and percent gait cycle with the use of usual assistive device compared to use of walking poles (r= -0.768515, p= 0.000047).

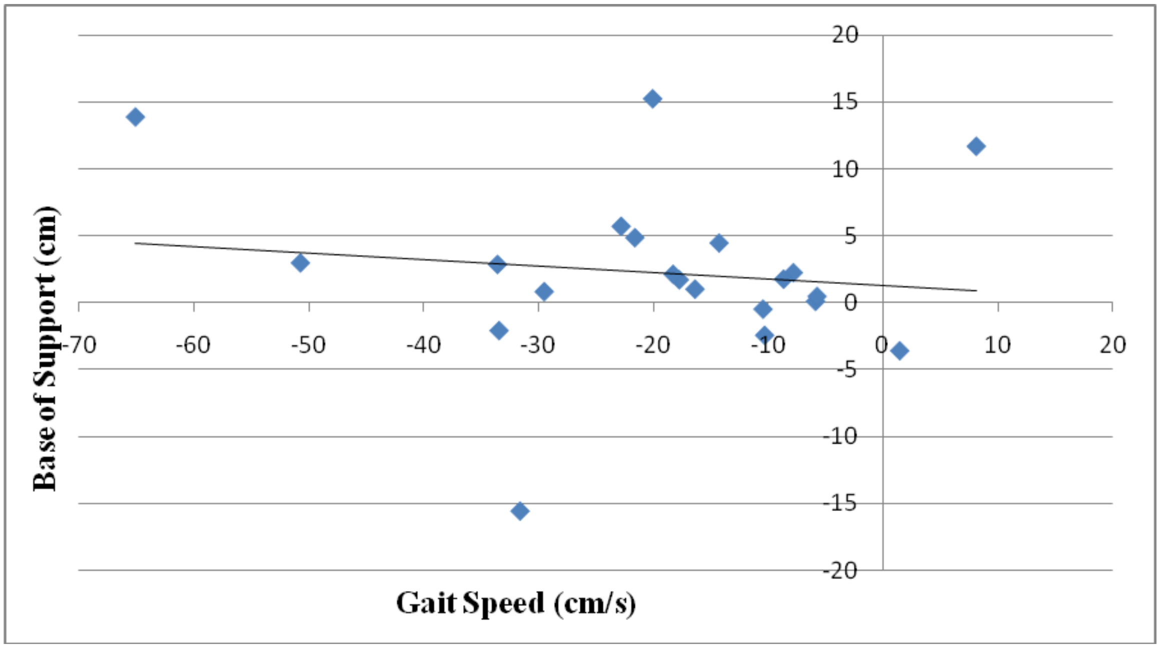

Figure 8. No statistically significant relationship between gait speed and base of support with the use of usual assistive device compared to use of walking poles (r= -0.127069, p= 0.583088).

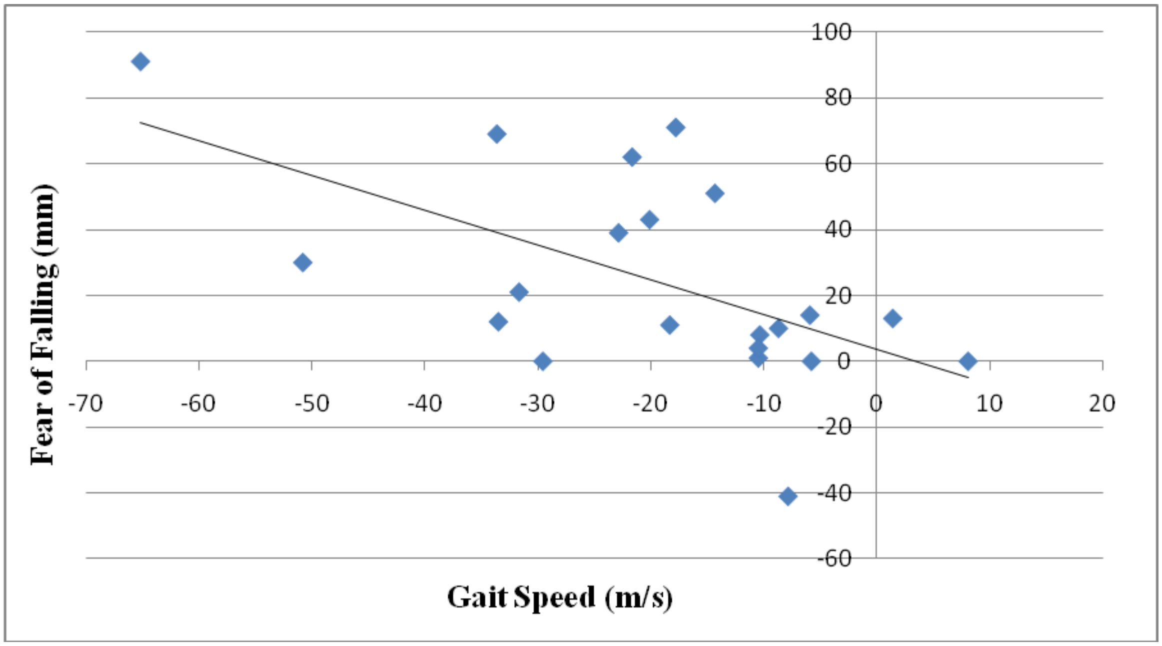

Figure 9. A statistically significant relationship between gait speed and fear of falling with the use of usual assistive device compared to use of walking poles (r= -0.573, p= 0.0066).

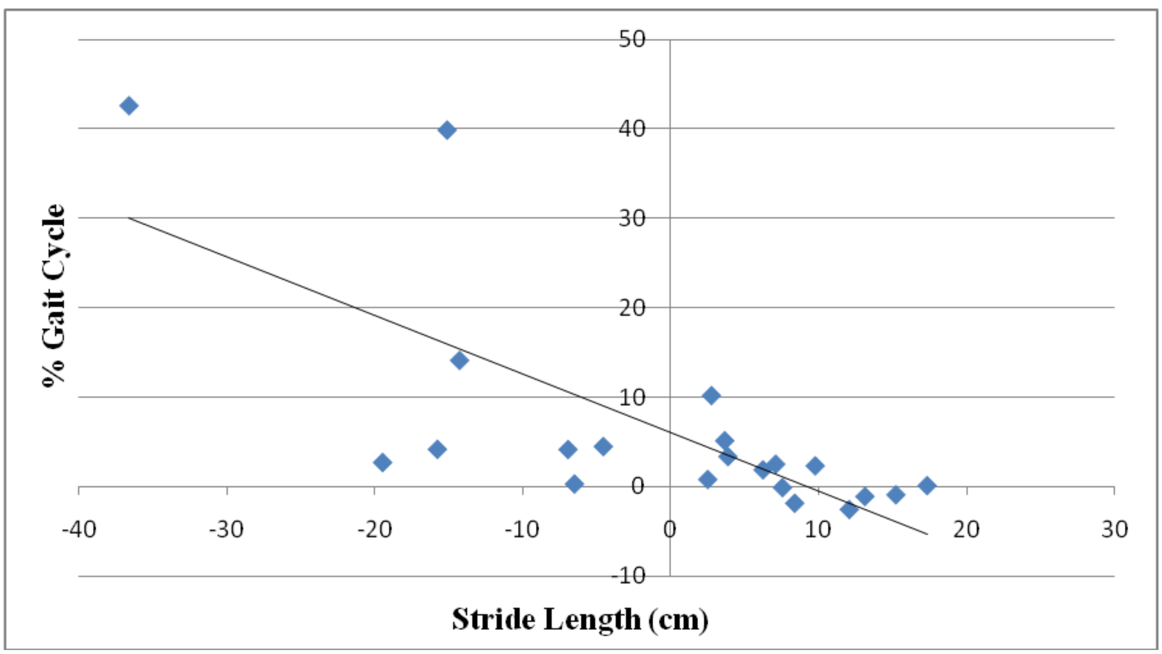

Figure 10. A statistically significant relationship between stride length and % gait cycle with the use of usual assistive device compared to use of walking poles (r= -0.728425, p= 0.000181).

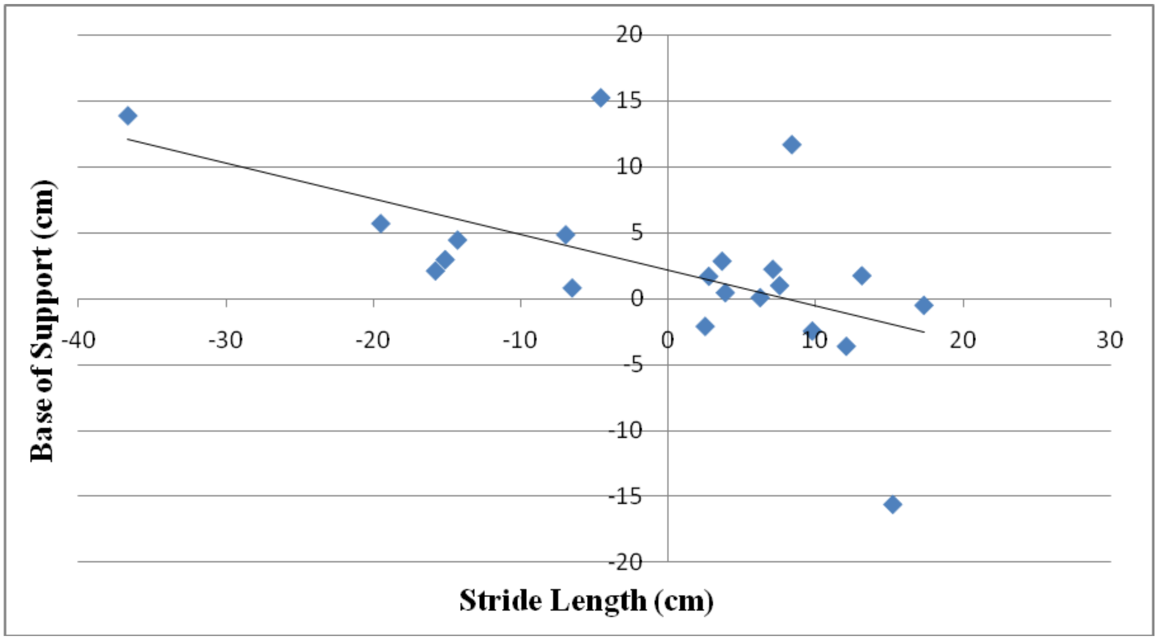

Figure 11. A statistically significant relationship between stride length and base of support with the use of usual assistive device compared to use of walking poles (r= -0.565168, p= 0.007591).

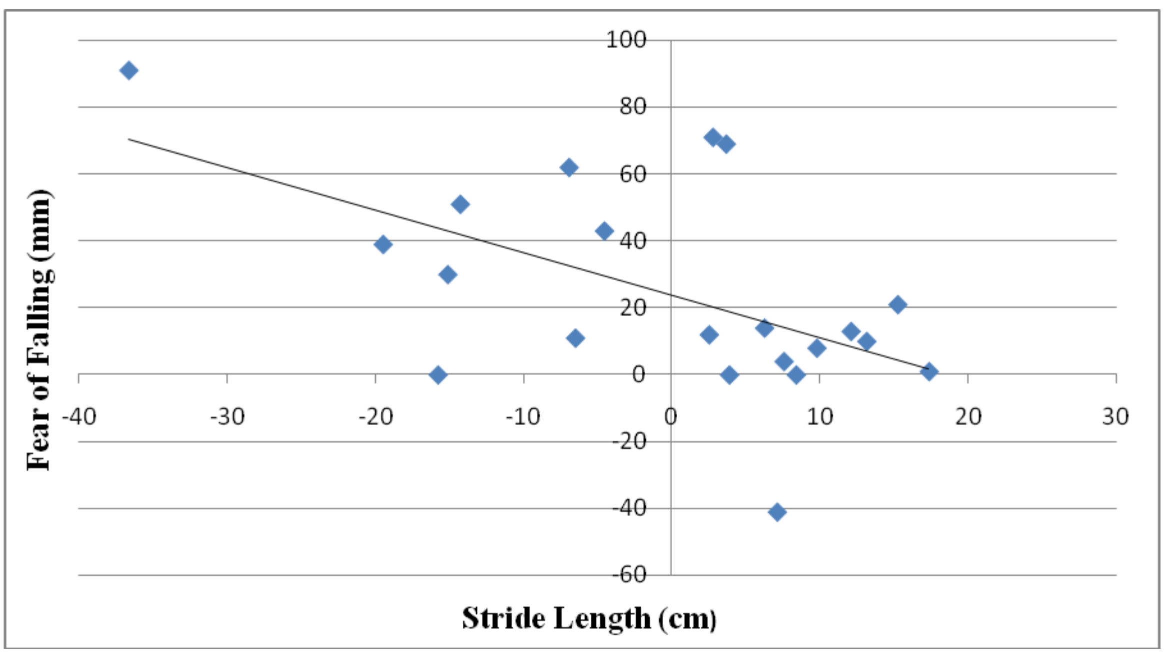

Figure 12. A statistically significant relationship between stride length and fear of falling with the use of usual assistive device compared to use of walking poles (r= -0.557292, p= 0.008676).

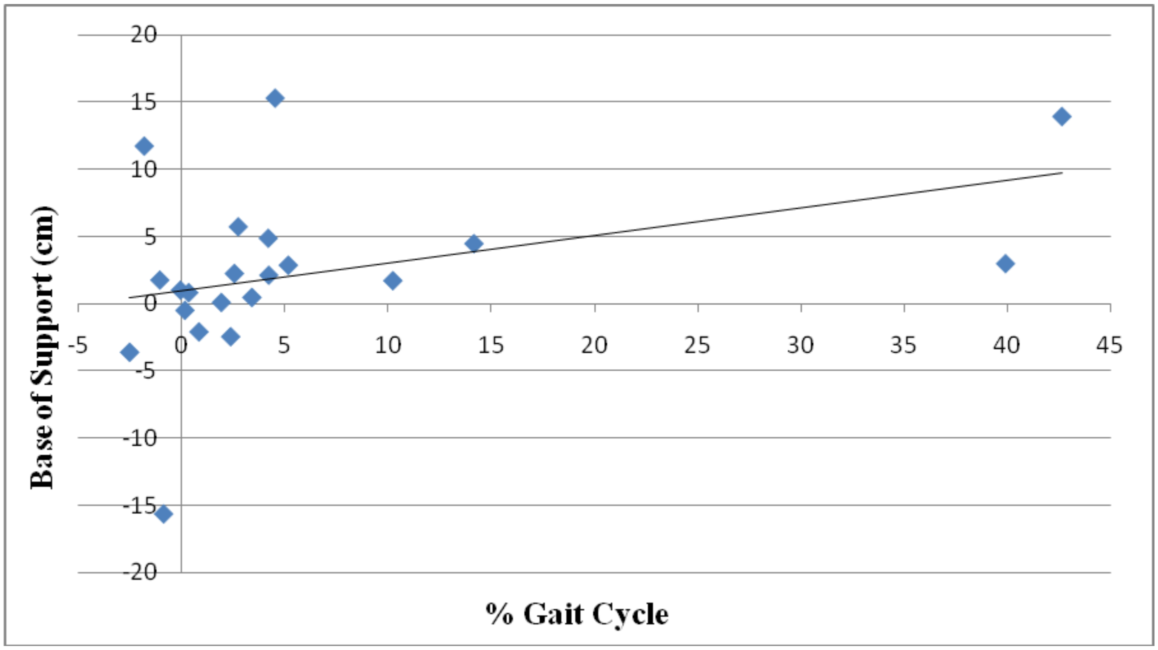

Figure 13. A fair, non-statistically significant relationship between percent gait cycle and base of support with the use of usual assistive device compared to use of walking poles (r= 0.387904, p= 0.082293)

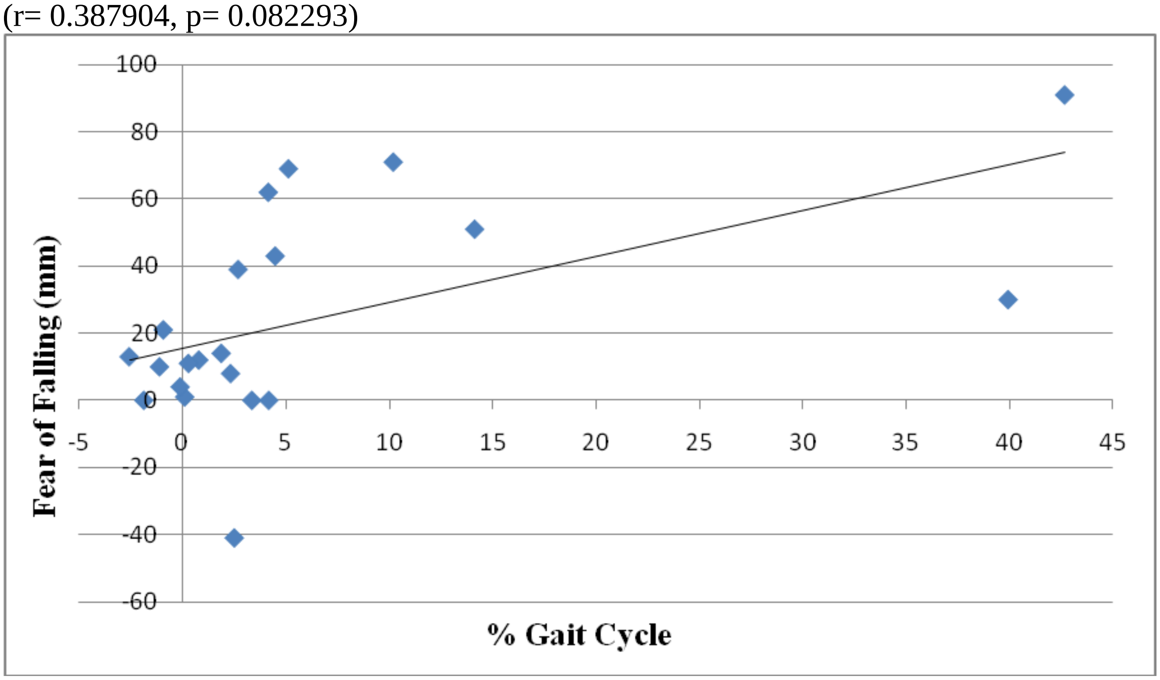

Figure 14. A moderate, statistically significant relationship between percent gait cycle and fear of falling with the use of usual assistive device compared to use of walking poles (r= 0.538902, p= 0.011711).

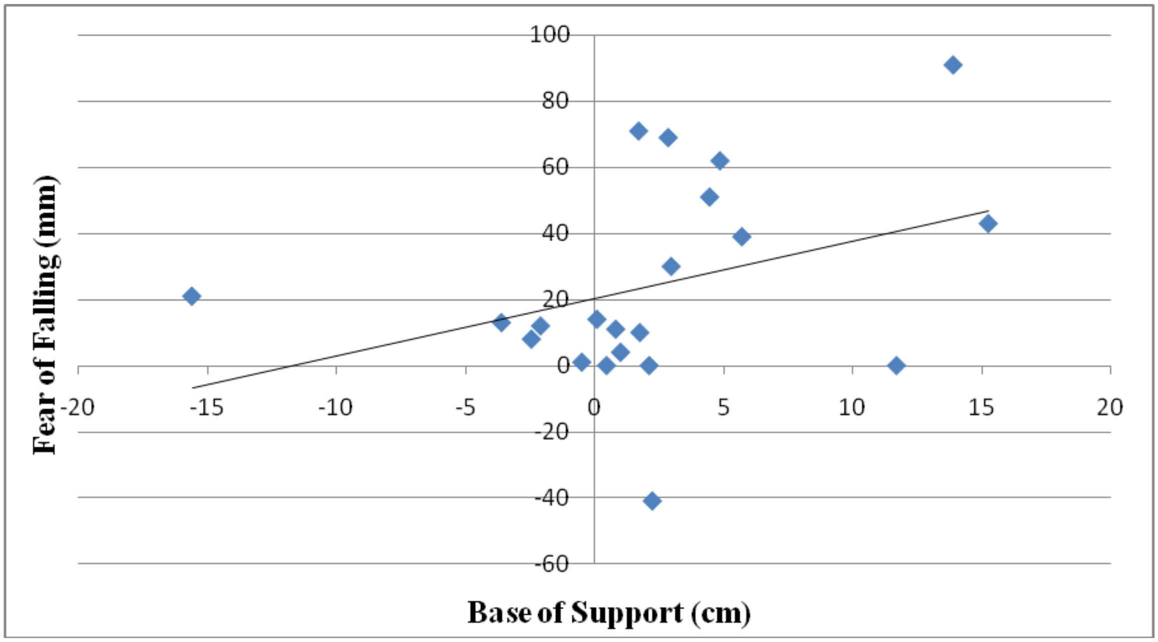

Figure 15. A fair, non-statistically significant relationship between base of support and fear of falling with the use of usual assistive device compared to use of walking poles (r= 0.363109, p= 0.105693).

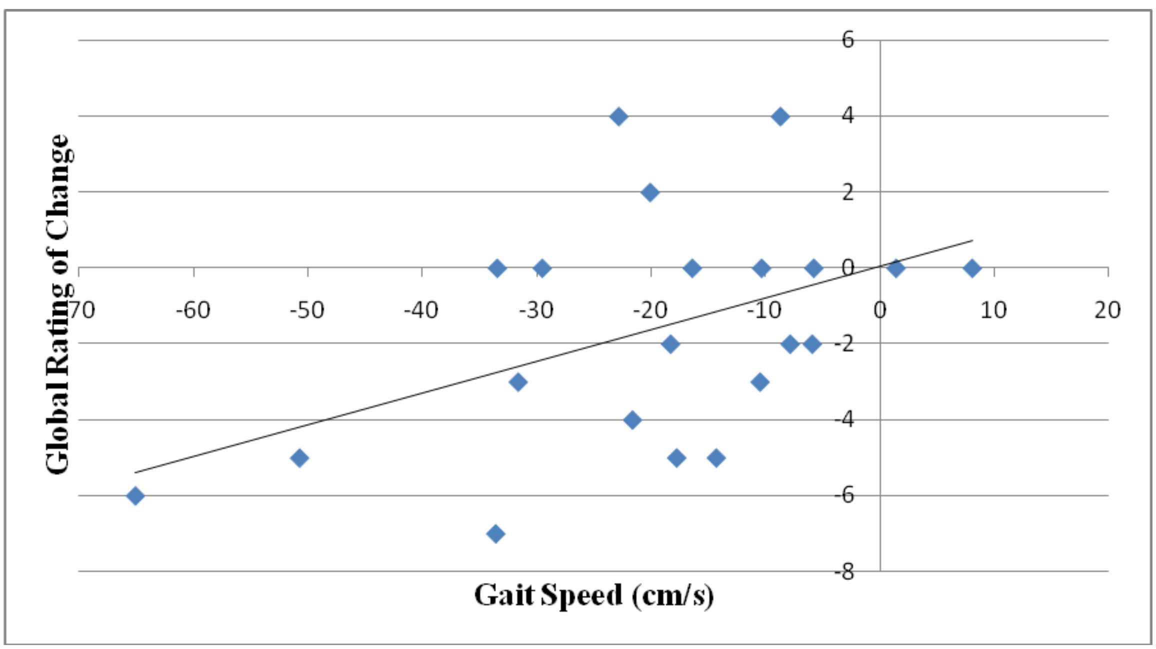

Figure 16. A statistically significant relationship between changes in gait speed and perceived change in walking quality measured with Global Rating of Change Scale. (r= 0.462091, p= 0.034948)

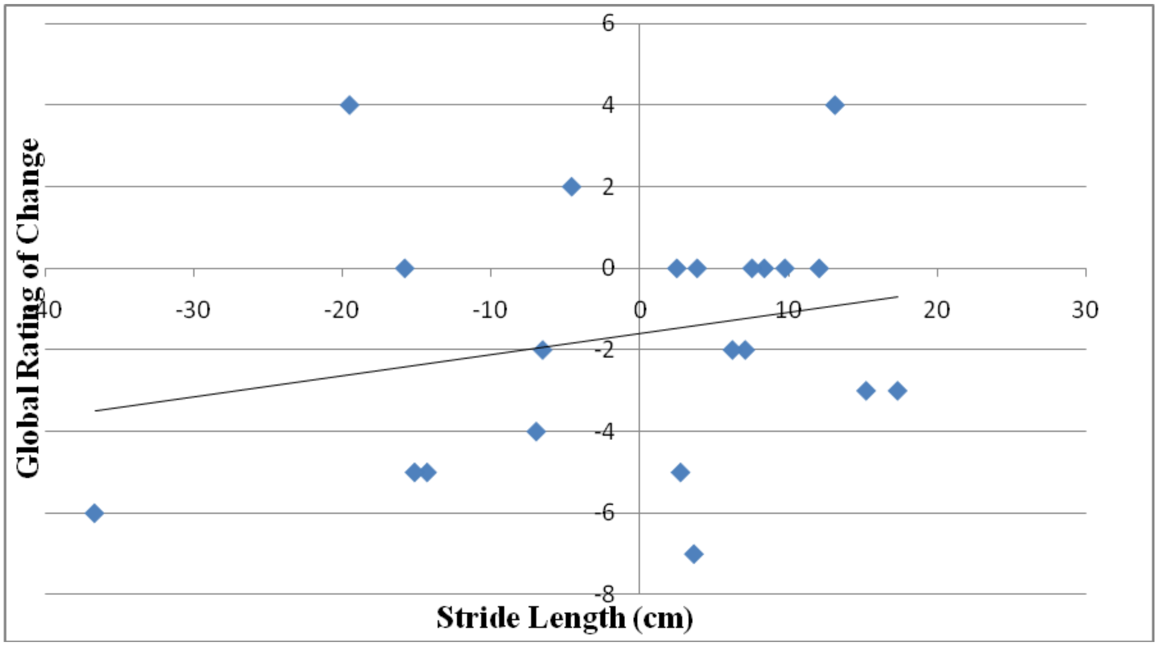

Figure 17. A fair relationship between changes in stride length and perceived change in walking quality measured with Global Rating of Change Scale that was not statistically significant. (r= 0.232309, p= 0.310899)

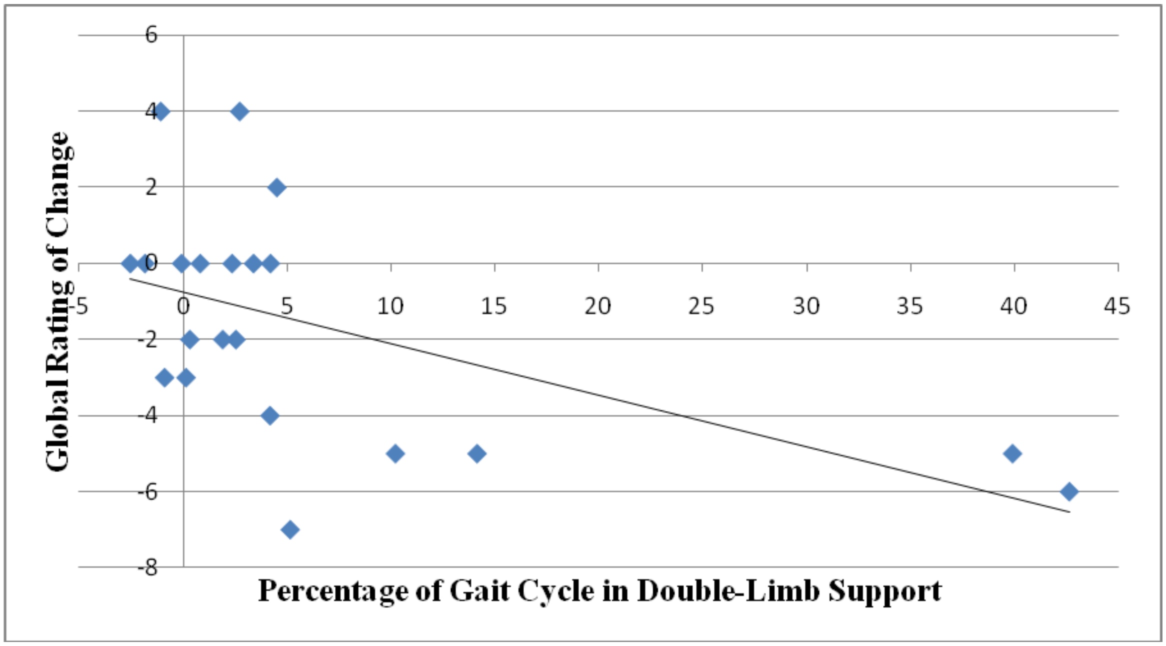

Figure 18. A statistically significant relationship between change in percentage of gait cycle spent in double-limb support and perceived change in walking quality measured with Global Rating of Change Scale. (r= -0.542652, p= 0.011031)

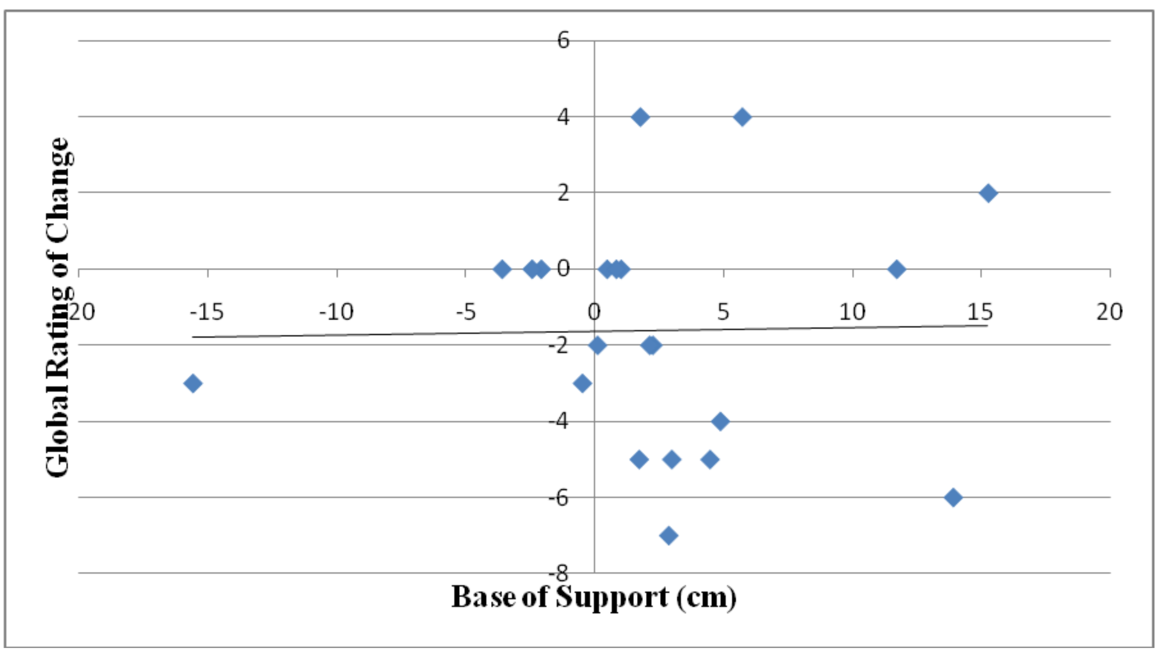

Figure 19. No relationship between changes in base of support and perceived change in walking quality measured with Global Rating of Change Scale. (r= 0.021411, p= 0.926603)

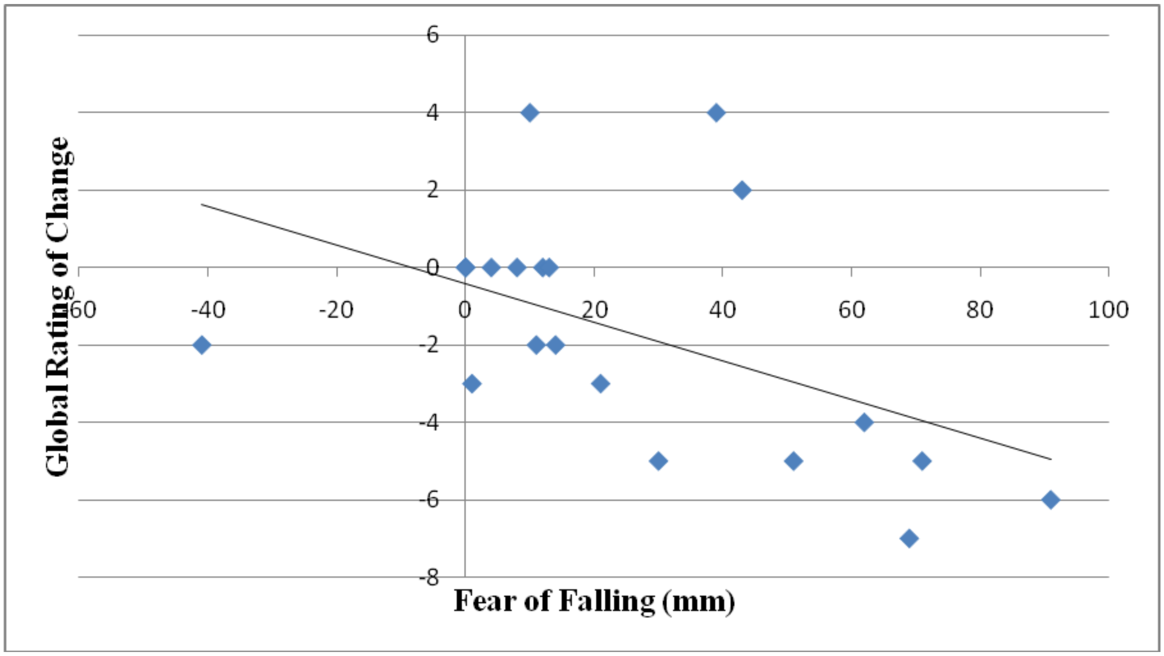

Figure 20. A statistically significant relationship between changes in fear of falling and perceived change in walking quality measured with Global Rating of Change Scale. (r= -0.506743, p= 0.019060)

APPENDIX A: INFORMATION AND CONSENT FORM

Introduction:
You are invited to participate in a research study investigating how walking poles affect walking in individuals who normally use a walker, cane, or no assistive device. This study is being conducted by Jennifer Gonnerman, Ellen Guerin, Karen Koza, and Courtney Tofte, Doctor of Physical Therapy students at St. Catherine University, under the supervision of Assistant Professor Deborah A. Madanayake. You were selected as a possible participant in this research because you walk by yourself with a cane, walker, or no device in the community and you have expressed an interest in this study. Please read this form and ask questions before you agree to be in the study.

Background Information:
The purpose of this study is to measure the effect of walking poles on your walking speed, length of steps, and fear of falling compared to when you use your usual walker, cane, or no assistive device. Approximately 44 people are expected to participate in this research.

Procedures:
If you decide to participate, you will be asked to go through six steps:

<u>Step 1</u>: Welcome (Time: 20 minutes)
We will describe this research study, review this consent form, and ask for your informed consent before proceeding. If you choose to participate, you will have your vision, hearing, arm range of motion, memory, and walking screened.

<u>Step 2</u>: Data gathering – with use of your usual walker, cane, or no assistive device (Time: 10 minutes)
You will be asked to walk 3 times down a 10-meter x 1-meter electronic mat that has been secured to the floor. You will use your usual walker, cane, or no assistive device (whatever you normally walk with outside your apartment). You will have a transfer belt around your waist and a researcher will stand just to the side and behind you to ensure your safety. Upon completing the laps, you will be asked to rate your fear of falling using a visual scale on a piece of paper. Rests will be provided as needed.

<u>Step 3</u>: Walking pole training (Time: 15 minutes)
A set of walking poles will be adjusted for your specific height for your use during this study. A researcher will then work with you, one on one, to show you how to properly use the walking poles. You will practice with the poles until you state that you are ready to walk with them on the electronic mat. You will continue to wear the transfer belt around your waist for safety. A researcher will provide standby assist, with manual assist

as needed, as you learn to use the walking poles. At no time will you be left alone to walk with the poles.

Step 4: Data gathering – with use of walking poles (Time: 5 minutes)
You will use the walking poles to complete the tasks outlined in Step 2 above. At no time will you be left alone to walk with the poles. Rests will be provided as needed.

Step 5: Data gathering – repeat - with use of walker, cane, or no assistive device (Time: 5 minutes)
This is a repeat of Step 2 above. Rests will be provided as needed.

Step 6: Thank-you (Time: 5 minutes)
The purpose of this step is to answer any questions you may have, as well as thank you for your participation in this study.

Overall, this study will take approximately 60 minutes of your time.

Risks and Benefits of Being in the Study:
The study has several risks. First, there is a potential fall risk during the study. In order to reduce this risk, you will wear a transfer belt around your waist and have standby assist at all times when on your feet. The assister will be a Doctor of Physical Therapy student, or a Physical Therapist, all of whom are skilled in assisting persons with walking/balance difficulties, as well as in training people how to use assistive devices for walking.

Second, there is a slight risk that your arm muscles may be sore for a few days following the study since pole walking involves a new motion for your arms. If at any time you become fearful of falling, or if your arms become tired or sore, or should you in any other way feel uncomfortable, you may terminate your participation in the study.

The benefits of participation do not extend beyond the fact that you will have an opportunity to experience walking with walking poles and have a brief training session with the poles. It is not the intent of this study to determine whether or not walking poles will be safe for your use, nor to prescribe walking poles.

In the event that this research activity results in an injury, such as that resulting from a fall or muscle strain from walking pole use, we will assist you in obtaining medical attention. Research related injuries are not always covered by insurance and you should check with your insurance company if you are concerned about this. If you think you have suffered a research-related injury, please let me/us know right away.

Confidentiality:
Any information obtained in connection with this research study that can be identified with you will be disclosed only with your permission; your results will be kept

confidential. In any written reports or publications, no one will be identifiable and only group data will be presented.

We will keep the research results in a locked office at St. Catherine University and on a password protected computer. Only the student researchers: Jennifer Gonnerman, Ellen Guerin, Karen Koza, Courtney Tofte, their research advisor, Assistant Professor Deborah A. Madanayake, and two supporting professors: Associate Professor Laura Gilchrist and Professor John Schmidt, both faculty members in the Doctor of Physical Therapy Program, will have access to the paper and electronic data while we work on this project. We will finish analyzing the data by December 2011. We will then destroy all original reports and identifying information.

Voluntary Nature of the Study:
Participation in this research study is voluntary. Your decision whether or not to participate will not affect your future relations with St. Therese Home or St. Catherine University in any way. If you decide to participate, you are free to stop at any time without affecting these relationships.

Contacts and Questions:
If you have any questions, please feel free to contact Assistant Professor Deborah A. Madanayake at 651-690-7787. You may ask questions now, or if you have any additional questions later I will be happy to answer them. If you have other questions or concerns regarding the study and would like to talk to someone other than the researchers, you may also contact Lynne Linder, IRB Office, at 651-690-6203.

You may keep a copy of this form for your records.

Statement of Consent:
You are making a decision whether or not to participate. Your signature indicates that you have read this information and your questions have been answered. Even after signing this form, please know that you may withdraw from the study at any time.

I consent to participate in the study.

Signature of Participant Date

Signature of Researcher Date

APPENDIX B: SCREENING FORM

Welcome/Screening ID: Name________________ Birth Year___

Gender: M / F

-Describe the research study

-Review consent form & obtain consent before proceeding

-Perform the following screens to determine eligibility

Screening Tool	Instructions for Patient	Results
Vision	-Better than 20/60 using eye chart -must get 3 letters correct on 20/50 line -Hold Snellen chart 10 ft away, in front of wall -May use corrective lenses -Test both eyes at same time (binocular)	_____/_____
Hearing	-Repeat a spoken sentence (which will be stated at conversational-level volume) -Done in context of Mini Mental	___ Normal ___ Abnormal
UE ROM	-Standing -Swing arms forward and backward to assure pain free, unrestricted ROM	___ Normal ___ Abnormal
Memory	-To learn how to use the walking poles we will need to teach you some new things, I need to ask you a few questions to screen your memory. -Take MMSE; administered according to test's protocol -Need 24/30 score	_____/30
Gait	-PT: observe gait while in apartment, looks for abnormalities -What do you use to walk to the mailbox? -How long have you used this assistive device? -Have you ever used walking poles?	Gait abnormalities? Y / N Normal AD: ___ none ___ (SEC – single end cane) ___(2ww) ___ (4ww) ___(other) How long have they used:

		Used walking poles before? Y / N If so, when?
Leg Length	-Measure leg length from greater trochanter to floor without shoes (right leg) -In centimeters	____ cm

APPENDIX C: FEAR OF FALLING (VAS)

NO FEAR
OF FALLING

VERY AFRAID
OF FALLING

APPENDIX D: GLOBAL RATING OF CHANGE SCALE

1. How would you say your quality of walking changed when using the walking poles compared to when you used your usual walker/cane/no device? (Circle choice)

___ No change

___ Worse

___ Better

1	A tiny bit, almost the same	1
2	A little bit	2
3	Somewhat	3
4	Moderately	4
5	Quite a bit	5
6	A great deal	6
7	A very great deal	7

2. If your walking did change, how important would you say the change was? (Circle choice)

1 A tiny bit

2 A little bit

3 Somewhat

4 Moderately

5 Quite a bit

6 A great deal

7 A very great deal

____ Not applicable (no change)

ID: ______________________________