Associations between Kyphosis and Scores on the Safe Functional Motion Test: A Retrospective Analysis on Quality of Life

by

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ABSTRACT

Background*:* Hyperkyphosis is a spinal deformity causing an exaggerated anterior curvature of the thoracic spine. While the causes and consequences of hyperkyphosis are not well understood, hyperkyphosis may be associated with an increased risk for clinical consequences and other adverse health outcomes, such as functional limitations, musculoskeletal alterations, poor quality of life and mortality.

Method*:* A retrospective study was conducted of 2500 patients at an Osteoporosis Clinic in northeast Georgia who sought initial treatment between January 2004 and March 2015 to evaluate the associations between spine curve measurements and functional motion associated with spine load, balance, strength, and flexibility during daily living tasks. Analyses conducted examined the associations between kyphosis and functional motion, as well as their associations with quality of life. These associations were assessed using the Pearson-product-moment correlational coefficient and Spearman's Rho.

Results: The author of the article observed that degree of kyphosis was significantly associated with functional motion ($r = -.274$, $p < .01$) and kyphosis was also significantly associated with quality of life ($r = -.071$, $p <. 01$) Scores on functional movement were also associated with quality of life ($r = .221$, $p< .01$). Despite these findings, the strength of these correlations were small.

Conclusions: While functional motion and kyphosis can impact quality of life, these associations may not be as strong as previously believed. This study calls for further exploration of the unique relationship of the multiple factors that can impact perceived quality of life, and a further analysis of confounding variables.

Keywords: kyphosis, functional motion, quality of life, activities, osteoporosis

Table of Contents

Acknowledgements

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Introduction

Kyphosis is a spinal deformity causing an exaggerated anterior curvature of the spine whose causes and consequences are not well understood. While age-related hyper-kyphosis is a widely recognized, but largely ignored condition, previous literature suggests that kyphosis may be independently associated with increased risk for clinical consequences and adverse health outcomes, such as functional limitations, musculoskeletal alterations, quality of life and mortality. [1-5]

To date, there is not a set clinical cut point that distinguishes hyperkyphosis versus normal kyphosis, but kyphosis can begin to increase in people after 40 years of age; and there is a 20-40% prevalence among older adults. [2,5] Kyphosis has been shown to have detrimental effects on physical performance, balance, walking speed, and activities of daily living. [4,6-8] Women tend to have a more rapid increase in kyphotic angle.[9] Women with kyphotic posture and also demonstrate difficulty rising from a chair repeatedly and have significantly poorer balance and slower gait velocity, wider base of support with stance and gait, as well as a decreased stair climbing speed. [2,7] Individuals with hyperkyphosis also report greater difficulty reaching and performing heavy housework and score lower on the ADL scale when compared to their peers.[2, 4, 6-8]

In terms of quality of life, those with kyphosis also tend to have more physical difficulties and need more adaptations in their lives, and report more generalized anxiety than those who do not have hyperkyphosis. Hyperkyphosis is also associated with poorer

satisfaction with subjective health, family relationships, economic conditions and their lives in general.[4,10]

Because osteoporosis is one of the most common causes of hyperkyphosis in older adults and leads to major loss of bone mass that could potentially weaken the spinal bones, causing them to become brittle and more prone to fracture, it has long been hypothesized that hyperkyphosis causes vertebral fracture. As such, many physicians have long felt that management strategies should focus solely on diagnosis and treatment of osteoporosis. [1,13] Recent studies, however, indicate that many older adults that are affected by kyphosis do not have vertebral fractures. [6,15]

Other risk factors for kyphosis also include osteopenia, muscle weakness, degenerative disk disease, decreased mobility, sensory deficits, polypharmacy, and other hereditary factors. [1,13] These factors can also severely limit functional movement, regardless of hyperkyphotic presentation. It is important to note that functional movement, while reflecting body mechanics and movement strategies that are used in everyday life, may also be compensating for poor flexibility, muscle weakness and balance issues; all of which could potentially place excessive loads on the spine.[15-17]

Despite the large amount of research related to risk factors and poor physical functioning, the impact of kyphosis and its association with functional movement, quality of life and valued activities is largely ignored by physicians, who often lack the necessary tools to quickly assess these measures in an evidence-based manner or in clinical practice with their patients. Therefore, to gain further understanding of the effect that kyphosis has on

functional motion on daily activities and how this affects quality of life, we used data from a large database of an orthopedic clinic, of which there were several objective measures of functional motion, spine curve assessments and valued activity.

My research questions were as follows: 1) What is the relationship between kyphosis and functional motion? 2) What is the relationship between kyphosis and quality of life? and 3) What is the relationship between functional motion and quality of life?

Method

Design

This study was a retrospective analysis of de-identified data from 2,500 patients who attended an osteoporosis specialty clinic in northeast Georgia between January 2004 and March 2015 for initial assessment. Both men and women 17 years of age and older were included if they had initial Safe Functional Motion (SFM) scores and corresponding data for spine curve assessment, and data corresponding to activity and quality of life.

Ethics

All participants who attended the specialty clinic were asked to read the Health Privacy Information Act advisory notice and provide written informed consent to allow their de-identified data to be entered into the clinic database registry and used for research and quality assurance purposes. The data was further encrypted and managed through the specialty clinic whose Institutional Review Board approved the study. A letter of support to use the data was granted by the specialty clinic, and this study was approved from exemption from full committee review by Youngstown State University.

Measures

Age of participants ranged from 17 to 97, with a mean age of 67.94 years.

Spine curve, which is a measure of the degree of kyphosis, was assessed by digital inclinometer via cellphone of the lumbrosacral angle, the lumbar standing posture, the lumbar standing posture and the thoracic standing posture, a highly reliable and valid assessment of kyphosis. [18]

Functional motion associated with spine load, balance, strength and flexibility was also assessed through an abbreviated version of the Safe Functional Motion Test (SFM). The SFM is an easy to administer test with standardized testing protocols, and tester credentialing were required before testing with demonstration of competency. Patients were allowed to use assistive devices according to testing protocol and may have included a step stool, reacher, long-handled shoe horn, walker or cane. For safety, a transfer belt was worn around the waist for the duration of testing, and the maximum weight lifted during any single task was limited to 4.54 kg.

The SFM takes 7-10 minutes to complete, and any task the patient had not completed at home in the past 6 months due to a recent change in health condition or which the patient feels uncomfortable in performing was scored as task not performed. One of the purposes of the SFM is to not only evaluate habitual movement patterns that could elevate the risk

of fracture or falls, but to also indicate an individuals' overall balance, flexibility and strength, and lower spinal loading forces.

The abbreviated SFM consists of 5 tasks: Foot Wear, Magazine, Sit to Floor, Carry Climb and Night Walk, and the tester used scripted language regarding each task. Patients were asked to complete each task in the same way he or she would normally do at home. The tasks were then entered and scored by computer software in a proprietary electronic database capture program, ensuring accuracy and checking for variance. Detailed scoring methods for the SFM have been published previously.[19,20]

Participants also completed the **Valued Activities Questionnaire**, which is a measure of quality of life. These measures were acquired at the time that reliability of performance based measures of activities of daily living (ADLs) and the short form of the SFM was completed. A Valued Activities Score (VAC) was then assigned to each patient based on the answers to responses regarding valued activities performed and presentation of symptoms during the task. To calculate the VAC score, the number of symptoms during a valued activity from the Valued Activities Questionnaire was divided by the total number of valued activities performed. (VAC = 100 - symptoms with valued activities/ total number of valued activities). In 2005, a prospective study of the VAC as a quality of life construct was a valid and highly reliable assessment of quality of life. [21] A list of these activities is found in Table 5.

Statistical Analysis

All statistical analysis were performed using SPSS Version 22. All data was tested for normality and summarized using the mean (SD) and median (minimum, maximum). The statistical hypothesis that spine curve measures are associated with functional motion (mobility and ADL scores) and quality of life were tested using Pearson's coefficients (r) and Spearman's correlation coefficients (r_s). Correlation analysis was performed to assess the strength of this relationship and the coefficients of determination were used to account for the variance between each of the variables.

Results

During the study period, 2,500 individuals presented to the clinic for an initial SFM test. Of these individuals, 303 were males and 2,197 were female, and ages ranged from 17 to 97, with the mean age being 67.94 years. Of these individuals, 2,394 had data available for all covariates of interest. The characteristics of the participants are summarized in Table 1.

A preliminary analysis was performed on all variables of interest to ensure no violation of the assumptions of normality, linearity and homoscedasticity.

The relationship between kyphosis and scores of functional motion (as measured by the SFM) was investigated using the Pearson-product-moment correlational coefficient, as was the relationship between functional motion and quality of life as measured by the VAC score. Further correlational analysis was also conducted between kyphosis and quality of life.

As expected, there was a negative correlation between kyphosis and functional motion, ($r = -.274$, $n = 2415$, $p < .001$), suggesting that higher kyphosis is associated with poorer functional movement. This leads us to determine that the degree of kyphosis helps to explain approximately 8% of the variance in participants' scores on functional motion.

There was also a very small negative correlation between kyphosis and VAC scores, ($r = -.071$, $n = 2394$, $p < .001$), suggesting that higher kyphosis is associated with lower ability to perform valued activities. The also leads us to determine that kyphosis explained less than 1% of the participants scores on quality of life.

Finally, there was a small, positive correlation between scores on the SFM and valued activities ($r = .221$, $n = 2,437$, $p < .01$), suggesting that better function is associated with greater quality of life, determining that functional movement explained approximately 5% variance of the participants' scores on quality of life.

Discussion

This study found a significant association between kyphosis and functional motion as assessed by multiple validated measures. Furthermore, significant evidence was found that suggests that higher scores on functional motion tests were associated with greater quality of life. While these findings are consistent with previous well-known studies that report associations between greater degrees of kyphosis and impaired physical functioning and reduced quality of life[1,4,6] , however, the strength of these correlations were found to be smaller than expected.

Using the coefficients of determination, it was especially interesting to note that less than 1% of the variance in respondents' scores on valued activities was due to kyphosis.

While this study has a number of strengths, including a large number of participants who were not preselected for hyperkyphosis or co-morbidities, participants were mainly comprised of community-dwelling participants living in one geographic area who were already presented to the clinic as a referral for osteoporosis. As such, extrapolation of these results to other populations may be difficult. Furthermore, there is no standard definition of hyperkyphosis using the measures described. We were unable to account for possible confounding variables that may have affected functional motion and quality of life, and it is also possible that the small correlations were affected and highlighted by the large sample size.

Despite these limitations, this preliminary study suggests that future analysis should be done to look at confounding variables such as age, medication use, co-morbidity, bone mineral density, prior hospitalization, injurious falls, and prevalence of hip and incident vertebral fracture to determine their role in assessing functional movement and quality of life. Thus far, there is very little in the current research that addresses these issues together with degree of kyphosis.[4,7,9,13]

Furthermore, along with the treatment of osteoporosis, care of kyphotic patients should not focus solely on the improvement of mobility and functional movement. It is important

for clinicians to look at function not only from a risk assessment of fracture, fall and hospitalization, but also from a quality of life perspective from a patient's daily activities and it highlights the need for additional research.

While there may be many quality of life questionnaires in the literature that assess function, there are very few that also address symptoms and a broader view of valued activities. [4] When used in combination with an easy to administer test that assesses functional movement and other data capture information, we can provide new direction for busy healthcare providers who can then quickly assess quality of life and employ the correct methods to enhance quality of life based on valued activities.

Reliable and easy to use data collection tools have the ability to transform the future of medicine, but only if there is real time access to them. This study calls for further exploration of the unique relationship of the multiple factors that can impact perceived quality of life, and a further analysis of confounding variables.

Table 1: Descriptive Statistics

	N	Minimum	Maximum	Mean	Standard Deviation	Skewness		Kurtosis Statistic	Kurtosis [***]Error
[*]SFM	2500	6	100	73.99	19.800	-1.038	.049	.371	.098
Kyphosis	2415	1	101	49.17	13.234	.445	.050	.418	.100
[**]VAC Score	2437	0	100	82.90	23.488	-1.642	.050	1.984	.099
Age	2500	17	97	67.94	11.139	-.365	.049	.310	.098
Valid N (listwise)	2394								

		Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Female	2197	87.9	87.9	87.9
	Male	303	12.1	12.1	100.0
	Total	2500	100.0	100.0	

Table 2 Correlations

Gender			SFM	Kyphosis	VAC Score	Age
Female	SFM	Pearson Correlation	1	-.279**	.218**	-.473**
		Sig. (2-tailed)		.000	.000	.000
	Kyphosis	Pearson Correlation	-.279**	1	-.073**	.217**
		Sig. (2-tailed)	.000		.001	.000
	VAC Score	Pearson Correlation	.218**	-.073**	1	.093**
		Sig. (2-tailed)	.000	.001		.000
	Age	Pearson Correlation	-.473**	.217**	.093**	1
		Sig. (2-tailed)	.000	.000	.000	
Male	SFM	Pearson Correlation	1	-.219**	.201**	-.298**
		Sig. (2-tailed)		.000	.001	.000
	Kyphosis	Pearson Correlation	-.219**	1	-.075	.161**
		Sig. (2-tailed)	.000		.217	.007
	VAC Score	Pearson Correlation	.201**	-.075	1	.231**
		Sig. (2-tailed)	.001	.217		.000
	Age	Pearson Correlation	-.298**	.161**	.231**	1
		Sig. (2-tailed)	.000	.007	.000	

*Safe Functional Motion Test

**Valid Activity Score

*** Correlation is significant at the 0.01 level (2-tailed).

b. Gender=F,:Listwise N=2120

c. Gender=M,:Listwise N=274

Table 3 Activities

Basic activity of daily Living	Instrumental Activities of Daily Living	Leisure Activities	Productive Activities
Getting in/out of bed	Washing Dishes	Running	Sitting Tasks on The Job, Volunteer and Home
Bathing and Showering	Meal Preparation	Sitting and Watching	
Brushing Teeth	Cooking	Sitting and Doing	Standing Tasks on the Job, Volunteer and Home
Eating	Getting the Mail	Fishing	
Dressing	Laundry	Shopping	
Grooming	Ironing	Decorating	
Physically Intimate Relationship	Talking on Phone	Dancing	
Resting and Sleeping	Using Computer	Tennis	
	Household Maintenance	Golfing	
	Grocery Shopping	Bowling	
	Taking Out Trash	Walking	
	Load and Unload Dishwasher	Community Leisure	
	Reaching into Cabinet or Closet	Biking	
	Making and Changing Bed Sheets	Yard Games	
	Driving	Feeding the Birds	
	Getting Gas	Gardening	
	Car Passenger	Woodworking	
	Going to the Doctor	Hunting	
	Child Care	Exercising	
	Carrying a Purse	Horseback Riding	
	Cleaning Bath Tub	Canoeing and Boating	
	Light Cleaning	Traveling	
	Sweeping		
	Vacuuming		
	Mopping		
	Dusting		
	Car Maintenance		
	Caregiving		
	Caring for a Pet		
	Mowing the Lawn		
	Raking		

References

1. Katzman W, Wanek L, Shepherd J, Sellmeyer D. Age-Related Hyperkyphosis: Its Causes, Consequences, and Management. *J Orthop Sports Phys Ther*. 2010;40(6):352-360. doi:10.2519/jospt.2010.3099.

2. Kado D, Huang M, Karlamangla A, Barrett-Connor E, Greendale G. Hyperkyphotic Posture Predicts Mortality in Older Community-Dwelling Men and Women: A Prospective Study. *Journal of the American Geriatrics Society*. 2004;52(10):1662-1667. doi:10.1111/j.1532-5415.2004.52458.x.

3. Leech J, Dulberg C, Kellie S, Pattee L, Gay J. Relationship of Lung Function to Severity of Osteoporosis in Women. *Am Rev Respir Dis*. 1990;141(1):68-71. doi:10.1164/ajrccm/141.1.68.

4. Takahashi T, Ishida K, Hirose D et al. Trunk deformity is associated with a reduction in outdoor activities of daily living and life satisfaction in community-dwelling older people. *Osteoporosis International*. 2004;16(3):273-279. doi:10.1007/s00198-004-1669-3.

5. Kado D. Vertebral Fractures and Mortality in Older Women. *Arch Intern Med*. 1999;159(11):1215. doi:10.1001/archinte.159.11.1215.

6. Ryan S, Fried L. The Impact of Kyphosis on Daily Functioning. *Journal of the American Geriatrics Society*. 1997;45(12):1479-1486. doi:10.1111/j.1532-5415.1997.tb03199.x.

7. Cortet B, Houvenagel E, Puisieux F, Roches E, Garnier P, Delcambre B. Spinal Curvatures and Quality of Life in Women With Vertebral Fractures Secondary to Osteoporosis. *Spine*. 1999;24(18):1921. doi:10.1097/00007632-199909150-00010.

8. Balzini L, Vannucchi L, Benvenuti F et al. Clinical Characteristics of Flexed Posture in

Elderly Women. *Journal of the American Geriatrics Society*. 2003;51(10):1419-1426. doi:10.1046/j.1532-5415.2003.51460.x.

9. Ensrud K, Black D, Harris F, Ettinger B, Cummings S. Correlates of Kyphosis in Older Women. *Journal of the American Geriatrics Society*. 1997;45(6):682-687. doi:10.1111/j.1532-5415.1997.tb01470.x.

10. Martin A, Sornay-Rendu E, Chandler J, Duboeuf F, Girman C, Delmas P. The impact of osteoporosis on quality-of-life: the OFELY cohort. *Bone*. 2002;31(1):32-36. doi:10.1016/s8756-3282(02)00787-1.

11. Kado D. Narrative Review: Hyperkyphosis in Older Persons. *Annals of Internal Medicine*. 2007;147(5):330. doi:10.7326/0003-4819-147-5-200709040-00008.

12. Kado D, Miller-Martinez D, Lui L et al. Hyperkyphosis, Kyphosis Progression, and Risk of Non-Spine Fractures in Older Community Dwelling Women: The Study of Osteoporotic Fractures (SOF). *J Bone Miner Res*. 2014;29(10):2210-2216. doi:10.1002/jbmr.2251.

13. van der Jagt-Willems H, de Groot M, van Campen J, Lamoth C, Lems W. Associations between vertebral fractures, increased thoracic kyphosis, a flexed posture and falls in older adults: a prospective cohort study. *BMC Geriatr*. 2015;15(1). doi:10.1186/s12877-015-0018-z.

14. Kado D, Miller-Martinez D, Lui L et al. Hyperkyphosis, Kyphosis Progression, and Risk of Non-Spine Fractures in Older Community Dwelling Women: The Study of Osteoporotic Fractures (SOF). *J Bone Miner Res*. 2014;29(10):2210-2216. doi:10.1002/jbmr.2251.

15. Schneider D, von Muhlen D, Barrett-Connor E, Sartoris D. Kyphosis does not equal vertebral fractures: the Rancho Bernardo Study. *J Rheumatol*. 2004;(31):747-752.

16. Goh S, Price R, Leedman P, Singer K. The relative influence of vertebral body and intervertebral disc shape on thoracic kyphosis. *Clinical Biomechanics*. 1999;14(7):439-448. doi:10.1016/s0268-0033(98)00105-3.

17. Sinaki M, Itoi E, Rogers J, Bergstralh E, Wahner H. Correlation of Back Extensors Strength with Throacic Kyphosis and Lumbar Lordosis in Estrogen-Deficient Women. *American Journal of Physical Medicine & Rehabilitation*. 1996;75(5):370-374. doi:10.1097/00002060-199609000-00013.

18. MacIntyre N, Lorbergs A, Adachi J. Inclinometer-based measures of standing posture in older adults with low bone mass are reliable and associated with self-reported, but not performance-based, physical function. *Osteoporosis International*. 2013;25(2):721-728. doi:10.1007/s00198-013-2484-5.

19. MacIntyre N, Stavness C, Adachi J. The Safe Functional Motion test is reliable for assessment of functional movements in individuals at risk for osteoporotic fracture. *Clin Rheumatol*. 2009;29(2):143-150. doi:10.1007/s10067-009-1297-6.

20. Recknor C, Grant S, Recknor J, MacIntyre N. Scores on the Safe Functional Motion Test Are Associated with Prevalent Fractures and Fall History. *Physiotherapy Canada*. 2013;65(1):75-83. doi:10.3138/ptc.2011-25bh.

21. IONmed Systems. Product overview: bone safety evaluation. Gainesville (GA): IONmed Systems; 2012. [cited 2015 Aug 2]. Available from: https://www.ionmed.us/bse.

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April 4, 2015

Dr. Daniel Van Dussen, Principal Investigator
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Department of Sociology, Anthropology & Gerontology
UNIVERSITY

RE: HSRC Protocol Number: 158-2015
Title: Associations Between Kyphosis and Scores on the Safe Functional Motion Test: A Retrospective Analysis on Quality of Life

Dear Dr. Van Dussen and Ms. Plant:

The Institutional Review Board has reviewed the abovementioned protocol and determined that it is exempt from full committee review based on a DHHS Category 5 exemption.

Any changes in your research activity should be promptly reported to the Institutional Review Board and may not be initiated without IRB approval except where necessary to eliminate hazard to human subjects. Any unanticipated problems involving risks to subjects should also be promptly reported to the IRB.

The IRB would like to extend its best wishes to you in the conduct of this study.

Sincerely,

[redacted]

Dr. Scott C. Martin
Interim Associate Dean for Research
Authorized Institutional Official

SCM:cc

c: Qi Jiang, Chair
Department of Sociology, Anthropology & Gerontology