Investigating forward head posture and its influence on postural alignment among desk-based employees

Investigación de la postura adelantada de la cabeza y su influencia en la alineación postural en empleados que trabajan en oficinas

Authors

Amira E. M. Abd-ElHay [1]
Mohamed A. Elsayed [2]
Doaa Tammam Atia [3]
Ahmed M. Tawfick [4]
Radwa M. Shalaby [5]
Hadeer A. Morsi [6]

[1] Al al-BAYT University (Jordan)
[2] Philadelphia University (Jordan)
[3] Suez University, Suez, (Egypt)
[4] Modern University for Technology and Information (Egypt)
[5] City University of Cairo CUC, Cairo, (Egypt)
[6] Kafrelsheikh University (Egypt)

Corresponding author:
Amira Ezzat Mohamed Abd ElHay
dr.amira.ezzat.pt@gmail.com

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Abstract

Background: Forward Head Posture is a common musculoskeletal issue increasingly observed among desk-based employees, particularly those engaged in prolonged sitting and frequent use of digital devices. It's linked to musculoskeletal problems such as neck pain, headaches and decreased quality of life. this study examined the relationship between forward head posture and various postural deviations, including body alignment deviation, head tilt, shoulder misalignment, pelvic tilt, knee asymmetry and foot asymmetry.

Objective: to explore the connection between forward head posture and postural deviations in desk-based employees through cross-sectional study.

Methods: Ninety-eight desk-based employees exhibiting symptoms of forward head posture were assessed using two mobile applications: the assessment of postural and ergonomic conditions for workers application and the forward head posture app. Preliminary statistical analysis applied to the collected postural alignment parameters for identifying data outliers. Data were analyzed using Pearson correlation coefficients, multiple regression analysis and factor analysis to identify key factors influencing forward head posture.

Results: Forward head angle (FHA) was highly correlated with body alignment deviation ($r = 0.931$), head tilt ($r = 0.877$), shoulder alignment deviation ($r = 0.883$) and computer &mobile usage ($r = 0.819$). Regarding to factor analysis body alignment deviation was the most significant predictor of FHA.

Conclusion: FHP is strongly linked to poor upper body alignment and prolonged use of digital devices. Body alignment deviations and other biomechanical factors had a major effect on forward head angle and total posture with a regression model explaining 95.8% of the variance in forward head angle.

Keywords

Desk-based employees; forward head angle; mobile postural assessment; musculoskeletal disorders.

Resumen

Antecedentes: La postura de cabeza adelantada es un problema musculoesquelético común que se observa cada vez más entre los empleados que trabajan en oficinas, en particular entre quienes permanecen sentados durante períodos prolongados y utilizan dispositivos digitales con frecuencia. Se relaciona con problemas musculoesqueléticos como dolor de cuello, cefaleas y disminución de la calidad de vida. Este estudio examinó la relación entre la postura de cabeza adelantada y diversas desviaciones posturales, como la desviación de la alineación corporal, la inclinación de la cabeza, la desalineación de hombros, la inclinación pélvica, la asimetría de rodillas y la asimetría de pies.

Objetivo: Explorar la conexión entre la postura de cabeza adelantada y las desviaciones posturales en empleados que trabajan en oficinas mediante un estudio transversal.

Métodos: Se evaluó a noventa y ocho empleados que trabajaban en oficinas y que presentaban síntomas de postura de cabeza adelantada mediante dos aplicaciones móviles: la aplicación de evaluación de las condiciones posturales y ergonómicas para trabajadores y la aplicación de postura de cabeza adelantada. Se aplicó un análisis estadístico preliminar a los parámetros de alineación postural recopilados para identificar valores atípicos en los datos. Los datos se analizaron mediante coeficientes de correlación de Pearson, análisis de regresión múltiple y análisis factorial para identificar los factores clave que influyen en la postura de cabeza adelantada. Resultados: El ángulo cefálico anterior (AAE) mostró una alta correlación con la desviación de la alineación corporal ($r = 0,931$), la inclinación de la cabeza ($r = 0,877$), la desviación de la alineación de los hombros ($r = 0,883$) y el uso de ordenadores y dispositivos móviles ($r = 0,819$). En el análisis factorial, la desviación de la alineación corporal fue el predictor más significativo del AAE.

Conclusión: El AAE está estrechamente vinculado a una mala alineación del tronco superior y al uso prolongado de dispositivos digitales. Las desviaciones de la alineación corporal y otros factores biomecánicos tuvieron un efecto importante en el ángulo cefálico anterior y la postura general, con un modelo de regresión que explicó el 95,8 % de la varianza en el ángulo cefálico anterior.

Palabras clave

Empleados de escritorio; ángulo de cabeza hacia adelante; evaluación postural móvil; trastornos musculoesqueléticos.

Introduction

Recently, the massive shift to a digital work environment has led employees to sit for extended periods in front of computer screens. This has led to a significant increase in postural disorders, particularly forward-headedness, which has become the most prominent posture problem among office workers. It causes musculoskeletal pain, negatively impacts the cervical spine, and impairs the job performance of office workers. Globally, about two billion suffering from musculoskeletal disorders (MSDs) that reduced their quality of life and decreased their productivity (WHO, 2022; Alhashim, 2025). Moradi-Lakeh et al. (2017) reported that more than 30% of employees are suffer from symptoms resulting from poor work posture in the Eastern Mediterranean region. Huang et al. (2019) indicated that office-based occupations which require prolonged sitting in front of a computer screen, are among the employees most vulnerable to these disorders. As Forward Head Posture (FHP) has been associated with prolonged computer usage and poor ergonomics (Sarfraz et al., 2025; Khayati et al., 2025), it has become one of the most prevalent and significant postural deviations in modern workplace environments (Nejati et al., 2015; Titcomb et al., 2024). This deviation can result in persistent neck and shoulder discomfort as well as restricted shoulder blade mobility because it alters the alignment of the spine and increases the strain on the cervical muscles (Vij et al., 2022; Chu et al., 2020; Mingels et al., 2019). Caneiro, Bunzli, and O'Sullivan (2021) stated that the musculoskeletal pain development and treatment are significantly influenced by the patient perceptions about their level of pain. Their study concluded that addressing increasing recovery and encouraging efficient pain management need addressing maladaptive pain beliefs through behavioral and educational strategies. Recent studies confirmed the key role of physical exercise and geometric therapies in improving patients' balance and musculoskeletal health. Verdugu et al. (2025) reported that strength training reduces falls in the elderly and Yudo et al. (2025) found that regular physical activity improves postural stability in students. Furthermore, Ratu et al. (2025) showed that geometric stretching alleviates lower back pain in nurses. Also Janageraman et al. (2025) demonstrated that neck stretching exercises relieve nonspecific neck pain. Reduced respiratory efficiency, poor balance, and reduced visual-vestibular coordination are other conditions linked to FHP (Arooj et al., 2022). Since FHP is linked to advanced postural abnormalities in office workers, a lower Craniovertebral Angle (CVA) is utilized as an objective metric to gauge the severity of the condition (Titcomb et al., 2024). Despite the advantages of digitalization, the desk-based pattern has grown popular in both industrialized and developing nations, including the Middle East and has been associated with health issues such as MSDs (White, 2012; Ahlers, 2016; Mcloughlin, 2013). However, many of these work environments lack proper ergonomic setups, with limited awareness or application of posture-preserving practices (Kwon et al., 2023). Prolonged static sitting, low monitor height, non-adjustable chairs and improper keyboard alignment are just a few of the risk factors that contribute to the gradual development of FHP among office workers (Daneshmandi et al., 2017). It is concerning because the slow development of symptoms frequently postpones the adoption of preventative interventions until the illness becomes chronic or functionally limiting (Halpin et al., 2021). In Egypt, Jordan and similar countries in the region, local data regarding FHP prevalence and its biomechanical consequences remain scarce (Ibrahim et al., 2024). While general musculoskeletal complaints have been documented in various studies, the specific relationship between forward head posture and postural alignment parameters has not been thoroughly explored (Nejati et al., 2015). Moreover, there is a gap in identifying workplace-related behavioral and ergonomic factors that contribute to the development of FHP in desk-based populations (Arooj et al., 2022; Sriram & Rajini, 2024; Wang, 2025). This represents a significant limitation in public health planning and occupational rehabilitation (Fan et al., 2022). FHP is a prevalent postural deviation in modern society, particularly among individuals engaged in prolonged sitting activities, such as Desk-Based Employees (Mishra & Sahi, 2025). The cervical spine is displaced beyond the center of gravity of the body due to FHP, which specifically causes the head to expand forward. This causes compensatory movements in other parts of the body by increasing the mechanical load on the muscles of the neck and upper back. For example, the body may try to regain equilibrium by tilting the head slightly, which can cause unequal muscular tension and a series of postural deviations that increase neck and head pain (Treleaven, 2008; Yin et al., 2025). One of the primary consequences of FHP is altered scapular alignment. The forward shift of the head often causes the shoulders to round, a condition known as "rounded shoulders". Shortening of the chest muscles and weakening and lengthening of the upper back muscles are the causes of this imbalance. Asymmetric loading of the shoulder girdle can often cause the shoulders to become unequal, with one side tilting downward. Such improper alignment can increase the risk of shoulder impingement and chronic pain (Capsulitis, 2013). FHP affects pelvic alignment as well. An anterior pelvic tilt may develop from the body increasing the curve of the lower back (lumbar lordosis) to compensate for the forward head position. The spine, hips, and lower extremities are all impacted by this pelvic tilt, which throws off normal biomechanics. It may eventually lead to hip strain, lumbar pain, and further lower body postural abnormalities (McGregor & Hukins, 2009). Since FHP may trigger knee alignment abnormalities, such as knees twisting inward (valgus) or outward (varus) in an effort to maintain balance, it has an impact on the body as a whole. This increases the risk of diseases like osteoarthritis and patellofemoral pain syndrome by putting unequal load on the knee joints. This syndrome may get worse with time, particularly if compensatory habits increase (Maupas et al., 2002). Additionally, FHP can alter the distribution of weight in the lower limbs, leading to foot abnormalities including high arches or flat feet. This may result in altered walking habits, raising the possibility of persistent foot and ankle discomfort (Dowling et al., 2014). Long work hours, computer usage, and inappropriate academic work methods put office workers at higher risk of having FHP (Arooj et al., 2022; Y. Wang, 2025; Yin et al., 2025). Developing successful preventive treatments requires an understanding of the relationship between FHP and other postural deviations. Research on the association between FHP and other postural alignment deviations, especially among university students, is still lacking, despite the fact that several studies have looked at the influence of FHP on musculoskeletal problems (Saeed et al., 2024). The main question of the current study is: How does FHP relate to other deviations in office workers postural alignment? The study's objectives are to ascertain the frequency of FHP in these workers, evaluate the extent of postural deviations, and investigate the connection between postural alignment characteristics and the severity of FHP. Additionally, it will look at work-related variables like office hours and daily routines that can be linked to the development of FHP and offer suggestions for better posture in the workplace.

Method

A descriptive cross-sectional study was conducted to assess the prevalence of FHP and its influence on overall postural alignment among desk-based employees. The study was carried out in multiple office workplaces in Suez University which includes faculty offices, administrative departments and university clinics. The Suez University workplace was selected due to its varied desk-based work environment types and the potential for significant findings on postural patterns at work. The study was conducted in Suez University and focused on the Faculty of Physical Therapy population. It was approved by the Research Ethics Committee, Faculty of Medicine, Suez University (SUEZ Med-IRB/No:105). Also, the study protocol was registered at Pan African Clinical Trial Registry. (Registry: PACTR202511644773738).

Participants

A total of ninety-eight male and female desk-based employees were included in the study, provided they met specific criteria. We assumed a medium effect size ($f^2 = 0.25$), $\alpha = 0.05$, and power = 0.80, yielding a minimum required sample of 96 participants. Participants were adults aged between 20 and 60 years to ensure the focus was on the working-age population (Theorell et al., 2015). They were currently employed in desk-based jobs, spending at least 6 hours per day working at a desk or on a computer. Additionally, participants had a minimum of 6 months of employment in their current desk-based role to ensure adequate exposure to desk work (Ryde et al., 2020). Those included in the study had no history of recent musculoskeletal injury or surgery that could affect their posture, as such factors were unrelated to workplace posture. Participants with no diagnosed neurological or systemic conditions that could influence posture were also included to avoid confounding medical conditions (Nonnekes et al., 2018). The employees who were interested in participation in the study were chosen from both genders males and females. Each participant was notified about their rights to pull back from the study any time and it's not necessary to write their names. They were additionally guaranteed of the secrecy of the data gathered and that they were to be utilized just for research and were willing to provide informed consent to participate in the study. Those included in the study aged from 20 to 60 years old and had no history of recent musculoskeletal injury or surgery that could affect their workplace posture. Participants with no diagnosed neurological or systemic conditions that could influence posture were also included to avoid confounding medical conditions (Nonnekes et al., 2018). Furthermore, employees who used computers and mobile phones for more than three hours per day were selected. The exclusion participants criteria were employees who did not desk-based work require more than six hours of sitting per day and desk-based employees with recent musculoskeletal injuries or surgeries within the past six months, or those with chronic neurological or musculoskeletal conditions that affect posture (Rosenbloom et al., 2013). Pregnant women were also excluded from the study due to their pregnancy impact on posture (del Rocío et al., 2023). Finally, any participant who was unwilling or unable to provide informed consent was excluded from the study (van Stuijvenberg et al., 1998).

Procedure

Participants were recruited via university-wide announcements, emails and posters and assessment appointments were scheduled at the university faculty clinic. Group allocation was based on participants' current job roles, verified by employer documentation. Upon enrollment, participants signed a written informed consent form after being informed about the study purpose, procedures, risks and benefits. The gathered data included personal information such as ages (years), gender (M) or (F), weight (Kg), height (cm), Body Mass Index (kg/m2) and work duration using computer &mobile usage per (hour/day). BMI was divided into four groups according to WHO as: Normal weight (18.5 – 25 kg/m2), Underweight < 18.5 kg/m2, Overweight (25 – 30 kg/m2) and Obese > 30 kg/m2 where weight "Kg". The primary postural measured being investigated in this study were degree of forward head posture, forward head angle, body alignment deviation, head tilt, shoulder alignment deviation, pelvic tilt, knee asymmetry and feet asymmetry. To assess postural alignment, FHP was evaluated using the Craniovertebral Angle (CVA), measured through digital photography and image analysis software. A smaller CVA indicates a more pronounced forward head posture. Overall postural alignment was evaluated through a standardized clinical assessment involving visual inspection and the assessment of specific postural landmarks, such as shoulder level, scapular position and spinal curvature (Fortin et al., 2011). For the photographic measurement of the CVA participants were asked to stand barefoot in a relaxed natural posture with arms resting by their sides looking straight ahead at a point marked on the wall at eye level to standardize head position. A lateral photograph was taken from the participant's right side using HONOR X8c smartphone camera with 108MP Ultra-Clear Night Photography mounted on a fixed tripod positioned at a distance of 1.5 meters from the participant and aligned horizontally with the level of the shoulder (seventh cervical vertebra; C7). We fixed the camera on tripod and we adjusted the height to match the approximate height of the participants tragus to minimize the perspective distortion. Before imaging every participant we marked two anatomical landmarks the tragus of the ear and the spinous process of the C7. Then we determined the CVA as the angle formed between a horizontal-line passing through the C7 point and the other line connecting the C7 point to the tragus. Each image was analyzed using standardized image analysis software to calculate the CVA to the nearest degree. To ensure reliability three images per participant were taken and the mean value was used for analysis. All photographs were captured under consistent lighting and background conditions to reduce measurement errors. A structured questionnaire was used to collect demographic information, work habits and a history of musculoskeletal complaints. The sample size for the study was calculated using power analysis to ensure sufficient statistical power to detect meaningful correlations between FHP and postural alignment. Participants were asked to stand in a relaxed posture while lateral photographs were taken to measure CVA. Postural alignment was then evaluated by a trained physiotherapist.

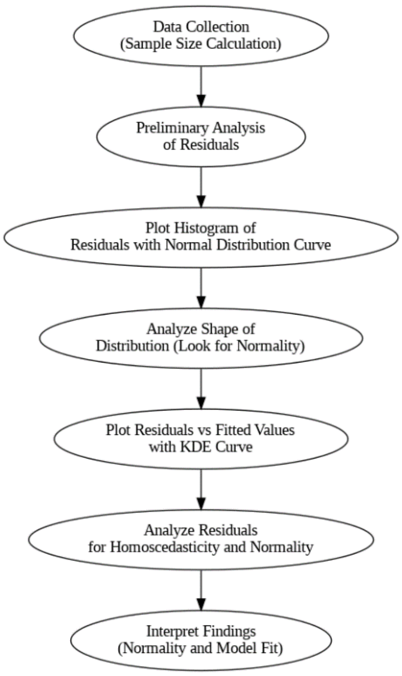
Instruments

Two mobile applications were employed for a more detailed assessment of posture deviations. The first application, the FHP Mobile Application, provides a reliable and efficient method for measuring the Forward Head Angle (FHA), defined as the angle between the ear hole and the top of the shoulder. Specific anatomical landmarks were palpated and manually marked on each participant and the app then automatically calculated the FHA based on these points (Singh et al., 2024). The second application, the APECS (AI Posture Evaluation and Correction System), was used to assess deviations in body alignment, including head tilt, shoulder alignment deviation, pelvic tilt, knee asymmetry and feet asymmetry. The APECS application utilizes standardized anatomical landmarks and angles to detect postural deviations. The APECS and the FHP Mobile Application are considered valid and reliable (Trovato et al., 2022; Moraru et al., 2025; Çankaya & Pouriyamanesh, 2022; Mehta et al., 2025). Key anatomical landmarks that were marked on each participant included the ear lobes for head tilt, the acromion process and suprasternal notch for shoulder alignment, the anterior superior iliac spine (ASIS) for pelvic tilt, the tibial tuberosity for knee asymmetry and the body of the talus for feet asymmetry (Casler et al., 2024; Rybski & Juckett, 2024).

Data analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS, Version 22) (Rovai et al., 2013). Descriptive statistics, percentage and frequencies summarized the demographic data of the desk-based employees namely gender, age, weight and height. Based on the collected data followed descriptive variables were used as variable averages, minimum, maximum, standard deviation (SDs), in addition to frequency, histograms and percentage (%) of participants age (years), gender (M) or (F), weight (Kg), height (cm), Body Mass Index (kg/m2) and work duration using computer &mobile usage per (hour/day). Pearson correlation (r) and coefficient of determination (r^2) values were calculated to indicate the strength and direction of relationships between the FHA and other postural deviations. The classes of (r) values were set as (r between 0-0.19) is regarded as very weak, (r between 0.2-0.39) as weak, (r between 0.40- 0.59) as moderate, (r between 0.6-0.79) as strong and (r between 0.8-1) as very strong correlation. To investigate potential predictors of FHP severity, multiple linear regression analysis was conducted. To ensure the validity of the regression and correlation analyses the statistical assumptions were validated before model interpretation. The normality of the residuals was assessed through visual inspection of histograms Q-Q plots and the Shapiro-Wilk test which indicated a near-normal distribution with a slight positive skew. The homogeneity of variance was examined using dispersion plots of standardized residuals against predicted values confirming that the residuals were evenly distributed around zero without regular patterns. Multicollinearity among the predictor variables was assessed using the Variance Inflation Factor (VIF) values all of which were less than 10 (ranging from 1.064 to 5.036) demonstrating acceptable independence among the variables and supporting the robustness of the regression model. The dependent variable was the severity of FHP measured through the craniovertebral angle. The independent variables included work-related factors such as working posture and the number of working hours. For all correlation and regression coefficients the significant level was set at 0.05 where the alpha level was set at confidence interval 95% ($p<0.05$) and clearly distinguished between their statistical significance and clinical relevance. Factor analysis was also performed to explore patterns in the data and identify underlying relationships between postural deviations (Straker et al., 2008).

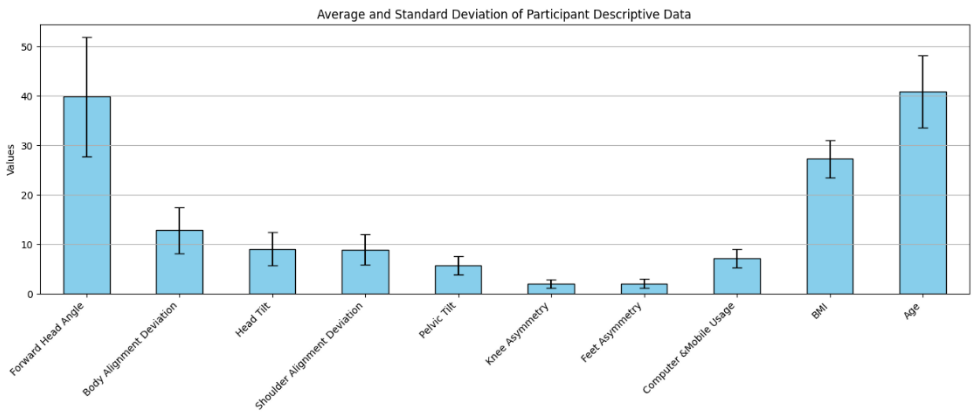
Figure 1. Flowchart outlines the methodology applied in the current study



Results

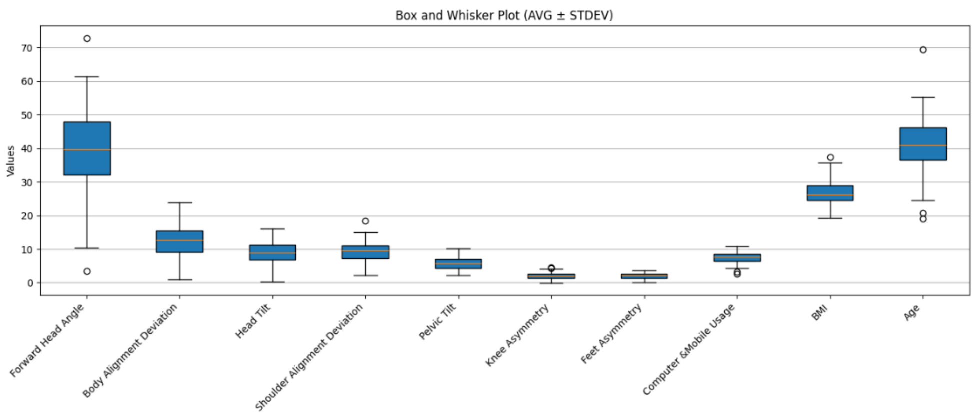
The demographic characteristics of the participants are shown in Figures 2 and 3. Figure 2 show the results of the study participants descriptive statistics while Figure 3 displays the results of box and whisker plot for the postural variables that we measured and assessed. Ninety-eight desk-based employees participated in our study with an average age 41.65 years and a standard deviation of 7.10. Regarding to BMI, the average was 26.31 kg/m² and 40% of the participants in the study had a normal weight ranged between 18.5 to 25 kg/m2, 11% of them were female and 29% of them were male. About 43% of the participants had overweight and about 17% had obesity with BMI>30 kg/m2, divided into 15% female participants and only 2% male participants. The results also showed that the participants used computers and mobile phones for an average of 6.61 hours per day. These reflect that many participants spend above average amounts of time using their phones and indicating potential negative impacts in musculoskeletal health due to this prolonged sedentary behavior. Additionally, the results of Pearson chi square test showed no significant correlation between the participants with normal weight and FHP (p=0.09). However, there was significant correlation between overweight and MSDs (p=0.03), also obesity FHP of participants (p<0.01).

Figure 2. Descriptive data of the measured variables and the study participants



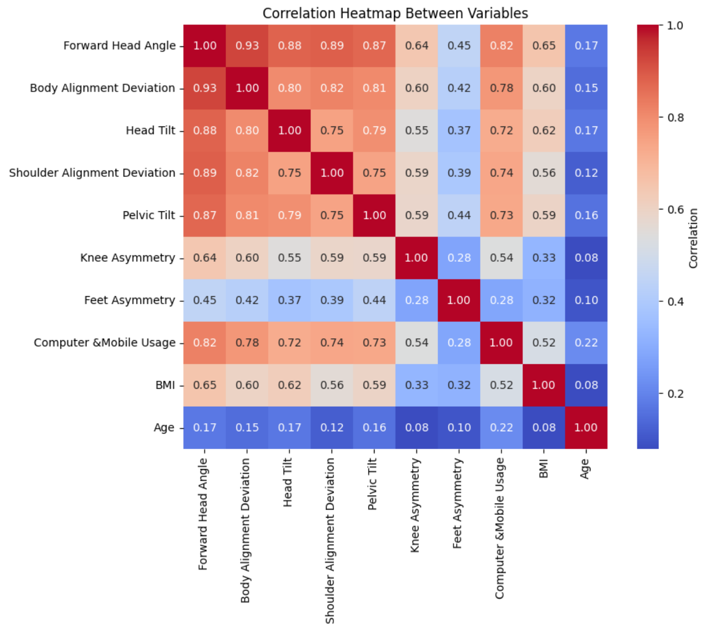
Regarding the measured postural variables, FHA was 39.79±11.95 degrees, with a large standard deviation indicating considerable variability in the extent of head forward tilt among participants. For other postural deviations, such as body alignment deviation, head tilt and shoulder alignment deviation, the average values were 12.82±4.60, 9.07±3.35 and 8.90±3.09 degrees, respectively. This reflects moderate variability in upper body alignment and highlighting the relationship between FHP and the observed postural deviations.

Figure 3. Box and whisker plot of the distribution of measured postural variables



For lower body deviations, pelvic tilt, knee asymmetry and feet asymmetry showed relatively smaller averages of 5.76±1.89, 2.03±0.80 and 2.06±0.90 degrees, respectively. Computer and mobile usage average value was 7.19±1.84. The results of the correlation analysis between FHA and various postural alignment variables are presented in figure 4.

Figure 4. Results of pairwise correlations matrix heatmap among the measured postural variables



The results showed that FHA was highly correlated with body alignment deviation (r=0.931) and coefficient of determination equal 0.8657. Also, the results showed significant correlation between FHA and shoulder alignment deviation approximately about 0.883 and coefficient of determination about 0.7814; head tilt (r = 0.877; R^2 = 0.7701) and computer &mobile usage (r = 0.819). These findings indicate that variations in upper body posture are strongly related to variations in FHA. However, moderate positive correlations were observed between FHA and lower body alignment variables. The coefficient of determination between FHA and pelvic tilt was 0.761, indicating a significant though less obvious correlation. Additionally, moderate correlation was found with knee asymmetry (r = 0.644) and feet asymmetry (r = 0.446).

In Table 1, we show the regression model performance metrics which showed that the model explained 95% of the variance in Forward Head Angle (R^2=0.958, Adj. R^2=0.935), a remarkably strong fit that indicates the chosen variables effectively capture the complexity of postural alignment. Regarding the model predictive performance, the Mean Squared Error (MSE) is 0.226 and the cross-validated MSE is 0. .226, indicating excellent model fit. These low error values demonstrate that the model predictions closely approximate the actual Forward Head Angles measured, reflecting it is a robust tool for understanding and predicting postural deviations in desk workers.

Table 1. Regression Model Performance Metrics

Metric	Value
R-squared	0.958
Adjusted R-squared	0.953
Mean Squared Error (MSE)	4.974
Cross-validated MSE	7.786

The ordinary least squares (OLS) regression model (Table 2) presents a significant tool on the determinants of forward head posture. Among the predictors body and shoulder alignment deviation shows as the most influential behavioral factors (coefficient = 0.8219, 0.5728 with p < 0.0001, respectively) reflecting the significant impact of prolonged screen time on increasing forward head posture. This supports existing literature on the adverse musculoskeletal effects of sustained device use. Similarly, computer &mobile usage plays a highly significant positive effect (coefficient = 0.2024, p < 0.034), highlighting that higher body mass is associated with greater forward head deviation. This could be due to the additional biomechanical load altering normal spinal alignment, consistent with previous ergonomic studies.

Table 2. Results of the OLS regression model

Variable	Coefficient	Std. Error	t-value	P-value	95% confidence interval	Significance
Intercept	37.8543	0.272	139.066	0.0001	[37.313, 38.395]	Yes
Body Alignment Deviation	4.1642	0.611	6.817	0.0001	[2.950, 5.378]	Yes
Head Tilt	2.3694	0.527	4.496	0.0001	[1.322, 3.417]	Yes
Shoulder Alignment Deviation	2.9234	0.52	5.622	0.0001	[1.890, 3.957]	Yes
Pelvic Tilt	1.8819	0.538	3.496	0.001	[0.812, 2.952]	Yes
Knee Asymmetry	0.5536	0.358	1.547	0.125	[-0.157, 1.265]	No
Feet Asymmetry	0.2974	0.311	0.957	0.341	[-0.320, 0.915]	No
Computer & Mobile Usage	1.0362	0.481	2.155	0.034	[0.081, 1.992]	Yes
BMI	0.5785	0.363	1.593	0.115	[-0.143, 1.300]	No
Age	0.1614	0.281	0.575	0.567	[-0.397, 0.719]	No

The results of the regression model indicated that biomechanical indicators such as body alignment deviation and head tilt have a clear and significant effect on forward head angle with coefficient values of 0.8219 and 0.477, respectively. Although these effects are not large, they are statistically significant (p<0.0001), which indicate that even a slight increase in these deviations causes a rise in the forward head. However, other variables namely shoulder alignment deviation, pelvic tilt, knee asymmetry and foot asymmetry showed positive but statistically insignificant effects, suggesting the possibility of indirect or cumulative effects on overall posture.

The intercept of approximately 17.845 degrees reflects the baseline forward head angle when all predictors are at zero, offering a physiological reference for the population studied.

Table (3) show the findings of the Variance Inflation Factor (VIF) analysis for the regression model predictor variables. The results showed that variance inflation factor values ranged between 1.064 and 5.036. Body alignment deviation had the highest value recorded equal 5.036 and the lowest was for the participants age with VIF about 1.09. These values less than the commonly accepted threshold of 10, indicating a low multicollinearity among the regression model predictor variables. Other postural variables including Head Tilt, Shoulder Alignment Deviation, Computer & Mobile Usage and BMI, also showed acceptable levels of independence. These findings suggest that each variable contributes unique and non-redundant data to the regression model, thus enhancing the accuracy of evaluating posture-related indicators in Desk-Based Employees where multiple biomechanical and behavioral overlapping factors influences are common.

Table 3. Variance Inflation Factor (VIF) Analysis for the regression model predictor variables

Feature	VIF
Body Alignment Deviation	5.036
Head Tilt	3.747
Shoulder Alignment Deviation	3.649
Pelvic Tilt	3.911
Knee Asymmetry	1.727
Feet Asymmetry	1.302
Computer & Mobile Usage	3.118
BMI	1.781
Age	1.064

This is critical because it ensures the reliability of coefficient estimates and strengthens confidence in interpreting the individual effect of each factor on posture. The results of the factor analysis are presented in Table 4. Factor 1 demonstrated the highest loadings for variables such as the computer &mobile usage variable (0.831), the body alignment deviation variable (0.923) and the head tilt variable (0.877), indicating that these are the strongest contributors to this component. This indicate that the first component shows strong loadings for the measured postural variables and explain most of the variance.

Table 4. Factor Analysis Components

Variable	Component 1	Component 2
Body Alignment Deviation	0.923	-0.051
Head Tilt	0.877	0.107
Shoulder Alignment Deviation	0.868	-0.123
Pelvic Tilt	0.879	0.089
Knee Asymmetry	0.649	-0.197
Feet Asymmetry	0.438	0.055
Computer & Mobile Usage	0.831	-0.085
BMI	0.647	0.333
Age	0.216	-0.038

Factor 2 showed its highest loadings for the BMI variable (0.333), the head tilt variable (0.107) and the pelvic tilt variable (0.089), reflecting that this factor reflects a different aspect of postural variance, possibly related to head and neck alignment. Meanwhile, other variables showed either low or negative loadings across both factors, such as the ninth variable (-0.038 in Component 2) and the computer &mobile usage variable (-0.085 in Component 2), indicating minimal or inverse contributions to the extracted factors. These results support the interpretation of multiple underlying dimensions in the dataset, with certain variables aligning more strongly with distinct postural patterns represented by the component. The results demonstrate that FHA significantly influences postural alignment across the kinetic chain, with the strongest effects observed in the upper body (body alignment, head tilt and shoulder alignment). Body alignment deviation was the most significant predictor of FHP, emphasizing the need to address FHP in clinical practice to improve postural integrity and prevent related musculoskeletal dysfunctions.

Figures 5 and 6 present the residuals from the regression model. The residuals were analyzed using the plots to evaluate the model normality and homoscedasticity fit. The normal distribution curve and the histogram of residuals represented in Figure 5. The results indicated that the residuals follow a quite normal distribution where the residuals approximately symmetric around zero. However, some bias in the data was found with slight positive skew which may reflect the model partial disagreement with the residual normal distribution. Furthermore, some deviations appear particularly at the higher ends of the distribution which could be due to the presence of outliers reflecting that the normality assumption is only partially achieved.

Figure 5. Distribution of Residuals with Normal Curve

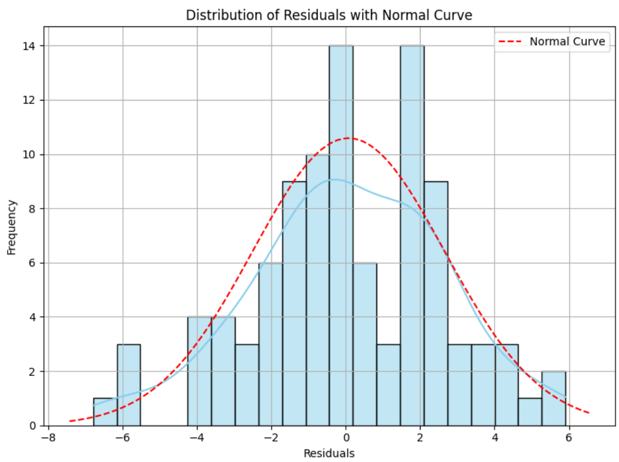
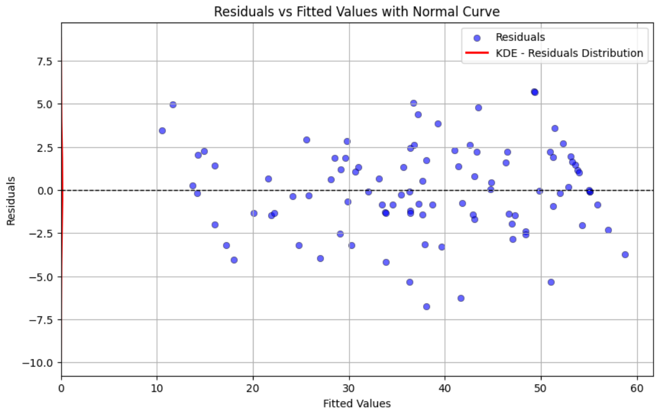


Figure 6 shows a plot of residuals against the fitted values (predicted values from the regression model) along with a Kernel Density Estimate (KDE) curve representing the distribution of residuals. This plot shows that the residuals are quite equally scattered around the horizontal zero line with no clear pattern. This reflects that variance of residuals not being constant and that the model does not show systematic errors in its predictions, which is a positive indication of model fit. Additionally, the overlaid KDE curve (red line) provides a smoothed estimate of the residuals' distribution. Although, some outliers shown at both extremes of the distribution, they do not significantly impact the overall normality of the residuals which have unidirectional distribution and resembles a bell curve. These findings indicated that the regression model fits the data well and there is no significant systematic bias in the residuals. However, we recommend future studies to conduct further outlier checks or use additional diagnostic tests to evaluate the mode performance deeply.

Figure 6. Residuals vs Fitted Values with Normal Curve



Discussion

The current cross-sectional study was conducted to investigate the relationship between irregularities in postural alignment and the FHP of desk-based employment. Since FHP is a common postural condition that frequently results in musculoskeletal problems, it is essential to comprehend how it affects total postural integrity in order to create effective therapies (Alrowili et al., 2024). Through the use of mobile apps to measure postural deviations, this study offers important new information on the biomechanical and clinical impacts of FHP (Khanum et al., 2023). Strong correlation between FHP and variations in upper body posture, particularly in shoulder alignment, head tilt and body alignment, were found in the literature (Singla & Veqar, 2017).

According to these results, FHP significantly affects upper body posture. Whereas knee and foot asymmetry showed lesser relationships, pelvic tilt showed moderate correlation. This pattern indicates that while FHP still impacts the entire kinetic chain, its influence diminishes with increasing distance from the cervical spine. The most important predictor of FHP was found to be body alignment, which was followed by head tilt and shoulder alignment. This suggests that upper body posture plays a key role in deviations linked to FHP. The biomechanical interconnectedness of the upper body and cervical spine explains the high correlation between FHP and upper body misalignments. The head forward motion modifies the center of gravity of the body, causing the cervical and thoracic spine to adjust. These alterations include compensatory extension in the upper cervical spine, greater flexion in the lower cervical spine and increased thoracic kyphosis, which throws off shoulder alignment and scapulothoracic rhythm (Neumann & Kelly, 2010; Quek et al., 2013). These postural abnormalities are further aggravated by muscle imbalances and fascial linkages. Chronic FHP causes asymmetrical activation patterns that disrupt scapular posture by straining muscles such as the levator scapulae, upper trapezius and suboccipital muscles (Cobanoğlu et al., 2024). Further exacerbating problems with upper body alignment are fascial lines like the superficial and deep front lines, which carry abnormalities from the cervical spine to the shoulders and thoracic spine (Caseley & Johnson, 2015). On the other hand, functional and biomechanical separation between the upper and lower kinetic chains is responsible for the lesser correlations between FHP and lower body abnormalities (pelvic tilt, knee asymmetry and foot asymmetry). Rather than cervical or thoracic deviations, variables including pelvic alignment and hip muscle imbalances have a greater impact on the lumbar spine, pelvis and lower extremities (Khamis & Yizhar, 2007). Examining the coefficients and their statistical significance (Table 1), several predictors demonstrate significant positive correlation with Forward Head Angle. Notably, Computer &mobile usage and BMI show strong positive effects, with highly significant t-values ($p < 0.001$), underscoring their critical role in influencing head posture. The positive coefficients of Body Alignment Deviation and Head tilt confirm their expected positive but more moderate impact on the dependent variable, aligning with the study hypothesis. Other postural deviations such as Shoulder Alignment Deviation, Pelvic Tilt, Knee and Feet Asymmetry exhibit positive but statistically non-significant contributions, suggesting a weaker or less consistent effect on forward head posture in this dataset. The results showed that VIF values ranged from 1.064 to 5.036, indicating a low multicollinearity among the regression model predictor variables where all VIF values well below the threshold of 10. The low mean squared error demonstrated a high predictive accuracy and confirmed the reliability of the regression model estimates. The high coefficient of determinations R^2 value (0.958) in the OLS regression results also enhances the reliability of the model and explaining 95% of the variance in forward head angle. The direct impact of FHP on the lower extremities is lessened by the dissipation of stresses through the lumbar and thoracic spine as well as neuromuscular control in the lower body (Alowa & Elsayed, 2021; Naroz et al., 2024). Our findings are consistent with other studies that found a substantial correlation between upper body misalignments and FHP. For instance, incorrect head placement has a major impact on total body alignment, especially in the cervical and thoracic areas, according to (Coskun et al., 2020; Sheikhhoseini et al., 2018). Research by (Neumann & Kelly, 2010; Quek et al., 2013) revealed compensatory mechanisms in people with FHP, such as scapular dysrhythmia and thoracic kyphosis. The findings that indicate local variables, such as hip muscle imbalances or leg length disparities, have a greater impact on pelvic tilt and lower extremity asymmetries than FHP are supported by the weaker correlations between FHP and lower body misalignments (Khamis & Yizhar, 2007). The factor analysis reveals two main components that represent latent structures within the data. The first component focuses largely on Body Alignment Deviation (0.923) and to a lower degree on head tilt (0.877) and computer and mobile phone use (0.831) indicating a combination of behavioral and biomechanical factors. The second component reflects different alignment deviations with mixed loadings, indicating underlying biomechanical patterns. This dimensional insight is useful for understanding how different variables change and can guide targeted ergonomic interventions by identifying key areas that influence forward head posture. These findings support the concept that FHP has a greater impact on the upper body and less on the lower kinetic chain. Although the majority of the literature supports our findings, several studies found a higher association between FHP and lower body misalignments (Czaprowski et al., 2018; Lin et al., 2022). Czaprowski et al. (2018) found a strong association between FHP, pelvic tilt and knee asymmetry. The study demonstrated that non-structural deviations in sagittal posture, such as forward head posture and pelvic tilt, are common among healthy individuals (Czaprowski et al., 2018). They concluded that these deviations may be related to functional and behavioral factors rather than structural abnormalities demonstrating a clear impact on the lower kinetic chain. This differencing may be due to variations in study design or participant sample characteristics. In similar study, Suwaidi et al. (2023) compared different approaches for enhancing head posture in the elderly with chronic non-specific neck pain and their findings indicated that correcting the cervical spine curvature approach was more effective than the traditional approach. In addition, a study by O'Sullivan et al. (2018) and Hodges & Falla (2015) emphasized that postural and movement control are not purely biomechanical but are also influenced by cognitive and behavioral factors. Persistent poor posture such as FHP may be adjusted by maladaptive movement patterns that alter sensorimotor control. The results of Wildenbeest et al. (2023) showed that perceived postural can modify motor control strategies even in the absence of pain which emphasize the role of psychological and environmental stressors in postural adaptations. Integrating these findings with the current study suggests that addressing FHP effectively requires not only biomechanical correction but also behavioral retraining to improve sensorimotor function and reduce maladaptive compensations. The results of the current study show that prolonged computer and mobile phone use mainly affects the FHP and upper body with a lower effect on the rest of the kinetic chain. This is agreed with studies by Jun et al. (2021) and Lindegård et al. (2012), which showed that behavioral and environmental factors such as psychological stress, lack of physical activity, and perceptions of stress like computer use for long time and the quality of the work environment, play an important role in the development of neck and upper extremity symptoms within office workers and cause musculoskeletal symptoms, highlighting the importance of correcting office-work postures. In order to enhance postural integrity and lower the risk of musculoskeletal illnesses, the results highlight the necessity of addressing FHP in clinical and ergonomic treatments. Our findings are in line with much of the literature currently in publication, but certain differences with other studies indicate that more study is needed to fully comprehend the processes and magnitude of FHP influence on global postural alignment. Therefore, early detecting FHP and associated postural deviations are mandatory to prevent chronic health problems associated with poor posture. Specialized physical therapy interventions and employee guidance to good posture in the desk workplaces are very important especially for office employees. It is also recommended to include posture checks in health monitoring programs to detect employees at risk. This study provides useful insights into the relationship between FHP and postural alignment among desk-based employees. However, several limitations should be noted. The cross-sectional design limits causal inference, as associations between screen time and postural deviations cannot confirm directionality. The use of mobile applications, while practical and cost-effective, may have introduced measurement variability compared with gold-standard motion analysis systems. Additionally, the absence of pain or functional outcome variables restricts understanding of the clinical implications of FHP.

Conclusions

This study investigated the relationship between forward head angle (FHA) and various deviations in postural alignment among office workers taking into account behavioral and biomechanical factors. The results indicated that FHP is a common problem within Suez University staff, with an average forward head angle of 17.84 degrees which reflect a significant deviation in cervical spine alignment. Moreover, it indicated that FHP in office workers was strongly associated with several postural alignment errors, such as body alignment, head tilt, and pelvic tilt. The study confirmed that FHP in office workers is strongly influenced by a range of behavioral factors, most notably prolonged computer and mobile phone use, and physiological factors such as body mass index. Biomechanical deviations, such as body alignment deviation and head tilt, also play an important role. The results showed a significant association between FHA and upper body deviations, particularly body alignment, head tilt, and shoulder alignment, with body alignment deviation being the most influential factor ($r = 0.931$, $p < 0.0001$; coefficient = 0.8219). Moderate correlations were also observed with lower body variables such as pelvic tilt and knee asymmetry, suggesting that the effect of FHA extends to a lesser extent across the kinetic chain. Digital device use showed a strong association with FHA ($r = 0.819$), highlighting the behavioral impact of this condition. A multiple regression model explained 95.8% of the variance in FHA ($r^2 = 0.958$) with no indications of multicollinearity, enhancing the model reliability. Factor analysis further supported the multidimensional nature of posture, with behavioral variables and upper body alignment emerging as key components. These findings confirm that FHA among office workers is a multifactorial problem resulting from poor upper body alignment and prolonged device use such as computers and mobile phones.

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Authors' details:

Amira Ezzat Mohamed Abd ElHay	amira.ezzat@aabu.edu.jo	Author
Mohamed Ali Elsayed	mabdullah@philadelphia.edu.jo	Author
Doaa Tammam Atia	Doaa.tammam@the.suezuni.edu.eg	Author
Ahmed Mokhtar Tawfick	ahmed.mokhtar@pt.mti.edu.eg	Author
Radwa M. Shalaby	radwa.shalaby@cuc.edu.eg	Author
Hadeer A. Morsi	Hader_Awad@pt.kfs.edu.eg	Author