

Variability of the Forward Head Posture in Healthy Community-dwelling Older Women

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ABSTRACT

Purpose: The purpose of this research was to describe the variability of forward head posture in healthy older women, and to investigate the influence of age on variability.

Methods: This cross-sectional descriptive study included 187 healthy community-dwelling women volunteers ranging in age from 65-96 years. The forward head posture (FHP) measurement was derived from a sagittal photograph. The subjects were asked to perform a series of standing activities, and the photograph was taken while the subjects were performing these activities. Data analysis included descriptive analysis, FHP measurement analysis for normalcy, one-factor ANOVA with FHP by age group, post-hoc Tukey analysis, and trend analysis for the age-FHP relationship.

Results: Three age-group normative FHP means were identified: 48.84° (SE 0.97) for the 65-74 year old group, 41.20° (SE 0.78) for the 75-84 year old group, and 35.60° (SE 1.76) for the 85+ year group. Significant differences were found in the FHP between these age groups. A subsequent trend analysis demonstrated a linear relationship between age and the FHP, with older women demonstrating a more severe FHP.

Conclusions: Age-associated variability in the FHP of healthy elderly women has been identified. The FHP values determined by this research may serve as normative guidelines for clinicians when conducting postural assessments, and in clinical decision-making regarding possible interventions.

Key Words: forward head posture, older women, posture variability

INTRODUCTION

Postural deviations among aging adults are often attributed to age-associated changes, and occasionally to gender-associated differences.¹⁻³ Age-associated changes in posture have been

frequently described by a cluster of postural deviations that includes a forward head, rounded shoulders, changes in lumbar lordosis, and increased flexion in the hips and knees.^{1,2} These age-associated postural changes may be attributed to age-related biological and physiological changes, functional or pathological causes, or a combination of these changes.^{3,4} Clinicians often based their postural assessments upon the standard "ideal" posture as defined by Kendall and associates.^{1,2,5} The physical therapist's decision to provide therapeutic intervention measures for impaired posture is then typically based upon the amount of variation from "normal" posture. Research literature, however, suggested that asymptomatic individuals demonstrated a range of normal values for posture rather than a single fixed point of reference, and that posture changes in asymptomatic adults may be associated with aging and with gender.⁶⁻⁹ While standard geriatric reference textbooks provided normative values for aging adults in various aspects of the geriatric assessment, there was a distinct absence of normative values relating to posture variables in general, and to the forward head posture specifically.¹⁻³

The forward head posture (FHP) places the head anterior to the vertical ideal as defined by a plumb line measure.⁵ Kendall and associates indicated that the deviation of the head relative to the ideal plumb line posture should be considered faulty and should be measured in terms of slight, moderate, or marked.⁵ This type of analysis would suggest that any deviation from the ideal represents an abnormal state, and does not afford an objective and quantifiable measure of the postural deviation. Researchers have described normal head posture in asymptomatic adults using a range of measured values rather than a distinct point,⁶⁻⁹ suggesting that simply having the head anterior to the vertical ideal may not be a pathological condition but rather may be representative of the variation found in the normal population.

Varying methodologies in measuring head postures make direct comparisons of some existing studies difficult.¹⁰⁻¹⁴ However, several studies^{6-9,15,16} have used a similar measurement methodology as described by Braun and Amundson,¹⁷ which incorporated a tragus-seventh cervical spinous process(C7)-horizontal angle measurement to define the head position in the sagittal plane. Using this measurement, a smaller tragus-C7-horizontal angle indicated a more severe forward head position.

Most of the available data regarding the FHP ranges were drawn from small samples of young adults. These small ($n < 45$), gender-mixed, young adult (age ≤ 45) studies using the tragus-C7-horizontal angle measurement, reported an average head-position measurement clustered within a range of 49° to 52°,^{6,7,15,16,18} with one study⁸ reporting an average of 59°. The small number of subjects in these investigations may have contributed to the large range of head position measurements.

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Based upon a summary of these studies, a clinician could expect young healthy adults to exhibit an average normal FHP within a 10° range from 49° to 59°.

Age-associated differences were identified by Raine and Twomey⁸ in a study which included a 55+ age group with an age range of 55 to 81 years. Although these investigators used the tragus-C7-horizontal angle as the measure of the forward head posture, they reported the measured angle value as the supplementary angle to the technique of Braun and Amundson.¹⁷ The average FHP value reported by Raine and Twomey for the 55+ group was 131.1° (SD 6.5°).⁸ By reverse scaling this value to match the angle measure described by Braun and Amundson,¹⁷ the average FHP in the Raine and Twomey study was 48.9°. The average value of the older age group differed significantly from younger age groups, suggesting that older adults demonstrated a more acute FHP.⁸ Hanteen and associates¹⁰ did not find age-associated differences in their analysis of total head flexion/extension excursion and resting head posture in 214 subjects. However, these researchers included only individuals under the age of 60. This finding may suggest that age does not play a role in head posture variation until later in adulthood.

The literature regarding gender-associated differences in FHP is inconsistent. Braun,⁶ using the tragus-C7-horizontal measurement method, reported that men tended to display a more forward neutral head position. However, this study included only 40 young, healthy subjects, of which 20 were men (average age 29.0 years) and 20 were women (average age 28.4 years). Conversely, Raine and Twomey,⁸ who also used the tragus-C7-horizontal measurement, reported no significant gender difference in their study of 160 healthy adults who were divided into 3 age groups. These age groups included 17-29 years, 30-54 years, and 55-81 years. While the number of men and women in each group was similar, the age range variability was not similar with the oldest group starting at 55 years and spanning 26 years while the youngest group spanned only 12 years.⁸ Hanteen and colleagues^{10,11} have also reported gender-associated postural differences in their subjects. However, the measurement methodology in their studies was significantly different from the tragus-C7-horizontal measure. These investigators used total head flexion/extension excursion measured in centimeters, and calculated the resting head position as a percent of the total excursion. Significant methodological differences prohibit direct comparisons of these studies, and may account for apparent inconsistencies within the literature.

Several studies have been conducted on the subject of the FHP with both age-associated and gender-associated findings reported. While some inconsistencies were evident within the results and conclusions of the studies, the literature suggests that age and gender differences tended to influence the forward head posture. Identification of the diversity of FHP positions within a healthy older population would afford clinicians normative ranges upon which to base postural assessment decisions, and would subsequently improve therapeutic intervention measures for older individuals exhibiting impaired posture. The purpose of this study was to identify FHP variability, or diversity of positions, within healthy community-dwelling women age 65 and older, and to investigate the likelihood for age-associated variability in this population.

METHODS

Subject Selection

This study used a secondary analysis of a subset of data from a larger study involving the relationship between balance and posture (T.M.N., J.W.M., unpublished data, 2007). The sample for this secondary analysis included 190 women, average age 78.31 years (SD = 6.42) with a range from 65 to 96 years. The original sample was recruited from senior citizen centers, senior wellness centers, retirement communities, and from private gatherings via short informational presentations. Inclusion criteria were as follows: living independently in the community, not requiring assistance with any ADL activities, not using assistive gait devices, experiencing no current balance difficulties, and not currently under direct care of a physician for problems with balance or for a major medical problem. All volunteers signed an informed consent prior to individual data collection. This study was approved by the Institutional Review Boards of Oklahoma State University and Langston University.

Forward Head Posture Measurement

Braun and Amundson¹⁷ described a measurement of the sagittal plane head alignment as the acute angle between the line joining C7 to the tragus of the ear and the horizontal line at C7. The authors obtained side profile photographs, and used a custom computer program to analyze the angle. The tragus-C7-horizontal angle measurement for the FHP with photographic analysis has demonstrated high reliability ($r = .88$)^{8,18} and very high intrarater and interrater reliability ($100\% \pm 2^\circ$).⁷ This method of photographic analysis was ideally suited for assessment of the head position during dynamic movement, and therefore was used for this research. The following paragraphs outline the methodology for the original photographic data collection.

A small 1.5 cm plastic disk with a 1 cm center post wrapped with photosensitive tape was placed on the subjects' skin directly over the seventh cervical spinous process (C7) using double sided tape. A small triangular white adhesive marker was placed on the subjects' tragus of the right ear. Both markers were used for ease of photo analysis. The use of markers for landmark identification was consistent with the protocol described by Raine and Twomey.⁸

The subjects were then asked to complete the Berg Balance Scale. The photograph was taken during the seventh task of the Berg Balance Scale (standing with feet together for one minute). Individual subjects were not informed of the timing of the photograph for the following 2 reasons: (1) to insure the subject did not pose for the photograph with an attempted "perfect posture," and (2) to insure the subject's attention was focused on the particular activity and thus the individual's typical posture would be captured. All photographs were taken from the subject's right side thus reflecting a right-sagittal profile.

A 5.0 megapixel digital camera (Canon PowerShot A95, Canon Inc., Lake Success, NY), with a real-image optical viewfinder, a 7.8-23.4mm lens with 3x optical zoom, and a built-in flash, was used for all photographic data collection. The camera was mounted on a tripod with an adjustable ball-head grip and multiangle bubble level allowing the photographer to level the camera in horizontal and vertical planes, regardless of possible distortions in the surface of the floor. The camera

was positioned 5 feet from the subject. The subject was photographed perpendicular to the right sagittal plane in order to obtain capture a sagittal view of the head and neck during the standing activity.

The photographs were downloaded to a laptop computer (Gateway M500 Notebook, Gateway, Inc, Poway, CA) for cataloging and subsequent printing. The bottom of each printed photograph represented a true horizontal line relative to the subject because the tripod's ball-head camera mount incorporated a horizontal-vertical bubble level. On the printed photograph of each subject, a horizontal line was drawn through C7, and a second line was drawn connecting the tragus of the right ear to the C7 marker. The intersection of these lines defined the sagittal plane relationship between C7, the tragus of the right ear, and the horizontal. The angle was then measured to the nearest degree (Figure 1).

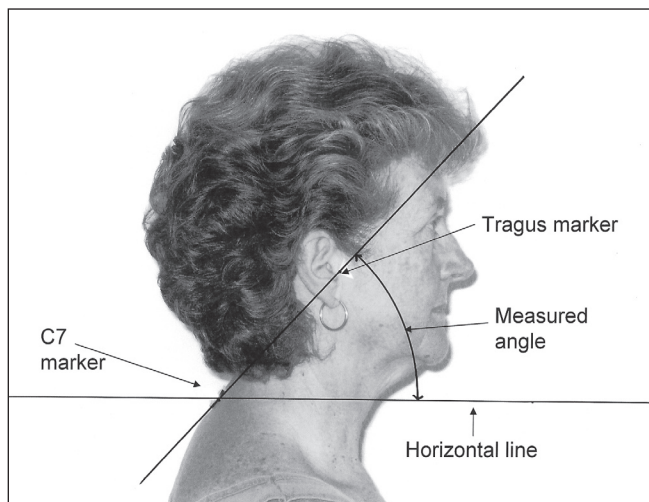


Figure 1. Illustration of body markers and forward head posture measurement on individual photo. (Photo used with written permission of subject)

Data Analyses

Subject data were compiled and analyzed using the Statistical Package for the Social Sciences (SPSS® for Windows, v. 14.0, Chicago, IL). Analyses included descriptive analysis, FHP measurement analysis for normalcy, one-factor ANOVA with FHP by age group, post-hoc Tukey analysis, and trend analysis for the age-FHP relationship. All analyses were completed with an alpha level of .05.

RESULTS

The norming process began with a sample of 190 women, aged 65-96 (Mean = 78.42, SE = .476, SD = 6.57). Three of these women demonstrated a FHP measurement beyond 3 standard deviations from the group mean of 41.6° (SD 10.4). Although all 3 subjects met the inclusion criteria, they also demonstrated an associated severe thoracic kyphosis and thus were eliminated from the normative sample. Given that the retained sample size was fairly large (N = 187), individual FHP scores were converted to z-scores. This served to standardize the metric of this ratio-level scale. This standardization initiated the norming process of determining the score range typically attained by older women. Those cases exhibiting z-scores beyond

the 3.0 standard deviation units above or below the mean were considered to be outliers,¹⁹ which resulted in one additional case being removed from the sample. A final sample size of 186 cases (women ranging in age from 65-96, Mean = 78.31, SE = .471, SD = 6.42) was used for the remainder of the investigation.

Univariate statistics were then developed to examine the distribution of forward head position scores for the sample as a whole (N = 186). The primary goal of this analysis was to assess the data distribution for normality. These women's raw scores ranged from 15-63°. The overall mean score was 42.38°, with SE = .667 (SD = 9.09°). Although the index of skewness (-.251, SE = .178) suggested a slight negative skew, it was well within the ± 1.0 range indicating a symmetrical distribution.²⁰ According to Stevens,¹⁹ kurtosis has little effect on the level of significance or power of parametric statistics conducted with a symmetrical distribution. Nevertheless, an examination of the kurtosis statistic in the current study (-.247, SE = .355) revealed a very limited platykurtic distribution. Absolute values of two standard errors of kurtosis or more signal a significant problem with the relative peakedness or flatness of the distribution.²¹ Kurtosis was well within the expected range of chance fluctuations in that statistic for this data sample. Thus the data distribution of scores created by the forward head position measure was deemed symmetrical, with normality assumed.

Within-group norms were then developed to allow for an evaluation of an individual woman's FHP within the context of a comparable age group. These within-group norms may provide a uniform and clearly defined quantitative score interpretation by age. The initial age-grouping consisted of 5-year increments. Since year groupings in previous studies were not consistent, the 5-year grouping was chosen in an attempt to identify the smallest year grouping with significant differences. Forward head posture descriptive indices by age category are presented in Table 1. A one-factor ANOVA, conducted to assess FHP differences by age group [$F_{(5,180)} = 11.689$; $p < .0001$], revealed statistically significant overall group differences. A follow-up Tukey analysis provided pair-wise difference tests between these age groups to uncover the source of the significant age effect. This post-hoc test yielded a complex pattern of group differences, thus an iterative post-hoc approach was undertaken to produce the final age-group categories for forward head position scores.

In the first Tukey test, no real differences in FHP were detected between those in the 65-69 and 70-74 age groups ($p = .769$). Additionally, no real differences in FHP were found between those women aged 65-69 and 75-79 ($p = .094$). However, statistically significant FHP differences did occur between the 70-74 and

Table 1. Forward Head Posture Descriptive Indices by 6 Age Categories

Age Category	N%	Mean Degrees	SD	SE	Score Range Degrees
65-69	18 (9.68)	46.83	6.94	1.63	29-58
70-74	32 (17.20)	49.97	6.66	1.18	38-63
75-79	52 (27.96)	41.06	8.82	1.22	24-58
80-84	55 (29.57)	41.33	7.38	0.99	22-59
85-89	23 (12.37)	36.37	9.51	1.98	22-53
90-96	6 (3.22)	32.67	9.52	3.89	15-41

75-79 age groups ($p < .0001$) which suggested that these 2 groups should remain distinct. Taken together, these results suggested that it would be best to combine the 2 youngest age categories (65-69 and 70-74) into a single group of women aged 65 to 74. This first Tukey test also revealed significant FHP differences between the 65-69 group and both the 85-89 group ($p = .001$) and the 94+ group ($p = .003$). Forward head posture differences were also statistically significantly different between those in the 70-74 age group and the 85-89 ($p < .0001$), and between those in the 70-74 group and the 94+ ($p < .0001$) group, thus the 2 oldest age categories were collapsed into a group consisting of women aged 85+.

Due to the lack of clarity of FHP differences by age in the mid-range age categories (75-79 and 80-84) in the first Tukey analysis, the ANOVA was re-conducted with women grouped by the 4 previously established age categories (65-74, 75-79, 80-84, and 85+). As expected, this analysis reached statistical significance [$F_{(3,182)} = 18.474$; $p < .0001$] indicating that FHP did vary by age group. The follow-up second Tukey tested FHP differences between all pairs of age groups. As anticipated, the 65-74 age group differed significantly in FHP from the group of women ranging in age from 85+. Further, women in these 2 age groups significantly differed in FHP from those in both mid-range groups (75-79, $p < .0001$; 80-84, $p = .020$). The mid-range groups, however, did not significantly differ from each other in FHP ($p = .998$), thus these 2 groups (75-79 and 80-84) were combined into a single mid-range group which contained women aged 75-84.

As a check on the validity of the final groupings, a final ANOVA, which accounted for unequal group sizes, was conducted to assess FHP differences between the 3 collapsed groups (65-74, 75-84, and 85+). Results indicated significant overall group differences [$F_{(2,183)} = 27.844$; $p < .0001$] with omega squared²² revealing an effect size of .224. This suggested that about 22% of the variability in FHP was attributed to the age category, which may be interpreted as a large effect.²³ The final age grouping thus consisted of 3 categories (65-74, 75-84, and 85+) with about 10-year age increments which have both statistical and clinical relevance (Table 2). Combining the age categories also served to increase power in subsequent statistical tests.

Table 2. Forward Head Posture Descriptive Indices by 3 Age Categories

Age Category	N%	Mean Degrees	SD	SE	95% Confidence Interval (degrees)	Score Range Degrees
65-74	50 (26.88)	48.84	6.86	0.97	46.89 – 50.79	29 – 63
75-84	107 (57.53)	41.20	8.07	0.78	39.65 – 42.74	22 – 59
85+	29 (15.59)	35.60	9.47	1.76	32.00 – 39.20	15 – 53

Given the theoretical notion that forward head position should increase by age, a trend analysis was then conducted which explored the functional relationship between age and forward head. The resulting F-test of the linear and quadratic functions revealed a statistically significant linear component ($F_{(1,183)} = 50.188$; $p < .0001$). Forward head position scores were plotted according to the three age groups (Figure 2). As noted in the figure, the data plotted are moderately well-described by the linear function. It would appear that a forward head position is directly related to increasing age among older women.

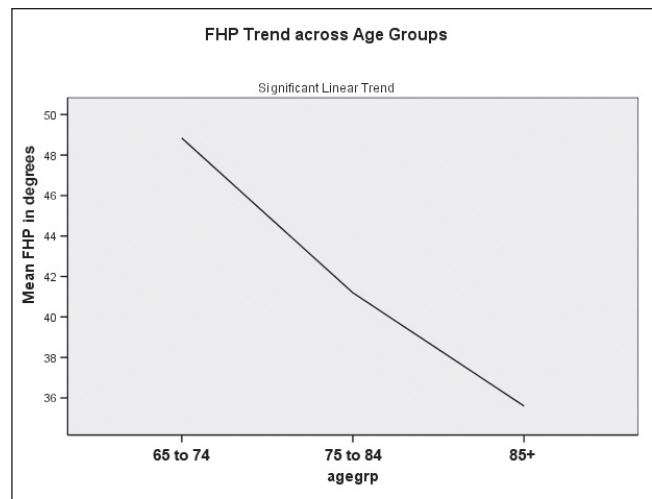


Figure 2. Forward Head Posture (FHP) trend across age groups.

DISCUSSION

The purpose of this study was to develop a set of FHP baseline norms for healthy elderly women. The FHP measure in this study was designed to be norm-based, meaning that the score for an individual woman would be interpreted by a clinician after comparing her score with the scores of a group of women who defined the typical score range for this test. Therefore, these norms were developed to serve as a guideline to enhance score interpretations in applied clinical settings. It is essential that individual norms are not interpreted in isolation.

The overall mean for FHP of the current study was 42.38° (95% CI 41.06-43.69) and was lower than that reported by Raine and Twomy (48.9°; 95%CI 47.9-48.9).⁸ Given the confidence intervals, this difference might appear to be clinically significant. However the older age group used by these authors was “55 & above” with an average age of 65 (SD7.0) years and an age range of 55-81. Additionally, Raine and Twomy included only 24 women in this age span. The average FHP for the young-old age grouping in our study (48.8; 95%CI 46.89 – 50.79) is essentially identical to that of Raine and Twomy,⁸ suggesting there may be a greater change in the FHP posture with aging than Raine and Twomey were able to identify with such a small sample. Unfortunately Raine and Twomy⁸ did not subdivide the older group into smaller age categories; therefore, further comparisons with the current study are limited.

The final age groups clarified group FHP variations for the young-old (65-74), the old-old (75-84), and the oldest-old (85+) women. The 3 identified FHP means were both clinically and statistically different, giving clinicians identifiable normative values, and providing additional confidence for the clinician when using these normative values. Interestingly, the young-old mean of 48.84° is very near to the cluster of means, 49-52°, reported for young adults. This may suggest that age-associated effects on the forward head posture may not be significant until the mid-70s and older.

The trend analysis clearly demonstrated an age-associated change in the FHP of these women. As expected, this change reflected a more angled FHP with increasing age. The linear

nature of this trend would support of overall concept of age-associated postural changes. Additionally, the 3 age range groupings identified through the statistical normative process in this study are the same age groupings that are standard cohort divisions used in aging research^{24,25} and in demographic analysis,²⁶ thereby lending credence to the identified age-group cohorts.

Three distinct limitations were associated with this study. First, this study was designed as a cross-sectional investigation, so individual life-span changes could not be inferred. Second, the subjects in this study were selected by means of a convenience sample, and could not be construed as being representative of the population of healthy community-dwelling women 65 years and older. Third, individuals with musculoskeletal disorders were not specifically excluded. Thus, individuals exhibiting musculoskeletal disorders which possibly contributed to postural changes may have been included in the subject pool if they were not directly under the care of a physician at the time of data collection.

CONCLUSIONS

This research represented a large cross-sectional study of healthy elderly women, and assessed the variability of the FHP within this group of subjects. Three distinct age groupings were identified with significantly different mean FHP measures. Additionally, the data demonstrated an age-associated effect with the older women reflecting a more severe FHP. The normative values generated by this research can serve as a guideline to enhance postural assessment and clinical decision making in patient/client management. Additional research is needed to assess age-associated FHP variability in older men and in frail elderly populations. Research is also needed to identify effective intervention programs that demonstrate significant postural change in patients/clients.

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