SIGNIFICANCE OF POSTURE IN RELATION TO FALLS IN THE ELDERLY

by

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Abstract

Falls are a common occurrence in the geriatric population that lead to several complications. Solutions should be sought to reduce costs and morbidity of the elderly population related to the fall epidemic. This study investigated a connection between a person’s posture and their risk for falling. A survey was created to obtain opinions of a representative geriatric population regarding posture. Fall history and information on chronic health conditions were then voluntarily reported, and fear of falling was assessed using the Falls Efficacy Scale. Thoracic kyphosis was measured using the occiput-to-wall distance and the Flexicurve Index, and the final element of the study was to determine the risk of falling using the Tinetti Balance Test.

Data came from twenty geriatric participants aged 65 and older from skilled nursing facilities and the community of a rural northeastern area of Ohio. The postural measurements were compared to fall history, fear of falling, and fall risk. Statistical analysis was completed with IBM SPSS 24 using crosstabulations, chi-squares, and correlations. A trend was observed between posture and fall history but without a significant relationship (p = .343). There was significance displayed with an increased fear of falling and increased kyphosis (p = .025). A positive correlation was also discovered between posture and fall risk (r = 0.742, p = .001).

Hypotheses of this study observed relationships between posture and fall history, fear of falling, and fall risk. There was significant support for most of the hypothesized relationships, indicating relevance of posture in the topic of falls with geriatrics. Although causation cannot be determined from this study, the relationship observed implies a suggestion to focus more on posture in its course through aging to improve the fall epidemic in the elderly.
Introduction

Falls are a common occurrence in the geriatric population with numerous complications that follow, including non-fatal and fatal injuries as well as physical and emotional consequences (Kado, Huang, Nguyen, Barrett-Connor & Greendale, 2007). Loss of independence is a major result for most geriatrics who experience a fall, along with a substantial healthcare cost. With the baby boomer population of 76 million quickly aging, a large portion of the population deserves attention to receive improved quality of living and longer-lasting independence (King et al., 2016).

Another commonality among geriatrics is poor posture which has been associated with several complications, including pain, depression, and reduced motivation (Balzini et al., 2003; Barret, McCrereh & Lewis, 2013). The growing inactivity levels of the nation’s population will likely lead to more issues with posture, as too much time sitting leads to an overload of the lower spine and weakening of muscles necessary for adequate posture (Dzierzanowski et al., 2013; O’Sullivan, O’Sullivan, O’Sullivan & Dankaerts, 2012). This could lead to greater instances of hyperkyphosis.

Hyperkyphosis is an excessive anterior curve of the thoracic spinal region and occurs in 20-40% of geriatrics (Hojjati & Sheikhpour, 2013; Suzuki et al., 2016). It makes many daily functions and activities more difficult (Kado, Huang, Barrett-Connor & Greendale, 2005). Some consequences include physical performance issues, a reduced quality of life, decreased mobility, and problems with digestion and respiration (Katzman, Wanek, Shepherd & Sellmeyer, 2010; Yanagawa, Maitland, Burgess, Young & Hanley, 2000).

Understanding that posture and falls have a relationship with one another along with the initial complications of poor posture indicates a need to address the issue. Satisfactory posture
declines with age and reduced physical activity, and risk for falling increases with age (Jang, Kim & Kim, 2015; Kado et al., 2007). It is suggested that individuals with higher risk or fear of falling are less willing to participate in regular physical activity (Gusi et al., 2012). More attention can be devoted to preventing and fixing poor posture in the geriatric population to decrease the risk for falls.

**Methods**

**Participants**

The geriatric population was studied for being most commonly affected by falls. Both male and female geriatrics of age 65 and older were used in this study. The participants were recruited from two skilled nursing facilities and from the community of a rural northeastern town of Ohio. An incentive was given to be placed into a drawing to win donuts at the completion of the study. The researcher only requested participation from people of geriatric age and deemed fit by the therapists concerning cognition and physical ability.

The goal for the researcher was to obtain about twenty-five participants for an adequate sample pool, based off a different study concerning posture and risk of falls that used twenty-five participants (Sinaki, Brey, Hughes, Larson & Kaufman, 2004). Another study used twenty-three participants with kyphotic posture (Hojjati & Sheikhpour, 2013). This current study gathered a total of twenty participants for research.

**Materials**

A questionnaire was given to each participant verbally, so this required the hard copy of the questionnaire with a pen for the researcher, as well as six labeled cards for the first question. The questionnaire involved the validated Falls Efficacy Scale and the Tinetti Balance Test. A
tape measure was used for measurement of the posture as well as a Flexicurve ruler (Southern Technologies, IL), sketchbook, and pen.

Procedure

The Human Subjects Review Board of Ashland University gave permission for the researcher to conduct this study. Permission was also obtained from the directors of physical and occupational therapy from the two skilled nursing facilities. An informed consent form was read aloud to each participant and the researcher answered any questions regarding the project. All the participants signed the form agreeing to be part of the study.

The study began with a survey that the researcher chose to read aloud to the participants to ensure understanding of the questions and uniform answers. The first section of the survey involved four questions to gather participants’ opinions of posture and how it may relate to healthy living, as well as gender and independence information. The second section collected history of falling and falls leading to hospitalization. Two studies investigated history of falls within the past twelve months (Beauchamp, Hill, Goldstein, Janaudis-Ferreira & Brooks, 2009; Kado et al., 2007), while another asked about the past three months (Balzini et al., 2003). This current study used three time frames for data: five years, one year, and six months.

The participants were also asked if they had any diagnoses of chronic health conditions. Another study included in its questionnaire a self-reported history of medical conditions (Kado et al., 2005). Several studies involving falls ask about physical health conditions, and there are numerous ones regarding specific conditions in relation to falls. Some of these conditions include osteoporosis (Sinaki et al., 2004; Yanagawa et al., 2000), chronic pain, discopathy (Dzierzanowski et al., 2013), and COPD (Beauchamp et al., 2009).
A standardized questionnaire called the Falls Efficacy Scale was then implemented to assess participants’ fear of falling. This is a validated scale that has been used in studies about balance in relation to falls (Gusi et al., 2012; Sinaki et al., 2004). Fear of falling was a dependent variable hypothesized to be affected by a person’s balance. Balance confidence has also been suggested to play a role in predicting falls (Beauchamp et al., 2009; Schinkel-Ivy, Inness & Mansfield, 2016).

The second major step of the study was the measurement of posture for kyphosis. The Flexicurve Index was the first technique used (Wongsa, Amatachaya, Saengsuwan & Amatachaya, 2012). The process involved the participant standing in a comfortable position with a cue to stand tall, and a Flexicurve ruler was molded along their spine from vertebra C7 to vertebra T12. The molded ruler was transferred directly to the sketchbook to be traced with pen, and this was repeated two more times. The length and width of each curve was then measured, and the value \( \frac{\text{width}}{\text{length}} \times 100 \) was calculated. After completing the equation, an average was taken of the three curves to calculate the index for that participant. A higher index score reflects an increased curve representing an advanced level of kyphosis.

Posture was then measured using the occiput-to-wall (OTW) distance, shown to have a strong relationship with the Flexicurve (Balzini et al., 2003; Katzman et al., 2010; Wongsa et al., 2012). Participants were asked to stand as tall as possible with their back and heels against a flat wall. The distance between their occipital protuberance and the wall was taken twice from each side of the head and then averaged for a final score. The scores were placed into one of four severity levels of kyphosis: normal (0 cm), mild (\( \leq 5 \) cm), moderate (5.1-8 cm), and severe (> 8 cm).
An assessment of the participants’ risk of falling was the final step of the study. The Tinetti Balance Test was used because it is commonly used to test balance levels and determine fall risk in geriatric populations (King et al., 2016). It also incorporates both balance and gait as it observes sitting, standing, and walking (Mancini & Horak, 2010). Each aspect was scored based on specified criteria. The final score of the assessment placed the participant into one of three categories: no fall risk (>24), risk for falls (19-24), and high risk for falls (<19). Several factors have been discovered to affect postural control, including biomechanical measures, dynamics control, and cognitive processing. They justify the use of the brief skills observed in the Tinetti Balance Test and the application of the test in this study (Horak, 2006).

After the collection of data was completed, statistical analyses were performed using IBM SPSS 24. Survey questions were analyzed using frequency measures. The posture measurements taken by the OTW method were inputted into the data set as both raw distance numbers and representative scores. Posture was compared with independence using crosstabulation and Pearson chi-square. Fall history was compared with posture, gender, and independence also using the crosstabulations, as well as fear of falling with posture and fall risk with independence. A Pearson correlation was used when comparing fear of falling with fall risk and fall risk with posture. Significant relationships were achieved with p-values less than 0.05.

Results

This study recruited and used data from twenty participants. The participants were of both genders and from the community as well as one of two nursing facilities. Table 1 gives the demographics that are used in comparison with further data points. It is important to note that
majority of the community dwellers were female (88.9%), and most of the males were from a skilled nursing facility (83.3%).

<table>
<thead>
<tr>
<th>Demographic</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>6</td>
<td>30%</td>
</tr>
<tr>
<td>Female</td>
<td>14</td>
<td>70%</td>
</tr>
<tr>
<td>Community</td>
<td>9</td>
<td>45%</td>
</tr>
<tr>
<td>Skilled nursing facility</td>
<td>11</td>
<td>55%</td>
</tr>
<tr>
<td>Male - community</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Female - community</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Male - nursing facility</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Female - nursing facility</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Note: Bottom four demographics do not have a single percentage to display.

Survey

Opinions about posture were obtained from the participants. The first question from the survey asked to rank health factors for significance of healthy living. Table 2 shows the average scores of each factor. The scores from this table range from one to six, with one representing a factor most significant to a healthy life and six representing a factor least significant. Balance was chosen most often as the most significant factor. Posture was near the bottom of the list. Other questions revealed that all the participants believe posture is important to a healthy life and can affect balance. Only twelve of the twenty participants thought posture could affect hospitalization.

<table>
<thead>
<tr>
<th>Health factor</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>2.20</td>
</tr>
<tr>
<td>Endurance</td>
<td>3.25</td>
</tr>
<tr>
<td>Upper body strength</td>
<td>3.60</td>
</tr>
<tr>
<td>Flexibility</td>
<td>3.90</td>
</tr>
<tr>
<td>Posture</td>
<td>4.00</td>
</tr>
<tr>
<td>Lower body strength</td>
<td>4.05</td>
</tr>
</tbody>
</table>
Participants were also asked if they would be willing to share any diagnoses they have of chronic health conditions. Of the fourteen who volunteered information and were aware of their diagnoses, the following conditions were reported: five with diabetes, six with arthritis, seven with hypertension, two with a cardiovascular condition, and one each with cancer, a pulmonary condition, and osteoporosis.

*Posture*

The Flexicurve Index measurement for posture resulted in twenty distinct index values for each participant with a range of 9.87 (minimum 3.78- maximum 13.65). The average score for the sample group was 8.08. The second postural measurement used the occiput-to-wall (OTW) distance. The average OTW distance for the sample group was 7.35 cm. The distances were placed into categories with the breakdown shown in Table 3. Most participants were measured with severe kyphosis, which would be represented by a larger curve in the thoracic spine pushing the head further forward.

*Table 3*  
OTW Scores: Degrees of Kyphosis

<table>
<thead>
<tr>
<th>Normal (0 cm)</th>
<th>Mild (&lt;5 cm)</th>
<th>Moderate (5-8 cm)</th>
<th>Severe (&gt;8 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 4 shows the distribution of community dwellers and participants from the skilled nursing facilities with their OTW postural levels. There was a significant comparison among the two independence levels for postural measurements ($p = 0.012$). Majority of the community dwellers had normal posture or mild kyphosis, while participants from the skilled nursing facilities had more severe kyphosis.
### Table 4
*Degrees of Kyphosis among Independence Levels*

<table>
<thead>
<tr>
<th>Independence</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community dwellers</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Skilled nursing facility</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

### Fall history

Half of the participants had experienced a fall in the past six months. Twelve had a fall in the past year, and eighteen participants fell in the past five years. Table 5 displays the number of participants with and without falls reported in the past year distributed between levels of postural measurements. There was no significant relationship between degree of kyphosis and whether a fall occurred \( (p = 0.343) \), but a trend can be observed as the number of falls increase with an increased level of kyphosis.

### Table 5
*Presence of Fall in Past Year Compared with Degrees of Kyphosis*

<table>
<thead>
<tr>
<th>Degree of kyphosis</th>
<th>Fall</th>
<th>No fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Mild</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Moderate</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Severe</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

Gender was also incorporated into the data analysis. Table 6 shows the number of falls experienced in the past six months and the past year between men and women of the study. The history of the most recent occurrence of falls approached significance between males and females \( (p = 0.051) \), and the recorded falls in the past year displayed significance \( (p = 0.017) \). Although there were an equal number of men and women with falls in their recent history, more women than men did not have a fall.
Another degree of fall history was assessed as participants who had experienced falls were also asked about resulting hospitalization. Of the eighteen participants who had experienced a fall within the past five years, ten of them were then admitted to a hospital or nursing facility. This data set was compared to levels of kyphotic posture, displayed in Table 7. There was no significance when comparing these proportions \((p = 0.471)\) but a similar trend is detected as severity of kyphosis increases while the number of falls that lead to hospitalization also increases.

Table 7
Falls that did and did not Require Hospitalization between Degrees of Kyphosis

<table>
<thead>
<tr>
<th>Degree of kyphosis</th>
<th>Hospital</th>
<th>No hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Mild</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Moderate</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Severe</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 8 shows the number of participants that were either community dwellers or from a skilled nursing facility with their timeline of past falls leading to hospitalization. Independence levels were significant in predicting if a fall would lead to hospitalization \((p = 0.038)\). More of the participants from the skilled nursing facilities required hospitalization following their falls than the community dwellers.
Table 8
Timeline of falls that did and did not Require Hospitalization between Independence Levels

<table>
<thead>
<tr>
<th>Independence</th>
<th>6 months</th>
<th>1 year</th>
<th>5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hospital</td>
<td>No hospital</td>
<td>Hospital</td>
</tr>
<tr>
<td>Community dweller</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Skilled nursing facility</td>
<td>6</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Fear of falling

The Falls Efficacy Scale was read aloud following the survey to assess the participants’ fear of falling. None of the participants reached the marker of seventy points on the scale to indicate a fear of falling. Fortunately, though, relationships were found when using the raw data points, listed in Table 9. These scores are the sums of participants’ answers to having confidence in different activities without falling. A higher final sum indicates that the participants answered with higher numbers overall during the questionnaire, which represent a decreased level of confidence in performing the specified activities without falling. Thus, participants with higher Falls Efficacy Scale scores have a greater fear of falling.

There was a significant relationship between the scores from the Falls Efficacy Scale and the distances for the OTW posture measurement (p = 0.025). Participants with more severe kyphosis tended to have a higher level of fear. There was also a significant, direct relationship with risk for falling (p = 0.023). Higher risks were accompanied with greater fear for falling.

Table 9
Falls Efficacy Scale Scores

<table>
<thead>
<tr>
<th>Score</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>14</th>
<th>17</th>
<th>20</th>
<th>24</th>
<th>26</th>
<th>28</th>
<th>51</th>
<th>52</th>
<th>62</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Fall risk

The Tinetti Balance Test was used to determine each participant’s risk for falling. It incorporates aspects of ambulation and balance activities that were scored by the researcher and
then placed in standardized categories of risk levels based on score. The assessment found that nine of the twenty participants had no risk for falling, six were at risk, and five were at high risk. Table 10 shows the distribution of independence levels with fall risk. The relationship between community dwellers and participants from the skilled nursing facilities in terms of fall risk was significant (p = 0.001). Less independence often coincided with higher risk of falls.

Table 10
Fall Risk between Independence Levels

<table>
<thead>
<tr>
<th>Independence</th>
<th>None</th>
<th>Risk</th>
<th>High risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community dweller</td>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Skilled nursing facility</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

The major hypothesis of this study was that posture can make an impact on a person’s risk for falling. The postural measurements were compared to the scores from the Tinetti Balance Test. Table 11 displays the number of participants with certain OTW scores and levels of fall risk. A significant relationship was discovered among the postural levels and fall risk (p = 0.001). When using the raw numbers of OTW distance, there was a direct correlation of 0.742 indicating fall risk increases as kyphosis levels increase.

Table 11
Fall Risk among Degrees of Kyphosis

<table>
<thead>
<tr>
<th>Degree of kyphosis</th>
<th>None</th>
<th>Risk</th>
<th>High risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mild</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Moderate</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Severe</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Discussion

Survey

Questions asked of the participants served the purpose of obtaining information on their opinions of posture. The first question of ranking health factors displayed a higher frequency of
participants placing balance and endurance as the most important for healthy living. Majority of the time, posture and lower body strength were ranked as least significant. The most prevalent aspects of therapy that tend to receive more attention include balance, endurance, and strength, while posture often receives little to no attention in therapeutic exercise programs (Hojjati & Sheikhpour, 2013).

While answering the first survey question, many of the participants expressed that all the factors were important and often had trouble placing one in front of the other. Although posture tended to rank last, the entire sample group did believe that it was indeed important to a healthy life. Some participants agreed that posture is also able to impact balance, falling, and pain. Fewer participants believed hospitalization could be affected, but a trend was displayed with hospitalization and increased kyphosis.

Another question for the participants involved the presence of any chronic conditions. Rationale for this piece of information involves numerous research studies focusing on diseases and disorders common with geriatrics. A study by Horak (2006) investigated factors possible for affecting postural control. One factor involved biomechanical constraints caused by common diseases of the elderly, while another factor included sensory strategies that are affected by disorders of the central nervous system common in geriatrics as well.

Research has been dedicated to more specific conditions. For example, people suffering from chronic obstructive pulmonary disease (COPD) tend to have reduced balance and coordination compared to healthy counterparts. There is also a significant role for balance confidence to predict falls in patients with COPD (Beauchamp et al., 2009). Research has linked fear of falling and fall risk in individuals with stroke as well (Schinkel-Ivy et al., 2016).
The three common chronic conditions reported among the participants of this study were diabetes, hypertension, and arthritis. Studies suggest individuals with diabetes mellitus display more impairments relating to posture and ambulation and possess an increased risk for falling. History of falls have shown to be more plentiful in diabetic individuals than corresponding non-diabetics (Morris, Colberg, Mariano, Parson & Vinik, 2010). Other factors that attribute to increased risk of falling for diabetics include more medications, poorer walking abilities, and reduced cognitive functioning (Mettelinge, Cambier, Calders, Noortgate & Delbaere, 2013).

Hypertension has been studied regarding falls in the elderly, and it seems people with uncontrolled or orthostatic hypertension are at a greater risk for falling (Gangavati et al., 2011). There has been evidence of antihypertensive medications being associated with an increased risk of serious fall injury. Although it may not affect the initial risk of falls, antihypertensive medicine relates to people who do experience falls to more frequently suffer from a hip fracture or serious head injury as a result (Tinetti et al., 2014).

Studies involving arthritis and falls tend to focus on rheumatoid arthritis, but the principles may be applied to osteoarthritis as well. Arthritis can result in stiff and painful joints and muscle weakness, which can contribute to an increased risk for falling (Jamison, Neuberger & Miller, 2003). Falls are common in older individuals with this condition as is a fear of falling. Research has shown an association between rheumatoid arthritis and increased risk of osteoporotic fracture and reduced bone mass (Armstrong, Swarbrick, Pye & O’Neill, 2005).

Osteoporosis is a disease that has been more commonly investigated with posture and falls, due to its prevalence with aging often causing hyperkyphosis in older women (MacIntyre, Bennett, Bonnyman & Stratford, 2011; Sinaki et al., 2004). The disease involves low bone mass and deterioration of bone tissue (Hsu, Chen, Tsauo & Yang, 2014; Yanagawa et al., 2000). In the
current study, only one participant reported the diagnosis of osteoporosis. This participant only had one fall in the past five years and without hospitalization, was a female community dweller, and had no risk for falling. The OTW score was mild kyphosis for this subject with a 10.85 Flexicurve Index.

A 2004 study investigated kyphosis and osteoporosis relations and their effects on falls (Sinaki et al., 2004). The researchers monitored strength, gait, and balance. They suggested that thoracic hyperkyphosis may be due to reduced muscle strength in osteoporotic individuals and may lead to body sway and unsteadiness while walking. Vertebral fractures also occur often with osteoporosis, but evidence suggests sarcopenia and muscle weakness are more at fault for the declining posture (Hsu et al., 2014; MacIntyre et al., 2011). Regardless of the underlying cause, there is a definite relationship between osteoporosis and an increased risk for falling.

**Posture**

Changes in posture commonly observed with aging include a forward head, rounded shoulders, hip and knee flexion, and increased thoracic kyphosis (Hojjati & Sheikhpour, 2013). This study focused on the abnormal posture of kyphosis, defined as excessive outward and anterior curvature of the thoracic spine which causes hunching of the back (Jang et al., 2015). Elderly tend to carry their heads and neck in front of their torso, indicating the relation and reason for choosing this postural alignment (Cohen, Vasavada, Wiest & Schmitter-Edgecombe, 2016). Kyphosis pushes the head forward and shifts the center of mass of the entire body causing instability (Hsu et al., 2014). This suggests the abnormal posture may have an impact on fall risk (Katzman et al., 2010; Sinaki et al., 2004).

Adequate posture is achieved by coordinating bone and muscles to remain upright against gravity (Cohen et al., 2016). It is controlled by the integration of several different senses, central
motor control, and responses to the environment (Hsu et al., 2014). As people age, numerous changes occur anatomically and physiologically. Visual, vestibular, and other somatosensory inputs may become impaired, as well as central processing and muscular output. These changes contribute to the increased development of hyperkyphosis in geriatrics.

Some specific causes of the declining posture include degeneration of intervertebral discs and minor vertebral fractures (Balzini et al., 2003; Katzman et al., 2010; Yanagawa et al., 2000). Bone loses its density as people age, especially with added confounders such as smoking or low physical activity (Saladin, 2015). The resulting brittleness makes fractures more frequent and common. The fractures along with the changing disc shape and density transforms the shape of the spine causing the kyphosis to become exaggerated. It seems that increased kyphosis may lead to more vertebral fractures, causing a spiral effect of declining posture (MacIntyre et al., 2011).

Muscular changes play a key role in spinal kyphosis development as well. Muscle is enormously important for maintaining posture because it acts on the human skeleton to hold the body in certain positions (Deldicque, 2013). Hyperkyphosis has often been linked with muscle weakness, specifically in the spinal extensor muscles (Katzman, Sellmeyer, Stewart, Wanek & Hamel, 2007). Range of motion in the shoulders and hips have also been related to flexed posture. With less range of motion, the shoulders’ natural rigidness tends to round them forward, and the hips become more flexed. Overall, this causes a hunched-over posture.

Sarcopenia is characterized as low muscle mass that results from age-related muscle loss. This common condition of the geriatric population can impair functions as well (Hsu et al., 2014). The underlying cause of sarcopenia has been speculated to be from stress of the endoplasmic reticulum of muscular cells. Stress leads to cell death and anabolic resistance and
causes a reduction in muscle mass. (Deldicque, 2013). Muscular impairments seem to be more responsible for increasing kyphosis than skeletal changes (MacIntyre, Lorbergs & Adachi, 2014).

The first postural measurement of this study used the Flexicurve ruler. The American Physical Therapy Associations Section on Geriatrics has recommended this method to assess postural abnormalities (MacIntyre et al., 2011), and numerous studies have implemented the measurement of the Flexicurve into their procedures (Barret et al., 2013; Wongsa et al., 2012; Yanagawa et al., 2000). A higher score obtained from this method indicates more severe kyphosis in the individual. Flexicurve Index measurements with a value greater than thirteen represent hyperkyphosis and tend to be associated with reduced cardiovascular fitness, muscular strength, and physical function (Katzman et al., 2010; MacIntyre et al., 2011).

Only two of the participants were classified with hyperkyphosis with index values of 13.57 and 13.65. A study from 2013 used this measurement tool and found the following statistics from a sample pool of thirty participants: mean index score of 7.7, minimum of 3.1, and maximum of 13 (Barret et al., 2013). These findings are similar with the results from the current study. Although categories do not exist for the index values, the raw data set from the Flexicurve Index was incorporated into data analyses with other variables of this study.

Occiput-to-wall distance was the second method applied to investigate a postural relationship with elements of falling. The distances measured for each participant placed them into categories of severity of kyphosis (Balzini et al., 2003). There was an adequate representation of each level of kyphosis in this sample group of twenty participants. The largest group was the severe kyphosis level. These distances and scores were also analyzed with other variables in this study.
Although most recent literature focuses on postural measurements of geriatric women (Hojjati & Sheikhpour, 2013; Jang et al., 2015; Katzman et al., 2007; Katzman et al., 2010), this study chose to include both males and females. The reasons that most studies focus on women with posture are the increased population of aging women compared to men, the greater prevalence of hyperkyphosis and osteoporosis in women, and the more rapid increase in the angle of kyphosis for women (Kado et al., 2005; MacIntyre et al., 2011; Marsh & Geel, 2000; Yanagawa et al., 2000). This does not conclude that the condition is unseen in males, though.

Other research has included both males and females. Results from other studies suggest that men are more inclined to have a forward head posture and thoracic kyphosis than women; one of these studies indicated they are twice as likely as women to have hyperkyphosis (Cohen et al., 2016; Suzuki et al., 2016). A possible reason is that the method of measurement used involved the cervical spinal region more common to flatten with age in men (Kado et al., 2005). It is known that men also suffer similar consequences from age-related postural changes, but further detail is not well known compared to females. Some research including both genders found no significant difference of posture and falls between males and females (Kado et al., 2007).

There was not a noticeable difference between genders for posture in this current study. However, there was a significant difference among independence levels and posture. More independent participants that were classified as community dwellers tended to have greater posture and less kyphosis. The participants from the skilled nursing facilities were more often the ones with severe kyphosis. This relationship can be intertwined with the upcoming conclusion of hospitalized falls and fall risk with posture and independence.
Fall history

There is a fall epidemic occurring with the geriatric population supported by numerous statistics. Almost every participant from this study experienced a fall within the past five years. It has been estimated at least 1/3 of the geriatric population aged 65 and older will experience one fall or more every year (Hojjati & Sheikhpour, 2013).

Comparing the history of falls in this study with postural measurement of OTW distance displayed a trend of increasing falls with increased severity of kyphosis. The most participants with falls in the past year were from the group of participants with the highest level of kyphosis. The pattern was not significant but may begin to approach significance with a larger sample size. A study from 2007 discovered geriatrics with hyperkyphosis were more likely to report a fall in the past year than those with normal posture (Kado et al., 2007).

Gender played a role in fall history from this study as well. The data shows the number of men and women who had experienced falls in the past six months and the past year were equal, but more women compared to men had an absence of falling. Significance support was given that a higher proportion of non-fallers were female instead of men. These results are conflicting with majority of other studies. Typically, it is reported that a higher proportion of elderly women experience falls than men (Chang & Do, 2015).

A major issue with the fall epidemic in the geriatric society is the healthcare costs. Increasing statistics have been established that manifest the relevance of this problem. In the US, falls have become the leading cause for both fatal and nonfatal injuries in the geriatric population. They are the second most common cause of death for people 65 years and older (Hojjati & Sheikhpour, 2013). In 2013, there were over 730,000 geriatric citizens hospitalized
because of falling. This added up to $34 billion in healthcare costs solely for falls in that year (King et al., 2016).

The participants who had a fall were also asked if the falls led to hospitalization. Ten of the eighteen participants with a fall were sent to a hospital or skilled nursing facility. Although no significance was found comparing posture and hospitalization, a pattern emerged showing higher severity of kyphosis participants were more likely to require hospitalization.

Independence levels were compared with falls sending participants to a hospital with significant results. Community dwellers were less likely to be sent to the hospital following a fall than those restricted to a nursing facility. It has been demonstrated that falls are three times more common in institutionalized elderly than community-dwelling geriatric people (Gusi et al., 2012). Another study shows that falls tend to occur more frequently in residential care than in the community (Barker, Nitz, Low Choy & Haines, 2012).

**Fear of falling**

It has been supported that disorders of gait and balance contribute to a person’s fear of falling, and improvements in one area can lead to improvements in the other (Gusi et al., 2012). Confidence in balance, which is a similar reciprocal of fear of falling, also contributes to a person’s likelihood of falling (Beauchamp et al., 2009). This research used the Falls Efficacy Scale which has been used in several other studies and given reliability and validity (Sinaki et al., 2004). Results from this study indicated that none of the participants had an established fear of falling.

Due to the lack in distribution between fear and no fear, the researcher used the raw data points to analyze with other variables instead. There was a fair spread of scores among the participants. It was more likely for a person with a higher severity of kyphosis to have an
increased fear of falling. There was also a significant correlation between fear of falling and fall risk. Falls have been shown to contribute to a person’s fear of falling, considering 88% of stroke victims who experience a fall develop the fear (Schinkel-Ivy et al., 2016). Flipping the causation, fear of falling may also influence a person’s balance and control of ambulation, which affects fall risk and may lead to more falls.

_Fall risk_

It has been established that gait and balance disorders are major risk factors for falls in geriatric populations (Gusi et al., 2012). The main goal for this study was to investigate if posture may also play a role with falls, and a major component for this investigation was fall risk. The level of fall risk for each participant was determined using the Tinetti Balance Test. An even spread of risk levels were assessed among the sample group.

Fall risk was highly comparative with independence levels. Community dwellers can be described as having a higher rating of independence, and they were more likely to have no fall risk. Participants from the skilled nursing facilities were at higher risk for falling. This data coincides with the research finding more falls occur with geriatrics in care facilities compared to those in the community (Gusi et al., 2012). It has not been determined if this difference is due to opposing levels of active lifestyles or the presence of supervision.

A comparison was also made between fall risk and postural measurement. An increased severity of kyphosis was significantly correlated with an increased risk for falling. Other studies determined a similar relationship between hyperkyphosis and fall risk. (Katzman et al., 2010; Sinaki et al., 2004). Hyperkyphosis leads to an offset center of gravity for the elderly to maintain balance. This leads to more falls. Additionally, increased kyphosis makes it more difficult for a
person to control balance, mobility, and postural sway; therefore, this abnormal posture contributes to an increased risk for falling (Hojjati & Sheikhpour, 2013; Wongsa et al., 2012).

**Limitations**

Several limitations for this study must be recognized. Overall, the sample size for this study was too small to draw further conclusions specifically with the fall history results. This was a major limitation for the study, though significant results were made to support other hypotheses. There were many restrictions with facilities hosting geriatric populations. Some employees would not agree to the researcher conducting the survey in their facility or allow direct contact with the patients. It was also difficult to find patients mentally capable of answering the survey questions and physically capable of performing the activities of the fall risk and posture assessment.

Analyses were made that incorporated both gender and independence levels. Significant findings were made with posture, fall history, hospitalization, and fall risk in terms of gender and independence. These results should be read with caution, though, because there was an uneven spread between males and females as community dwellers or from a nursing facility. The most apparent data set to observe the misdistribution is with the conflicting fall history results in terms of gender. It would be more ideal to gather an equal representation of each group, and this could be better achieved with a larger sample size.

Another limitation involved the section about chronic conditions. A fair amount of research has been conducted observing various chronic conditions in comparison with factors such as posture and falls. The method of obtaining information for this variable did not deem rewarding for this current study. It is likely that many participants were unaware of some of their
conditions or unwilling to share. The lack of substantial data for this topic restricted the ability to gather significant comparisons with the other variables studied.

The final limitation was the Falls Efficacy Scale used to assess participants’ fear of falling. Other studies have used this scale and found valid results (Gusi et al., 2012; Sinaki et al., 2004), and it has been tested for reliability (Tinetti et al., 1990), but this study did not find a single participant to have a fear of falling according to the scale. These results were not accurately representative of the sample of geriatric patients. Some of the participants made explicit suggestions of being afraid to fall and it affecting their choice of activities and level of independence. There were ten different questions with ten answer options per question – the numbers 1-10. The range was too large for the participants to apply meaning to each number and the scale from very confident to not confident was hard to grasp.

A questionnaire version used in a 2012 study had a total of sixteen questions but only four answer choices per question (Gusi et al., 2012). It found significant results regarding the fear of falling and performance in dynamic balance. An alternative option to assess fear of falling used by a study in 2016 was directly asking participants if they were afraid of falling (Schinkel-Ivy et al., 2016). Changing the assessment method to figure out if the participants had a fear for falling would be ideal for the future.

**Conclusion**

Often, the factor of body posture is overlooked and bypassed to focus on other issues of the body. Along with the participants of this study, many people do not find posture as important as other components when working for a healthy lifestyle. This research shows, though, that posture does in fact seem to hold great significance in terms of healthy living especially for
geriatrics. Increased thoracic kyphosis leads to numerous problems including a higher risk for falls.

    As individuals age, physical activity levels often decline. Reductions in both muscle mass and bone mass are witnessed along with cognitive functions necessary for maintaining a solid posture. Postural changes and imbalance result, leading to further inactivity which again results in weaker limbs (Sinaki et al., 2004). It is a downward spiral of deterioration and decline that likely leads to the undesirable outcome of falling. Kyphosis is a gradual and progressive change in the spinal curve (Yanagawa et al., 2000), so programs to slow this progression would be welcoming to the solution of falls in the geriatric population.

**Future research**

    Due to the strong relationships found in this study between posture and falls in the elderly, it would be ideal to devote more time and attention to understanding poor posture for improvement or prevention. Hyperkyphosis is a condition that increases rapidly, so early intervention is also a priority (Katzman et al., 2010). Future research should involve investigation for better understanding and application of the information to attempt fixing or preventing severe kyphosis in geriatrics.

    Chronic conditions that regularly appear in geriatric populations have displayed effects on both posture and rate of falls. Further insight on these conditions as well as others would be helpful to better improve posture and fall risk of more individuals. For example, diabetics tend to have a higher risk for falling than non-diabetic individuals so researchers have begun using exercise to reduce their risk by targeting proprioception, sensation, and lower body strength (Morris et al., 2010).
Both physical and cognitive conditions can impact a person’s posture and likeliness to fall. Cognitive issues are common among geriatrics, and research suggests improving cognition is also helpful in reducing falls (Mettelinge et al., 2013). Concurrent tasks, or multitasking, deems difficult for many elderly individuals. Often attempting these things result in a fall due to the inability to control posture or correct a change in posture (Horak, 2006; Marsh & Geel, 2000).

Another factor to consider among the topic of posture and falls includes change in bone density. As stated previously, these changes may result in vertebral fractures and different shaping of the spine. Targeting ways to maintain or improve bone density may help in reduction of falls. This topic relates to the idea of osteoporosis being a basis for poor posture and falling, but research has suggested it is not the primary cause of flexed posture (MacIntyre et al., 2014). In fact, muscle weakness tends to be more responsible than vertebral fractures (Balzini et al., 2003).

The muscles most often weakest in geriatrics that lead to poor posture are the back extensors and lower extremities (Balzini et al., 2003; Sinaki et al., 2004). Issues with range of motion in the hips and shoulder also seem to contribute to postural issues, as well as muscle imbalance (Hojjati & Sheikhpour, 2013; Lewis, Green & Wright, 2005). A major contributor to the decline in postural stability control as well as weakened muscles is decreased activity levels with age (Hojjati & Sheikpour, 2013). This implies a need for exercise programs with specific targets of the mentioned muscle groups.

Jang et al. (2015) implemented an eight-week thorax correction exercise program for elderly women with age-related hyperkyphosis. They found the program effective in improving flexed posture. A seated physical activity program was used with the same population type. It
increased strength in the back extensors and flexibility of the pectoralis muscles and showed improvements with postural alignment (Hojjati & Sheikhpour, 2013). A program involving hip extensions, shoulder flexions, thoracic rotations, and more was successful in improving flexed posture of geriatric women along with strength and range of motion (Katzman, et al., 2007).

Muscle fatigue also has a major role because it affects a person’s ability to control posture, but it does not receive adequate attention for its impact on falls. Papa, Foreman & Dibble (2015) found that most falls that occur in the geriatric population are during tasks that require reactive postural control. The inability to produce a postural control response often leads to falls. Programs should not only incorporate muscle strengthening activities but ways to improve muscular endurance as well. It may also be helpful to investigate the correlation between fall risk and independence levels. Knowing whether this correlation is due to clinical supervision or levels of activity in one’s life could help in targeting populations to work on improvements of fall risk.
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Author’s Biography

Jessica Brown was an exercise science major at Ashland University with a coaching
minor. She graduated in 2013 from Fairfield High School in her hometown of Hamilton, Ohio.
At Ashland, she played as a college athlete on the women’s soccer team for four years, made the
Dean’s List every semester, and worked as a tour guide for three years. Her senior year she
received the honor of Academic All-American rewarded by CoSIDA, College Sports
Information Directors of America. Following her graduation from Ashland, Jessica will begin a
graduate program at the Ohio State University. She will be working towards a doctoral degree in
occupational therapy.
APPENDIX A

Survey
Survey (**will be read aloud to subject and filled out by researcher**)

1. Rank these cards in order of significance pertaining to a healthy life. Put the most significant card first and the least significant last.

(The following will be placed on individual cards and the subject will order the cards in rank: lower body strength, upper body strength, endurance, posture, balance, flexibility)

2. Do you believe posture is important for a healthy life?
   A. Yes
   B. No

3. Please give one or two reasons for your answer to question 2.

4. What aspects of functioning do you believe may be affected by body posture? (Select all that apply)
   A. Pain
   B. Balance
   C. Falling
   D. Hospitalization (or decreased dependence)
   E. Other (_________________________

5. (Optional) To be entered into the drawing for donuts, please give first name, facility, and room number.
Fall History

1. Have you had any falls in the past 6 months?
   A. Yes
   B. No
   → If yes, have any required hospitalization or stay in a nursing facility? If no, move on to question 2.

2. Have you had any falls in the past year?
   A. Yes
   B. No
   → If yes, have any required hospitalization or stay in a nursing facility? If no, move on to question 3.

3. Have you had any falls in the past 5 years?
   A. Yes
   B. No
   → If yes, have any required hospitalization or stay in a nursing facility? If no, move on to question 4.

4. Have you been diagnosed with any chronic health conditions (such as diabetes, arthritis, hypertension)? If so, are you willing to share those conditions with me for purpose of this research?