Head and Shoulder Posture Variations in 160 Asymptomatic Women and Men

Sally Raine, PhD, Lance T. Twomey, PhD

ABSTRACT. Raine S, Twomey LT. Head and shoulder posture variations in 160 asymptomatic women and men. Arch Phys Med Rehabil 1997;78:1215-23.

Objective: To quantitatively describe the postural alignment of the head and shoulders and the surface curvature of the thoracic spine in comfortable erect standing and to examine the effect of age and gender on head and shoulder alignment.

Design: Descriptive survey.

Setting: Gait research laboratory.

Participants: One hundred sixty asymptomatic volunteers aged between 17 and 83 years.

Main Outcome Measures: Five photographic measurements of head and shoulder posture in the coronal and sagittal planes and a photographic measurement of the surface curvature of the thoracic spine in the sagittal plane.

Results: Mean values of coronal head tilt, coronal shoulder angle, sagittal head tilt, sagittal C7-tragus angle, and sagittal shoulder-C7 angle were 180.1°, 181°, 172.1°, 131.1°, and 53.7°, respectively. The 95% confidence intervals for the means ranged between 1° and 3.8°. For each of the head and shoulder measurements there was no significant gender difference (p = .33 to .99). Of the five measurements, only sagittal C7-tragus angle was significantly correlated with age (r = .44), and none was correlated with surface curvature of the thoracic spine.

Conclusions: Head and shoulder posture was similar between genders. Only one postural description that has been described anecdotally was identified, ie, that age was related to the position of the head with respect to the trunk in the sagittal plane, although the strength of the association was of questionable clinical significance. In contrast, other longstanding assumptions were not supported, and accordingly, a forward head was not associated with increased thoracic curvature or upper cervical spine extension.

THE PHYSICAL APPEARANCE of the head, cervical spine (or neck), and shoulders is a principal topic in the debate concerning human posture.[1-13] Evaluation of head and shoulder posture has commonly considered the profile alignment of the body parts with respect to the trunk.[1,4,7,14-16] Alignment has been deemed ''poor'' when the head is held forward in relation to the trunk or when the shoulders appear slouched forward. Physical characteristics referred to as poor include ''forward head,'' ''poke chin,'' and ''rounded shoulders,'' and the nature of these characteristics is self-explanatory.[2,6,14,15,17-19] They have been widely cited in the literature and are usually associated with detriment based on anecdotal, empirical, or clinical reasoning. Consequently, there is little that defines or describes poor head and shoulder posture on the basis of measurement.

In contrast, extensive literature has described postural relationships of the head and shoulders in the sagittal plane or their clinical correlates. A ''forward head'' position has been described iteratively over decades and has been anecdotally linked to musculoskeletal dysfunction and pain including craniofacial pain, headache, neckache, and shoulder pain.[5,6,10,15-18,20-25] Other postural correlates have also been described without quantitative verification, such as the view that a forward head is related to an extended upper cervical spine, or to protracted shoulder girdles and a kyphotic thoracic spine, or less widely of hand preference being related to coronal plane shoulder asymmetry.[2,5,8,9,26,27]

Possibly the earliest major investigation to quantitatively document posture was conducted in 1941. Using a series of photographic measurements, Cureton[1] described the head and shoulder posture of young men, having examined 382 and 644 subjects for head and shoulder measurements, respectively. Head posture was quantified by the measurement ''poke neck,'' which was defined as the angle between two lines defined as: (1) through the 7th cervical spinous process (C7) and the tragus of the ear, and (2) a horizontal line through C7 with a mean value of 53.6° (±6.4°). Conclusions were not drawn from the measurements, nor were they contrasted with quantitative data of the time; however, the results were tabulated as percentiles, which can be compared to contemporary research. Indicatively, the angular ''poke neck'' measurement has been repeated in a number of postural investigations in recent literature,[21,22,28-30] and it is the most common method of measuring head posture. Cureton's[1] measurements of shoulder posture, in contrast, have not been repeated, most likely a reflection of their less standardized nature.

It is difficult to quantitatively define postural alignment of the head and shoulders because there are few conclusive data available. Recent investigations have addressed this deficit and have measured the posture of the head, cervical spine, or shoulders in the sagittal plane, as well as in relation to age, gender, cervical spine range of motion, and pain.[11-13,26,29] Although such studies are valuable, their conclusions are mostly not comparable due to limited samples or differing methods, and further research is needed to exemplify postural variation. Descriptive data have focused on young adults (less than 35 years) and there are few data available to describe the head and neck posture, especially of older men. The effect of gender on head posture is unclear because previous investigations have had conflicting outcomes[26,29] and have reported both men and women as demonstrating a more forward head position. There is also little information about the effect of gender on shoulder alignment, and postural differences between men and women have not been clearly defined. Braun[29] reported measurements of shoulder posture and mobility that had not been described previously, and notwithstanding the questionable statistics that

From the School of Physiotherapy, Curtin University of Technology, Perth, Australia.

Submitted for publication October 8, 1996. Accepted in revised form March 19, 1997.

Supported by the Physiotherapy Research Foundation, Fitzroy North, Victoria, Australia.

No commercial party having a direct or indirect interest in the subject matter of this article has or will confer a benefit upon the authors or upon any organization with which the authors are associated.

Reprint requests to Dr. Sally Raine, School of Physiotherapy, Curtin University of Technology, GPO Box U1987, Perth 6001 Western Australia, Australia.

0003-9993/97/7811-4208$3.00/0

were used to describe reliability, provided some initial comparative data indicating that women were more round-shouldered than men. Similarly, there is a lack of conclusive data describing the effects of age on the postural alignment of the head and shoulders, and the small number of relevant studies addressing this subject have reported conflicting results,[26,29] although this may be attributable to differences in methods.

The aim of this study was to quantitatively describe the postural alignment of the head and shoulders in the coronal and sagittal planes and the curvature of the thoracic spine in the sagittal plane in 160 asymptomatic men and women in comfortable erect standing.

METHODOLOGY

Subjects

One hundred sixty volunteers were recruited from the town of Albany and the city of Perth in Western Australia. The subjects ranged between 17 and 83 years of age and were divided according to gender and then into three age groups of relatively even size (17 to 29 years, 30 to 54 years, and 55 years and over). The mean age, gender, height, and weight of the groups are reported in table 1. Subjects gave written informed consent for the research, and ethical approval was granted by our university. Subjects wore underwear, brief shorts, or swimming attire for testing.

The subjects comprised a sample of convenience and had responded to articles published in suburban newspapers in metropolitan Perth, posted or circulated notices requesting volunteers, and verbal requests at a regional hospital, or were recruited through word-of-mouth by the investigator and existing volunteers. Subjects were excluded if they reported a history of back pain within the last 2 years, spinal surgery, idiopathic scoliosis, inflammatory diseases such as ankylosing spondylitis, Reiter syndrome, psoriatic arthritis, rheumatoid arthritis, or metabolic diseases such as osteoporosis, Paget disease, or osteomalacia. Subjects were also excluded if they reported traumatic or degenerative conditions such as spondylolisthesis, Scheuermann disease, or a spinal tumor or infection of the skeletal system.

Procedure

Left-sided profile photographs were used to obtain a series of measurements of postural alignment of the head and shoulders in the coronal and sagittal planes, and the curvature of the thoracic spine in the sagittal plane, in comfortable erect standing. A camera with 35-70mm zoom lens was mounted on a tripod and loaded with slide film. The lens aperture was set at F-stop 8, zoomed to 70mm, and the camera placed so that the center of the lens was 4m from the subject, with the subject in approximately the center of the lens so as to reduce lens error, and with the camera perpendicular to the ground, parallel to the facing plane of the subject, and approximately level with the subject's pelvis to minimize parallax error. Two plumb lines were suspended from the ceiling to provide a vertical and magnification reference. In addition, three anthropometric measurements were made directly from the subjects.

Table 1: Mean (and Standard Deviation) of Subjects' Age, Height, Sitting Height, and Weight

Age Group (yrs)	Age (yrs)	Height (mm)	Sitting Height (mm)	Weight (kg)
17-29 (n = 56)				
Women (35)	20 (±3.2)	1658.5 (±65.7)	874.5 (±32.5)	58.8 (±72.2)
Men (21)	22 (±4.4)	1791.4 (±100.8)	929.3 (±45.4)	75.2 (±12.4)
30-54 (n = 55)				
Women (28)	42 (±6.7)	1645.9 (±78.2)	872.4 (±35.6)	65.6 (±11.1)
Men (27)	20 (±6.6)	1757.3 (±73.0)	907.7 (±44.9)	77.0 (±11.5)
55-81 (n = 50)				
Women (25)	65 (±7.0)	1613.1 (±56.0)	846.8 (±27.2)	63.4 (±9.7)
Men (25)	65 (±8.3)	1750.3 (±71.0)	905.7 (±44.2)	80.4 (±12.0)

Total n = 161.

To commence, subjects stood in comfortable erect standing, the instructions being to place their weight evenly on both feet, with knees straight, hands at their sides, and with their eyes looking forward. Bony landmarks were palpated and marked with adhesive skin markers that would be visible in photographs. Accuracy of the investigator's surface landmarking was confirmed by two professors of anatomy.

The palpation and marking was carried out in the same standing position as the subject would later adopt for the photographs, to reduce any error that might have occurred from skin movement. If clothing was overlying a bony landmark it was moved aside and, if necessary, held out of the way with tape. Since marking the subjects required them to stand still, they were encouraged to walk around after the markers were applied, to prevent them from feeling uncomfortable or becoming faint. White adhesive dots of 14mm diameter were used as skin markers. The dots approximated the size of the investigator's thumb and middle fingertips, which enabled their placement over the center of bony landmarks. The following bony landmarks used were: (1) left mastoid process; (2) left and right coracoid processes; (3) lateral shoulder—the head of the left humerus was palpated at its posterior aspect under the angle of the acromion and its anterior aspect lateral to the coracoid process, and the marker was placed midway between these points on the lateral aspect of the humeral head; (4) immediately inferior to the sternal notch; and (5) C7, T6, and T12 spinous processes.

In order to be photographed, the subjects were next instructed to stand comfortably, in their "normal, loose, or habitual" posture for two photographs, with their weight evenly on both feet and looking straight ahead. They were asked not to stand erect, or in a "best posture," because the purpose of the photograph was to capture their habitual or usual standing posture. Subjects were given time to adopt a relaxed, comfortable posture, and a photograph was then taken from the front and then the left side. The photographs were taken within a few seconds of one another, and without subjects moving substantially. After both photographs were taken, the subjects were asked to walk or move around, as they had been standing still for most of the testing time.

The spine was marked next, so that spinal curve would be visible in the sagittal plane in a left profile photograph. This procedure was described in a previous publication[31] and is only outlined here. The subjects were instructed to stand comfortably erect as before, and spinous process tips including C7, T6, and T12 were palpated and marked. A low-density, narrow length of foam marker was adhered to the spine in the median plane from C7 to S2 with double-sided adhesive tape, which followed exactly the surface contour of the spine and therefore accurately reproduced the thoracic curvature in the sagittal plane. Adhesive dots were placed on the foam marker in line with the dots placed adjacent to the spinous processes tips of C7, T6, and T12, which were later used to delineate the thoracic region of the vertebral column.

Measurements and Data Processing

Measurements in the coronal and sagittal planes were made from anterior and left profile photographs of subjects using a digitizer of 0.1mm resolution, a Hewlett-Packard computer, and an IBM-compatible computer. The photographic slides were projected and digitized in one dimension, with the subject image magnified to approximately 33% of true size. Photographic markers, visible anatomic landmarks, and vertical reference points on the image were manually digitized to obtain x and y coordinates that were used to calculate the desired measurements. Results were stored and analyzed on a Macintosh computer.

Five measurements of head and shoulder posture were made:

- Coronal head tilt (fig 1)—a line was drawn between the inferior tip of the left and right ears, and the angle of this line to the horizontal was calculated in degrees. Clear visibility of the ear tips in the slide image meant that accurate identification of the same bilateral points was possible without markers. This measurement described how level the head was when viewed from the front. A value of 180° described the head as aligned horizontally, a lesser value described a tilt inferiorly on the left, and a greater value a tilt inferiorly on the right.
- Coronal shoulder angle (fig 1)—a line was drawn between the left and right coracoid process markers, and the angle of this line to the horizontal was calculated in degrees. This described the elevation of one shoulder relative to the other when viewed from the front. A value of 180° described the shoulders as even, a lesser value described a higher right shoulder, and a greater value described a lower right shoulder.
- Sagittal head tilt (fig 2)—a line was drawn between the inferior aspect of the fold of skin below the left eye, and the midpoint of the tragus of the left ear, and the angle of the line to the horizontal was calculated in degrees. The surface landmarks were clearly visible on the image of the subject. This measurement described the inclination of the head from the horizontal when viewed from the left side and related to the relative position of upper cervical spine. A value of 180° represented the Frankfurt Horizontal plane—that is, when the head was positioned level with the horizontal. When the angle was less than 180°, the head was tilted superiorly at the front such that the upper cervical spine was relatively more extended. When the angle was less than 180°, the head was tilted inferiorly at the front such that the upper cervical spine was relatively more flexed.

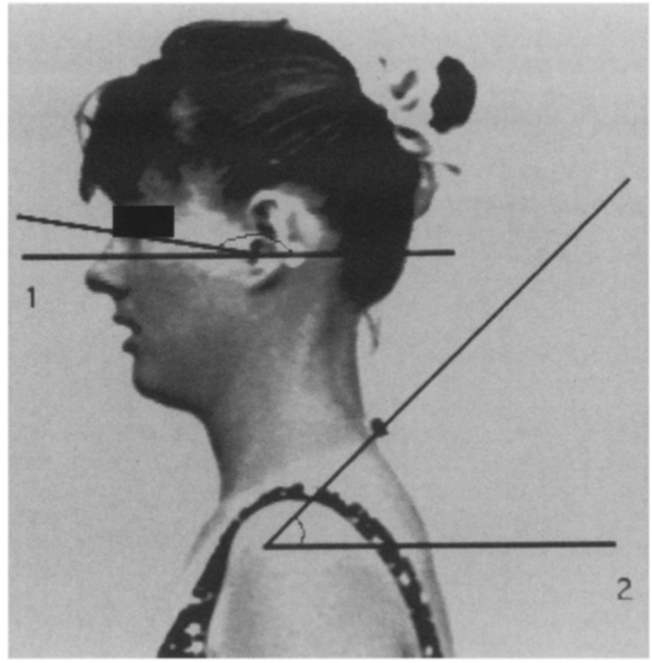

Fig 2. Measurements of (1) sagittal head tilt and (2) sagittal shoulder-C7 angle in a profile photograph of a subject.

- Sagittal shoulder–C7 angle (fig 2)—a line was drawn between the left lateral shoulder and the C7 markers, and the angle of this line to the horizontal was calculated in degrees. This described the position of the left shoulder with respect to C7 when viewed from the left side. A smaller angle indicated a relatively forward shoulder in relation to C7, and so represented a more rounded position of the shoulder.
- Sagittal C7–tragus angle (fig 3)—a line was drawn between the midpoint of the tragus of the left ear and the C7

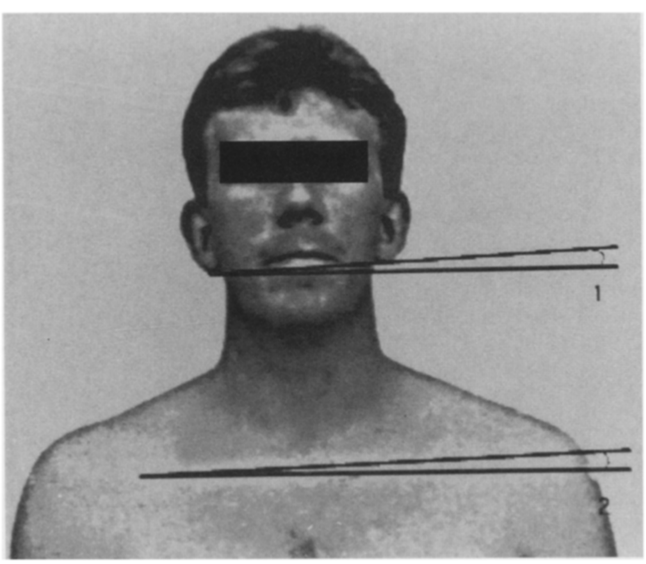

Fig 1. Measurements of (1) coronal plane head tilt and (2) coronal shoulder angle in an anterior photograph of a subject.

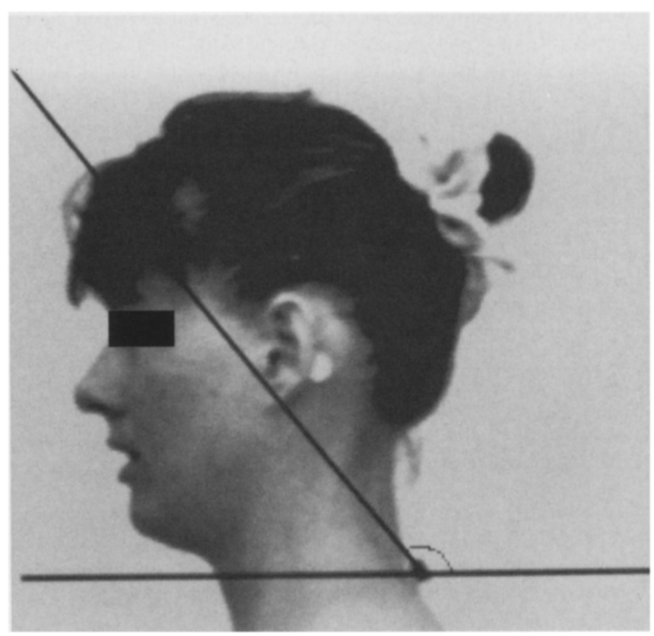

Fig 3. Measurements of sagittal-C7 tragus angle in a profile photograph of a subject.

marker, and the angle of this line to the horizontal was calculated in degrees. The midpoint of the tragus was clearly visible on the subject image. This angle described the position of the head relative to C7 when viewed from the left side. As the head was positioned more forward, the value increased.

The amount of surface curvature of the thoracic spine in the sagittal plane was measured from profile photographs of the subjects using a previously described measurement.[31] The outline of the surface contour between the markers C7 and T6, and T6 to T12 was used to calculate the amount of spinal curvature in the upper and lower thoracic spine, respectively. The digitized coordinates were magnified to true size and normalized through multiplication by a factor necessary to standardize the subject's sitting height to 900cm. This was necessary as the curvature measurement was not angular and otherwise the raw value would have related proportionally to a subject's size, undermining comparison of individual measurements. Sitting height was used because height in sitting is proportional to spine length and would reflect the "size" of the spine. The surface curvature for the upper and lower thoracic regions was calculated from the change in tangent angles at equal distances along the curve for each given region. The units of curvature were radians per millimeter and on average were to five decimal places with three significant figures.

Three anthropometric measurements were made directly from the subjects: standing height, sitting height, and weight. Standing height was measured in millimeters with a portable stadiometer that consisted of a sliding vertical ruler attached to a stable base, with a horizontal arm or headboard attached to the top of the ruler. Three measurements were made in succession with the subject moving briefly between them, and the average reading calculated. Sitting height was measured in millimeters with subjects seated on an anthropometer consisting of a 46cm wooden box that had 1m vertical rulers attached at each side. Three measurements were also made in succession, and the average reading calculated. Body weight in standing was obtained for each subject using either a beam balance scale or a portable scale, which had been calibrated to the beam balance scale to 0.5kg.

Finally, each subject's hand preference was described using a "laterality quotient" according to the Edinburgh handedness inventory.[32] This involved a series of tasks listed in the questionnaire, such as sweeping or throwing, for which subjects ascribed their tendency to use the left, right, or both hands. The responses to the Edinburgh Hand Inventory tasks listed in the questionnaire are converted to an index of hand preference ranging from −100 to +100. A subject preferring to use only the left hand for the tasks would score −100, and a subject preferring to use only the right hand would score +100. A subject who used the left hand or the right hand equally for each of the tasks would score zero.

Reliability

Reliability of the measurements was examined in a pilot study before the investigation.[33] Intraclass correlation coefficients for the measurements of coronal head tilt, coronal shoulder angle, sagittal head tilt, sagittal C7-tragus angle, and sagittal shoulder-C7 angle were .71, .89, .82, .88, and .91, respectively, describing high reliability except for coronal head tilt, which was acceptable. Similarly, intraclass correlation coefficients for surface curvature in the upper and lower regions of the thoracic spine in erect standing were high, being .92 and .94, respectively.

Statistical Analysis

Statistical analysis of the data was performed on Macintosh computer (alpha <.05). Statistical power was calculated for the continuous variables using "stplan." Data analyses were performed using Statview, SuperANOVA, and Statistical Analysis Software software. Intratester reliability was calculated using a series of repeated-measures analysis of variance (ANOVA) from which intraclass correlation coefficients were derived.[34] To identify significant differences between subject groups, a series of analysis of covariance (ANCOVA), using age as the covariate, and ANOVA were calculated for the continuous variables. A one-way ANCOVA was performed for each continuous variable and when age was not a significant covariate, a one-way ANOVA was performed. Hand preference was correlated to coronal shoulder angle using a Pearson correlation coefficient.

Statistical Power

Statistical power[35] was calculated for each of the dependent measurements that was to be compared between men and women (alpha = .05). Table 2 lists the actual statistical power of the measurements of head and shoulder posture as well as the sample size estimate for a power of .80. The statistical power of the measurements varied significantly. Coronal head tilt and sagittal shoulder-C7 were extremely similar in mean and standard deviation between men and women; hence, very large sample sizes of more than 1,000 subjects were required to obtain a statistical power of .80. The remaining variables differed in mean and standard deviation between men and women; hence, sample sizes of between 164 and 952 subjects were required to obtain a statistical power of .80.

RESULTS

Descriptive Statistics

Descriptive statistics for the measurements of head and shoulder posture are provided in table 3. Statistics are given separately for women and men, for the complete group, and for three age categories of 1 to 29 years, 30 to 54 years, and 55 years and above.

The mean coronal head tilt and coronal shoulder angles of the women and men were between 180° and 181.2°, within 1.2° of the horizontal plane. This indicated that the mean tilt of the head and the alignment of the shoulders, when viewed from the front, were close to horizontal and so relatively level. The mean values of sagittal head tilt of the women and men (171.4° and 172.8°, respectively) described the tilt of the head in the sagittal plane as inclined upward with respect to the horizontal, indicating an extended position of the upper cervical spine. The mean values of sagittal C7-tragus angle and sagittal shoulder-C7 angle for the women and men described the position of the head and shoulders as placed anterior to the 7th cervical vertebra.

In table 4, the means of the measurements of head and shoulder posture are reported from the women and men combined, together with the upper and lower 95% confidence limits and the confidence interval of the means. For coronal head tilt and coronal shoulder angle, the range of the confidence interval was

Table 2: Statistical Power for Comparison of Women and Men, and a Sample Estimate for the Total Number of Subjects Required to Obtain a Power of .80, for the Measurements of Head and Shoulder Posture

Measurement	Sample Size	Actual Statistical Power	Sample Estimate for Power = .80
Coronal head tilt	160	.04	21,220
Coronal shoulder angle	163	.21	952
Sagittal head tilt	158	.29	618
Sagittal C7-tragus	165	.80	164
Sagittal shoulder-C7	165	.09	2,942

Table 3: Descriptive Statistics of the Five Head and Shoulder Measurements From the Women and Men for the Different Age Categories

Measurement/Age Category (yrs)	*n*	Mean	SD	Minima-Maxima
Women				
Coronal head tilt				
All	84	180.0	2.6	176-186
17-29	32	180.0	2.1	176-185
30-54	28	180.2	2.8	176-186
55 & above	24	179.8	2.9	176-185
Coronal shoulder angle				
All	85	180.8	2.2	173-185
17-29	33	181.6	1.6	178-185
30-54	28	180.4	2.3	173-184
55 & above	24	180.3	2.5	175-185
Sagittal head tilt				
All	86	171.4	6.2	157-187
17-29	34	174.2	5.7	162-187
30-54	28	170.1	4.8	163-180
55 & above	24	168.8	6.9	157-181
Sagittal C7-tragus angle				
All	87	129.9	5.5	117-145
17-29	35	128.1	4.4	117-137
30-54	28	129.2	4.8	119-137
55 & above	24	133.2	6.2	121-145
Sagittal shoulder-C7 angle				
All	87	54.3	11.5	32-92
17-29	35	50.3	11.2	33-93
30-54	28	55.2	12.3	32-78
55 & above	24	59.3	9.2	42-83
Men				
Coronal head tilt				
All	76	180.1	2.6	171-186
17-29	20	180.0	2.0	178-185
30-54	26	180.4	3.0	171-185
55 & above	30	180.4	2.7	175-186
Coronal shoulder angle				
All	78	181.2	2.2	176-186
17-29	21	181.1	1.7	178-184
30-54	27	180.9	2.5	176-185
55 & above	30	181.5	2.3	177-186
Sagittal head tilt				
All	78	172.8	6.2	161-189
17-29	21	174.1	5.5	164-189
30-54	27	172.5	5.6	161-189
55 & above	30	172.2	7.1	162-187
Sagittal C7-tragus angle				
All	78	132.6	7.3	118-152
17-29	21	127.8	5.2	118-140
30-54	27	132.4	5.9	122-145
55 & above	30	136.0	7.9	118-152
Sagittal shoulder-C7 angle				
All	78	53.0	13.5	25-83
17-29	21	46.7	12.9	28-82
30-54	27	56.1	12.9	30-80
55 & above	30	54.6	13.5	25-83

Values (mean, SD, and minima-maxima) given in degrees.

narrow and less than 1°. For sagittal head tilt, sagittal C7-tragus angle, and sagittal shoulder-C7 angle, the confidence intervals were all reasonably narrow, suggesting that the sample means provided a good estimation of the true population mean. The wider confidence intervals for the sagittal plane measurements indicated that there was a larger amount of variability in the sampling distribution of these and that they were less indicative of the true mean of the population than were the means for coronal head tilt and coronal shoulder angle.

Table 4: The Means, Upper and Lower 95% Confidence Limits, and Confidence Intervals of the Means of the Head and Shoulder Posture Measurements From the Women and Men Combined

	Mean	95% Upper Limit	95% Lower Limit	Confidence Interval
Coronal head tilt	180.1	180.5	179.7	0.8
Coronal shoulder angle	181.0	181.3	180.6	0.7
Sagittal head tilt	172.1	173.0	171.1	1.9
Sagittal C7-tragus angle	131.1	132.1	130.1	2.0
Sagittal shoulder-C7 angle	53.7	55.6	51.8	3.8

Frequency histograms demonstrating the distribution of the head and shoulder measurements from all the subjects are provided in figure 4. A curve representative of the distribution has been superimposed on each histogram. The histograms show that all the variables were normally distributed.

Differences Between Genders

Examination of the head and shoulder posture measurements in order to identify gender differences between the women and men reference groups using ANCOVA with age as the covariate, or ANOVA, are reported in table 5. For the measurements of coronal head tilt and coronal shoulder angle, age was not found to be a significant covariate under ANCOVA, and hence ANOVAs were performed to identify significant differences between the measurements according to gender. No significant differences were observed in coronal head tilt and coronal shoulder angle, indicating that the men and women were similar in the tilt of the head and the elevation of one shoulder relative to the other when viewed from the front. In contrast, for the measurements of sagittal head tilt, sagittal C7-tragus angle, and sagittal shoulder-C7 angle, age was found to be a significant covariate under ANCOVA, and thus ANCOVAs were used to examine gender-related differences. No significant interaction

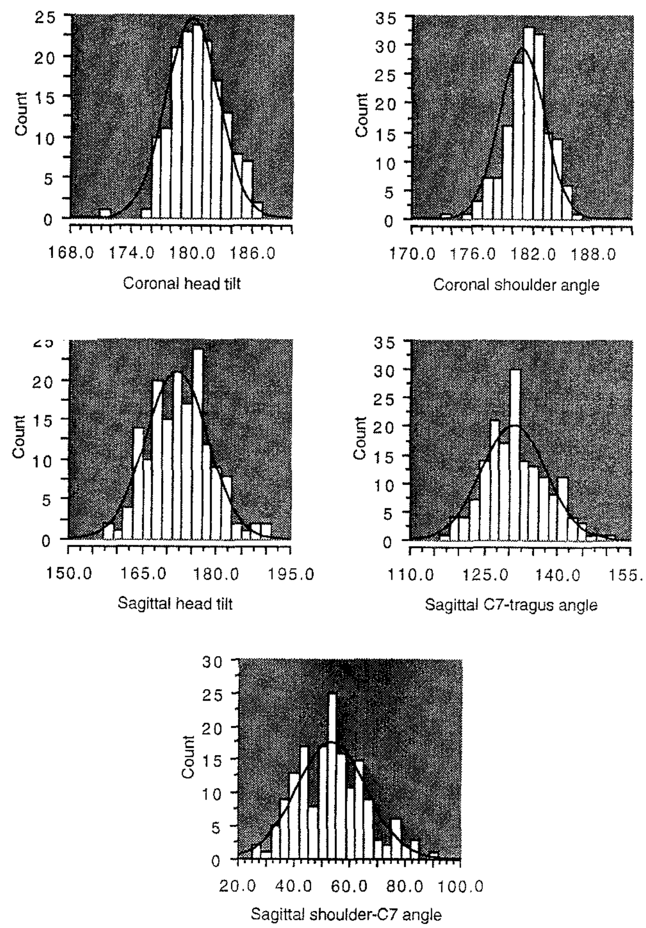

Fig 4. Frequency distributions of the head and shoulder measurements (degrees) of the total sample. A curve representative of the distribution (normal) of the data is superimposed on each histogram.

Table 5: Summary of ANCOVA (Using Age as the Covariate) or ANOVA Results for the Effect of Gender on the Five Dependent Variables of Head and Shoulder Posture

Measurement	*df*	SS	MS	*F*	*p*
Coronal Head Tilt					
Gender	1	3.343	3.343	.504	.48
Residual	158	1047.632	6.631		
Coronal Shoulder Angle					
Gender	1	4.760	4.760		
Residual	161	775.142	4.815	.989	.33
Sagittal Head Tilt					
Gender	1	12.458	12.458	.345	.56
Age	1	300.279	300.279	8.312	.005*
Gender* age	1	78.821	78.821	2.182	.14
Residual	160	5780.019	36.125		
Sagittal C7-Tragus Angle					
Gender	1	3.558	3.558	.105	.75
Age	1	1185.176	1185.176	35.012	.0001*
Gender* age	1	58.833	58.833	1.738	.19
Residual	161	5449.904	33.850		
Sagittal Shoulder-C7 Angle					
Gender	1	.002	.002	.000	.99
Age	1	1661.391	1661.391	8.312	.001*
Gender* age	1	39.344	39.344	2.182	.61
Residual	161	23771.932	147.652		

* Statistically significant.

was found between gender and age, and no significant differences were observed between men and women. Men and women were therefore found to have similar tilt of the head with respect to the horizontal in the sagittal plane, and similar positions of the shoulder and head with respect to the 7th cervical vertebra in the sagittal plane, when viewed from the left side.

Effect of Age and Associations Between Variables

Pearson product-moment correlation coefficients were calculated to describe the degree of association between the three sagittal plane measurements of head and shoulder posture and age in the total sample. The relation between sagittal C7-tragus angle and age was statistically significant ($r = .44$), indicating that subjects had a more forward-placed head with increasing age. In contrast, the measurements of sagittal head tilt and sagittal shoulder-C7 angle were not significantly related to age. Thus, older subjects had a more forward head posture, while in contrast, the tilt of the head or the forward position of the shoulders when examined from the left side did not change with increasing age.

No significant correlation was found between sagittal C7-tragus angle and sagittal head tilt, indicating that as subjects positioned their heads further forward in the sagittal plane they did not concomitantly incline their heads upward with a relatively extended upper cervical spine. In addition, there were no significant correlations between the variables of sagittal C7-tragus angle, sagittal head tilt, sagittal shoulder-C7 angle, and the surface curvature of the thoracic spine. This indicated that a forward position of the head, or tilt of the head upward in the sagittal plane involving upper cervical spine extension, was not associated with forward-positioned shoulders or increased curvature of the thoracic spine.

Finally, no significant association was observed between subjects' hand preference and the posture of their shoulders in the coronal plane ($r = .13$). This indicated that the level of the shoulders with respect to the horizontal was unrelated to left- or right-sided hand preference.

DISCUSSION

Two coronal measurements (coronal head tilt and coronal shoulder angle) and three sagittal plane measurements (sagittal head tilt, sagittal C7-tragus angle, and sagittal shoulder-C7 angle) of head and shoulder posture were examined in 160 asymptomatic women and men. All the measurements were normally distributed and reliable, and none were found to show significant differences between men and women. Exclusion criteria for the investigation included a history of back pain within the last 2 years, spinal surgery, and inflammatory or metabolic diseases including osteoporosis, which may have markedly altered posture. Although a relatively small number of subjects were excluded from the investigation because of these criteria, the sample was not representative of the population of Western Australia since it excluded subjects with disease that may involve postural deformity. One aim of the investigation was to describe the head and shoulder posture of asymptomatic subjects, rather than to describe that of a "normal" sample of subjects, and hence the investigation recruited subjects without vertebral pain or disease that may involve postural deformity, including osteoporosis.

Head and Shoulder Posture in the Coronal Plane

The measurement "coronal head tilt" described the tilt or levelness of the head with respect to the horizontal in the coronal plane, whereas the measurement "coronal shoulder angle" described the amount of elevation of one shoulder relative to the other in the coronal plane. The mean coronal head tilt of the total sample was 180.1° (±2.6°), indicating that generally, subjects stood with their head positioned symmetrically or horizontally in the coronal plane. The mean coronal shoulder angle of the total sample was 181° (±2.2°), indicating that on average, the subjects stood with their right shoulder 1° lower than the left, or not quite symmetrically in the coronal plane. This suggested that when viewed from the front, most subjects stood with their head level rather than tilted to the side, and with their shoulders relatively even rather than with one shoulder substantially higher than the other. The confidence interval of the means (0.8° and 0.7°) was narrow, being less than 1°, and this indicated that there was a small amount of sampling error for the measurements such that the sample mean accurately represented the population mean. Age was not significantly related to the measurements; hence the symmetrical head and shoulder positions were similar across the young and older subjects. These findings were not surprising, especially for the measurement of coronal head tilt. References to age-related changes in a person's posture do not usually involve asymmetry in the anterior view, although in comparison there is widespread opinion that such changes are likely to affect postural alignment from the sagittal perspective.

The data for coronal shoulder angle from this investigation revealed that on average, subjects stood with their right shoulder slightly lower than their left. This difference in shoulder height from the horizontal, or from a symmetrical shoulder position, produced an angle of just 1° and the confidence limits of the mean suggested that the difference would be expected to vary from 0.6° to 1.3°, which is certainly not extreme. The difference in shoulder height between sides of the body was defined as the angle between a line joining the coracoid processes and the horizontal, and for individuals whose bi-coracoidal widths ranged from 20 to 30cm, a 1° angle corresponded to a vertical difference in shoulder height of 2.5 to 4mm. Such a difference in coronal plane alignment is unlikely to be observable by eye. One standard deviation from the mean value, however, was ±2.2°, which suggested that for 68% of subjects, anterior shoulder posture varied from being 1.2° lower on the left to 3.2° lower on the right. This result furnishes only tentative support for the observation that people tend to demonstrate asymmetrical shoulders in the coronal plane,[5,36] as the finding would be difficult to discern purely by observation or without accurate measurements. Dieck and colleagues[36] observed that a majority of more than 800 subjects demonstrated moderate or great shoulder asymmetry in the coronal plane, but as the asymmetry was not defined in degrees the outcome cannot be compared directly to the finding in this study.

Shoulder Posture and Hand Preference

It has been suggested anecdotally[5,9] that there is a relation between unevenness of the shoulders and hand preference, such that an individual is likely to demonstrate a lower shoulder on the side corresponding to the preferred hand or "handedness." Although the mean coronal shoulder angle of 181° described the right shoulder as being 1° lower than the left, this difference was small and, as already stated, would not be discernible clinically. Our results do not strongly support the posit that hand preference is related to shoulder height in the coronal plane, because the mean of the sample did not indicate that subjects had a clinically discernible lower right shoulder. Further, there was no association found between hand preference and the measurement of coronal shoulder angle.

Posture of the Head in the Sagittal Plane

It has been suggested that women and men may have different resting head postures, and there are conflicting reports in the literature that indicate that men have a more forward head posture than women[28] and that women have a more forward head posture than men.[26] No difference was found in this investigation between the genders for sagittal C7-tragus angle, the implication being that the women and men held their heads in approximately the same position with respect to the trunk and, therefore, were similar in their propensity for a "forward head posture." The result of this investigation achieves some credibility in that the statistical power for the comparison of sagittal C7-tragus angle between men and women was high (.80), therefore lessening the likelihood of a type 2 statistical error. The mean sagittal C7-tragus angle of the total subject group was 131.1° (±6.5°) and the narrowness of the confidence interval (1.0°), implying a small sampling error, substantiates this conclusion. A "normal" sagittal C7-tragus angle (values within 2 standard deviations of the mean) determined in the current study would therefore be between 144.1° and 118.1°. However, caution is warranted in extrapolating the result to the wider community. Although the data were derived from a reasonably varied sample, it was not derived randomly, nor from a sample that represented the population of the state of Western Australia. Nonetheless, the results agreed reasonably well with previous investigations from Australia, the United States, and Canada, which used smaller samples but did not include both genders or as broad an age range.[28-30] In contrast, the mean value in the current study appeared to be much greater than the mean value reported in a much earlier study by Cureton,[1] who measured sagittal plane head posture in more than 600 young men while standing. Cureton's study[1] also used an angular measurement taken from profile photographs of subjects while standing, and described a mean head position equivalent to 126.4° (±6.4°) of the current sagittal C7-tragus angle. The results indicated that Cureton's[1] subjects stood with a significantly less forward head posture than did the subjects measured in this study. It is most likely that methodologic and sampling differences accounted for this difference, and it is difficult to draw any firm conclusions since more than 50 years have elapsed since Cureton's investigation and a change in the habitual sagittal-plane head posture of people at rest over such a period of time is a possibility.

Effect of Age

A significant relationship was observed between sagittal C7-tragus angle and age, and the positive correlation coefficent of .44 suggested that older individuals tended to have a more forward-placed head. It was not a particularly strong correlation, and the coefficent of determination (r^2 = .194) indicated that 19% of the measurement variation could be accounted for by the effect of increasing age. Although a number of investigations have described the resting posture of the head in the sagittal plane,[26,28-30] the relationship of age has not been clearly defined. Previous investigations[26,29] demonstrate conflicting outcomes, although a fairly weak association has been described by some authors.[29] Significant but weak correlations between age and posture of the head in the sagittal plane, as observed in this study, call into question the clinical relevance of age in the examination of head posture. Age-related changes of such weak strength are unlikely to be apparent in the clinical setting. No relationship was observed between age and the other parameters of head and shoulder posture in the sagittal plane.

Forward Head Posture

It has been reasoned by clinicians that a forward head posture implies a relatively extended upper cervical spine and a relatively flexed lower cervical spine.[2,8] The measurement "sagittal head tilt" described the inclination of the head from the horizontal, and reflected the relative posture of the upper cervical spine since the further the head is inclined anteriorly from the horizontal, the more the upper cervical spine would be extended. It was found that sagittal head tilt was not related to the sagittal C7-tragus angle, and therefore as the head was held further forward there was no tendency to tilt the head upwards. Thus, this finding did not concur with the anecdotal relationship described in the literature of a forward head posture being strongly associated with an extended upper cervical spine.[2,26,27] The mean of 172.1° (±6.2°) for the total sample accorded reasonably well with the meticulous anthropometric measurements of Farkus,[37] who described the normal sagittal plane inclination of the head as the equivalent of 175° sagittal head tilt, in subjects aged between 6 and 18 years. Farkus[37] used the porion of the ear to measure the inclination of the head, rather than the tragus of the ear as was used in this study, and this would have led to Farkus recording a smaller measurement and also perhaps accounted for his smaller mean. Contrary to the anecdotal notion, age was not significantly related to sagittal head tilt and the purported characteristic of a more extended upper cervical spine occurring with age was not apparent.

Posture of the Shoulders in the Sagittal Plane

The postural alignment of the shoulders in the sagittal plane has been infrequently described in previous investigations in an objective manner. In the general community, "rounded shoulders" are often attributed as relevant or important to postural alignment and there is some evidence in the literature to suggest that women are more round-shouldered than men.[28] In the present investigation the measurement "sagittal shoulder-C7 angle" described the position of the shoulders with respect to the trunk. Sagittal shoulder-C7 angle was found to be similar in men and women, and did not change with age. There was a trend for the values to increase with advancing age, but this was not significant. The mean shoulder position for the total sample was 53.7° (±12.5°). The relatively wide confidence interval for this variable (3.8°) in comparison to the other measurements of head and shoulder posture implied there was greater sampling error for the sagittal plane position of the shoulders and indicated that the mean value was a less accurate representation of the true population mean. The statistical power was extremely low (.095, table 2), however, which indicated that the measurement was very similar in mean and standard deviation between the women and men, and 2,942 subjects were required to obtain a statistical power of .08. This vindicated the finding of no difference between the genders because any statistical difference would therefore be very small in magnitude and of questionable clinical relevance. In contrast, a study by Braun,[28] which quantitatively investigated sagittal-plane shoulder posture in adults, described women as having significantly more forward-positioned shoulders than men. In addition, subjects were reported as having a much more protracted shoulder girdle position than were subjects in this study. Braun[28] defined shoulder posture in the same way as was done in this study, except that the subjects were measured while the subject was sitting rather than standing. Variable instructions to subjects, or the different positions adopted for measurements, might have contributed to the contrasting outcomes. Sagittal-plane head posture was measured similarly in both studies, but in contrast, did not differ substantively between them and so apparently was not affected by subject positioning.

A Forward Head, Forward Shoulders, and Increased Kyphosis

A relation between the sagittal plane features of a forward head, forward shoulders, and increased thoracic kyphosis has also been described anecdotally in the literature,[2,5,10,18] and therefore the posture of the head and shoulders in the sagittal plane was also examined in relation to the curvature of the thoracic spine. Sagittal C7-tragus, sagittal head tilt, and sagittal shoulder-C7 angle were not found to be related to curvature of the upper or lower thoracic spine. This countered the notion that the postural characteristic of a forward head is associated with forward-positioned shoulders or increased curvature in the thoracic spine.

CONCLUSION

Postural attributes continue to receive attention in the rehabilitation setting, and anecdotal beliefs persist about the clinical significance of posture. This research examined the posture of the head and shoulders in a reasonably large number of asymptomatic subjects, providing evidence that will assist in the clinical evaluation of posture. Further research is needed to assess specifically the role of posture in relation to the development of pain or in association with disease such as osteoporosis; however, this study provides quantitative data about the nature of postural relationships in subjects without vertebral pain or disease.

Women and men were found to have similar posture of the head and shoulders in both the coronal and sagittal planes. When viewed from the front, they were found to position their head level with the horizontal, and to stand with their shoulders relatively even with respect to the horizontal although their right shoulder was slightly lower (1°) than the left. Age was related to only one measurement, that describing the position of the head with respect to the 7th cervical vertebra when viewed from the side. The position of the head with respect to the 7th cervical vertebra was observed to be further forward in subjects with increased age, although this relationship was not very strong. Contrary to the anecdotal notion, age was not significantly related to the tilt of the head in the sagittal plane, and the purported characteristic of a more extended upper cervical spine occurring with age was not apparent in the reference subjects measured in this study. In addition, as the head was positioned further forward, subjects did not demonstrate the concurrent features often described of more forward shoulders or increased curvature in the thoracic vertebral column when viewed in the sagittal plane.

Acknowledgments: This research was conducted with financial assistance from the Physiotherapy Research Foundation, Fitzroy North, Australia. The authors wish to thank Mr. Ed Scull, Mr. Robert Day, and Mr. Trevor Jones, Department of Bio-medical Engineering, Royal Perth Hospital, for their advice and technical assistance in the processing of data.

References

1. Cureton TK. Bodily posture as an indicator of fitness. Res Q 1941; 12:348-67.
2. Darnell MW. A proposed chronology of events for forward head posture. J Craniomandibular Practice 1983;1:50-4.
3. Enwemeka CS, Bonet IM, Ingle JA, Prudhithumrong S, Ogbahon FE, Gbenedio NA. Postural correction in persons with neck pain: I. J Orthop Sports Phys Ther 1986;8:235-9.
4. Griegel-Morris P, Larson K, Mueller-Klaus K, Oatis CA. Incidence of common postural abnormalities in the cervical, shoulder, and thoracic regions and their association with pain in two age groups of healthy subjects. Phys Ther 1992;72:425-31.
5. Kendall FP, McCreary EK. Muscles testing and function. 3rd ed. Baltimore (MD): Williams and Wilkins; 1983. p. 270-85.
6. Lezberg SF. Posture of the head: its relevance to the conservative treatment of cervicobrachial radiculitis. Phys Ther 1966;46:953-7.
7. MacEwan CG, Howe EC. An objective method for grading posture. Res Q 1932;3:145-57.
8. McKenzie R. Treat your own neck. New Zealand: Spinal Publications; 1983. p. 15.
9. Singer KP. A new musculoskeletal assessment in a student population. J Orthop Sports Phys Ther 1986; July:34-41.
10. Tan JC, Nordin M. Role of physical therapy in the treatment of cervical disk disease. Orthop Clin North Am 1992;23:435-48.
11. Refshauge KL, Bolst, Goodsell M. The relationship between cervicothoracic posture and the presence of pain. J Manual Manipulative Ther 1995;3(1):21-4.
12. Haughie L, Fiebert IM, Roach KE. Relationship of forward head posture and cervical backward bending to neck pain. J Manual Manipulative Ther 1995;3(3):91-7.
13. Lee W, Okeson JP, Lindroth J. The relationship between forward head posture and temporomandibular disorders. J Orofacial Pain 1995;9:161-7.
14. Bak EI. Exercise therapy of posturally defective school children. Phys Ther Rev 1957;37:287-91.
15. Kendall HO, Kendall FP, Boynton DA. Posture and pain. 1st ed. Melbourne (FL): Robert E. Krieger; 1952.
16. Turner M. Posture and pain. Phys Ther Rev 1957;37:294-7.
17. Kuhns JG. The late effects of minor degrees of poor posture. Phys Ther Rev 1949;29:165-8.
18. Mannheimer JS, Rosenthal RM. Acute and chronic postural abnormalities as related to craniofacial pain and temporomandibular disorders. Dent Clin North Am 1991;35:185-208.
19. Turner PG, Green JH, Galasko CSB. Back pain in childhood. Spine 1988;13:812-3.
20. Ayub E, Glasheen-Wray M, Kraus S. Head posture: a case study of the effects of the rest position of the mandible. J Orthop Sports Phys Ther 1984;5:179-83.
21. Braun BL, Amundson LR. Quantitative assessment of head and shoulder posture. Arch Phys Med Rehabil 1989;70:322-9.
22. Darling DW, Kraus S, Glasheen-Way MB. Relationship of head posture and the rest position of the mandible. J Prosthet Dent 1984; 52:111-5.
23. Passero PL, Wyman BS, Bell JW, Hirschey SA, Schlosser WS. Temporomandibular joint dysfunction syndrome. Phys Ther 1985; 65:1203-7.
24. Rocabado M. Arthrokinematics of the temporomandibular joint. Dent Clin North Am 1983;27:573-94.
25. Thurnwald PA. The effect of age and gender on normal temporomandibular joint movement. Physiother Theory Pract 1991;7:209-21.
26. Hanten WP, Lucio RM, Russell JL, Brunt D. Assessment of total

head excursion and resting head posture. Arch Phys Med Rehabil 1991;72:877-80.
27. Lindstrom M. The effect of physical therapy on pathological postures with special regard to the cervical spine. Phys Ther Rev 1957; 37:292-3.
28. Braun BL. Postural differences between asymptomatic men and women and craniofacial pain patients. Arch Phys Med Rehabil 1991;72:653-6.
29. Dalton MB. The effect of age on cervical posture in a normal female population. In: Proceedings of the Manipulative Therapists Association of Australia 6th Biennial Conference; 1989; Adelaide, Australia. North Fitzroy, Australia: Manipulative Therapists' Association of Australia; 1989. p. 34-43.
30. Watson DH, Trott PH. Cervical headache: an investigation of natural head posture and upper cervical flexor muscle performance. In: Proceedings of the Manipulative Physiotherapists Association of Australia 7th Biennial Conference; 1991; Blue Mountains, Australia. North Fitzroy, Australia: Manipulative Physiotherapists Association of Australia; 1991. p. 19-24.
31. Raine SA, Twomey LT. Validation of a non-invasive method of measuring the surface curvature of the erect spine. J Manual Manipulative Ther 1994;2:11-21.
32. Oldfield RC. The assessment and analysis of handedness: The Edinburgh Inventory. Neuropsychologia 1971;9:97-113.
33. Raine S. Variations of a series of physical characteristics related to the comfortable erect standing posture and how these are affected by age, gender, back pain and physical activity [dissertation]. Perth (Western Australia): Curtin University of Technology; 1995.
34. Crowder MJ, Hand DJ. Univariate analysis of variance. Analysis of repeated measures. London: Chapman and Hall; 1990.
35. Welkowitz J, Ewen RB, Cohen J. Interferential statistics. In: Introductory statistics for the behavioural sciences. New York: Academic Press; 1982. p. 152-255.
36. Dieck GS, Kelsey JL, Goel VK, Panjabi MM, Tech D, Walter SD, et al. An epidemiologic study of the relationship between postural asymmetry in the teen years and subsequent back and neck pain. Spine 1985;10:872-7.
37. Farkas LG. Anthropometry of the head and face in medicine. New York: Elsevier; 1981.