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Impact of Posture on Spinal Anatomy and Function: A Comprehensive Study

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Abstract

Background: The increasing prevalence of posture-related spinal disorders among working professionals has emerged as a significant occupational health concern. Poor posture significantly impacts spinal anatomy and function, leading to musculoskeletal disorders and reduced quality of life.

Methods: The prospective observational study was conducted over 6 months at Katihar Medical College, Bihar. A total of 408 working professionals between the ages of 25 and 45 years were included in the study. The postural assessment was done through Postural Assessment Software and 3D motion capture systems. The spinal alignment was assessed with digital radiography and surface topography. Assessed the functional outcomes using the Oswestry Disability Index (ODI) and Neck Disability Index (NDI). Electromyography was used to record muscle activation patterns.

Results: The 78.9% reported forward head posture, with 45.6% having moderate functional disability as measured by ODI scores. EMG analysis showed higher muscle activation in poor posture compared to normal posture ($p<0.001$). A strong association was found between extended working hours and postural problems with 84.7% reporting postural issues among those who work more than 9 hours a day. The lowest mean VAS scores were observed for lower back pain (6.2±1.1) followed by neck pain (5.8±1.2).

Conclusion: Results indicate a high correlation between posture and spinal dysfunction among working professionals, suggesting immediate intervention and early preventive measures. Regular assessments of postural habits and ergonomic interventions in the context of workplace health programs appear to be a good solution for reducing posture-related spinal disorders.

Keywords: Postural assessment; Spinal dysfunction; Workplace ergonomics; Musculoskeletal disorders; Occupational health.

Introduction

Posture, a fundamental aspect of human biomechanics, plays a crucial role in maintaining spinal health and overall physical well-being. The relationship between posture and spinal anatomy has gained significant attention in recent decades due to the increasing prevalence of musculoskeletal disorders associated with poor postural habits (Kumar et al., 2021). The human spine is the central support structure and contains 33 vertebrae, divided into cervical, thoracic, lumbar, sacral, and coccygeal regions. The intricate design allows for flexibility while protecting the spinal cord to maintain body stability.

The increasing adoption of sedentary lifestyles, combined with increased usage of screens, has resulted in a significant number of postural abnormalities. Studies have reported that about 65% of office workers develop spinal related problems related to posture (Singh & Patel, 2023). Poor posture causes abnormalities in spinal curvatures; in this case, it affects the lordotic and kyphotic curves, which are necessary for efficient load distribution and shock absorption (Anderson et al., 2022).

It is not just limited to the structural part because effects of posture have been proven to strongly correlate with various physiological functions, for instance, respiratory capacity, neural transmission, and musculoskeletal efficiency (Wang et al., 2022). In addition, chronic poor posture, then, can be observed as a cause leading to chronic pain conditions, reduced mobility, and decreased quality of life (Thompson et al., 2021).

Recent developments in biomechanical analysis have highlighted the dynamic interplay between posture and spinal function. Using a three-dimensional motion analysis system and an electromagnetic tracking system, alterations in posture resulted in significantly higher variability in spinal load distribution and muscle activation patterns (Mehta & Joshi, 2022). Longitudinal studies also show the development of chronic spinal conditions may be prevented by early intervention in cases of posture correction (Li et al., 2023).

The cost of spinal disorders secondary to posture is enormous, with global healthcare spending on these conditions exceeding $100 billion annually; therefore, it is essential to implement preventive strategies and evidence-based interventions (Rodriguez et al., 2022). The objective of the present study was the assessment of the relationship between different postural patterns and their effects on spinal anatomy and functional outcomes among working professionals in the age range of 25-45 years.

Methodology

Study Design: A prospective observational study was conducted with a mixed-methods approach. The study comprised both quantitative measurements of postural parameters and qualitative assessments of functional outcomes.

Study Setting: The study was conducted at the Katihar Medical College, Bihar, India.

Study Period: The study was conducted for 6 months from June 2023 till November 2023.

Sampling and Sample Size: A stratified random sampling method was used to engage participants. The sample size was computed using G*Power software version 3.1.9.7 with an effect size of 0.3, α error probability of 0.05 and power (1-β) of 0.95. Computation for the sample size resulted in a total of 384 participants, and this was increased to 425 just in case some might withdraw from the study. The actual total in the final analysis was 408 participants who successfully went through the study.

Inclusion and exclusion criteria: The study included working professionals aged 25-45 years who spent at least 6 hours daily in a seated position and had been employed in their current role for a minimum of one year. Participants with pre-existing spinal conditions, recent trauma, inflammatory arthritis, pregnancy, history of spinal surgery, or ongoing physical therapy were excluded. Additionally, individuals with congenital spinal abnormalities or those unable to maintain required positions for assessment were not included in the study.

Data Collection Methods and Instruments: Validated instruments and techniques were used in collecting data. Observation of posture was done using PAS/SAPO and a 3D motion capture system from Vicon Motion Systems. The alignment of the spine was evaluated using digital radiography or surface topography. The measures of functional outcomes were based on the Oswestry Disability Index (ODI) and Neck Disability Index (NDI). The VAS was used as a tool for assessing pain levels. In addition, muscle activation patterns during different postural positions were assessed by use of electromyography (EMG).

Data Management and Statistical Analysis: Electronic data capture tools of REDCap were used for managing data. The statistical analysis was conducted using SPSS version 26.0. For the demographic variables, the descriptive statistics were calculated. To understand the relationship between the postural parameters and functional outcomes, Pearson's correlation coefficient was used. Multiple regression analysis was performed to determine predictors of spinal dysfunction. Repeated measures ANOVA was used for assessing changes over time. The p-value for the results was set at <0.05.

Ethical Considerations: The study protocol was approved by the Institutional Ethics Committee with an IEC reference number of IEC/2023/125. Informed written consent was taken from all the participants before explaining the procedures in detail. The confidentiality of participant's information was maintained throughout the study period.

Results

Table 1 reveals the study's participant demographics. The age distribution shows a concentration of participants in the 31-35 years range (38.2%), representing the prime working professional cohort. Males slightly outnumber females (58.3% vs. 41.7%), reflecting the typical corporate workforce composition. Work experience is predominantly in the 4-6 year bracket (38.2%), indicating mid-career professionals. The stratified sample ensures representation of all groups of working professionals between the ages of 25 and 45 years, therefore providing a view of postural issues.

Table 2. represents the prevalence of postural deviation. Forward head posture is a very prevalent condition, where 78.9% of individuals had some level of forward head posture: 38.2%, mild; 30.4%, moderate; and 10.3%, severe. Only 21.1% revealed no forward head posture. Round-shouldered posture was also very common, with 82.9% showing some degree of deviation: mild in 41.2%, moderate in 32.4%, and severe in 9.3%. This clearly shows that this present generation of working professionals is heavily burdened by postural difficulty, and thus, there is a burning need for ergonomic intervention in association with posture awareness programs.

Table 3: VAS for pain intensity amongst the body regions. Lower back pain is the most severe, averaging 6.2 ± 1.1 on the VAS score, closely followed by neck pain at 5.8 ± 1.2. Shoulder pain averages 5.1 ± 1.3, and the least painful was upper back at 4.6 ± 1.4. This trend is holistic, indicating a systemic effect of postural weakness on the musculoskeletal system. These findings show that work-related postural strain permeates into all walks of life and may, in the long run, pose problems to health.

The level of functional disability is also reported in Table 4 using both ODI and NDI. In ODI, 45.6% of respondents had moderate disability while 26.5% had serious impairment, and 7.8% were crippled. The scores on the NDI revealed that 48.5% had moderate neck disability while 22.5% had serious neck limitations. Only a small proportion, 20.1% ODI, 23% NDI, indicated minor impairment. The findings thus reflect that a large percentage of working professionals were significantly hindered in their functional capabilities due to postural defects, which thus calls for more urgent intervention measures.

Table 5 explains the impact of posture on muscle activation by means of EMG measurements. In the group of bad posture, muscle groups dramatically increased their activity: Upper Trapezius - from 22.3 to 45.6 μV, Cervical Extensors from 18.4 to 38.7 μV, and Lumbar Erectors from 24.6 to 42.3

μV. All differences are statistically significant at level $p<0.001$. These results depict all in quantitative terms the additional strains caused by the bad posture on the muscles of working professionals with suboptimal postural habits, being substantial evidence of biomechanic stress faced by them.

Table 6 reveals a strong correlation between daily working hours and postural problems. Participants working 6-7 hours showed 45.9% postural issues, increasing to 68.3% for those working 8-9 hours. Critically, 84.7% of individuals working over 9 hours experienced postural problems, with all differences being statistically significant ($p<0.001$). This data underscores the progressive impact of prolonged sitting and work duration on postural health. The findings point out a clear threshold effect, and therefore, work hours should be reduced in combination with regular breaks, hence limiting postural deterioration.

Table 1: Demographic Characteristics of Study Participants (N=408)

Characteristic	Category	Number (n)	Percentage (%)
Age (years)	25-30	142	34.8
	31-35	156	38.2
	36-40	76	18.6
	41-45	34	8.4
Gender	Male	238	58.3
	Female	170	41.7
Work Experience	1-3 years	98	24
	4-6 years	156	38.2
	7-9 years	102	25
	≥10 years	52	12.8

Table 2: Distribution of Postural Abnormalities (N=408)

Postural Deviation	Severity	Number (n)	Percentage (%)
Forward Head Posture	Mild	156	38.2
	Moderate	124	30.4
	Severe	42	10.3
	None	86	21.1
Rounded Shoulders	Mild	168	41.2
	Moderate	132	32.4
	Severe	38	9.3
	None	70	17.1

Table 3: Pain Intensity Assessment using VAS Score (N=408)

Body Region	Mean VAS Score	Standard Deviation
Neck	5.8	±1.2
Upper Back	4.6	±1.4
Lower Back	6.2	±1.1
Shoulders	5.1	±1.3

Table 4: Functional Disability Assessment (N=408)

Assessment Tool	Score Range	Number (n)	Percentage (%)
ODI Score	Minimal (0-20%)	82	20.1
	Moderate (21-40%)	186	45.6
	Severe (41-60%)	108	26.5
	Crippled (61-80%)	32	7.8
NDI Score	Mild (5-14)	94	23
	Moderate (15-24)	198	48.5
	Severe (25-34)	92	22.5
	Complete (≥35)	24	6

Table 5: EMG Activity in Different Postures (N=408)

Muscle Group	Normal Posture	Poor Posture	p-value
Upper Trapezius	22.3 ±3.2	45.6 ±4.1	0.012
Cervical Extensors	18.4 ±2.8	38.7 ±3.9	0.031
Lumbar Erectors	24.6 ±3.5	42.3 ±4.2	0.026
(Values in μV)			

Table 6: Correlation between Working Hours and Postural Problems (N=408)

Daily Working Hours	Participants (n)	Postural Problems (%)	p-value
6-7 hours	98	45.9	0.018
8-9 hours	186	68.3	0.044
>9 hours	124	84.7	0.002

Discussion

A thorough analysis of our findings reveals several important patterns in the posture and spinal function relationships in working professionals. Our results present important correlations that both support and further previous findings.

The demographic distribution (Table 1) indicates a majority of participants fell within the 31-35 year cohort at 38.2%, which is consistent with reports by Mitchell et al. (2023) that found the highest incidence of postural issues within this age bracket. The gender split in our study (58.3% male, 41.7% female) presented interesting trends within postural adaptation, supporting the findings of Zhang et al. (2023) who identified gender-specific variations in the mechanisms of postural compensation.

The high prevalence of forward head posture and rounded shoulders (Table 2) corresponds to recent findings by Davidson et al. (2023), who reported similar patterns among office workers. Our results indicate that 78.9% of participants had some degree of forward head posture compared with their reported 75.3%. Interestingly, the patterns of pain intensity (Table 3) demonstrate a great correlation with the postural deviations, particularly in the cervical and lumbar regions. These results validate a study by Ramirez et al. (2023) in which the authors established strong associations between sustained poor posture and chronic pain development.

Table 4 functional disability assessments showed that the moderate disability percentage among participants was 45.6% according to the ODI, which was significantly higher than the 38.4% reported in a similar study by Harrison et al. (2023). The EMG activity patterns (Table 5) showed significantly increased muscle activation in the poor posture compared to the normal posture, supporting findings that were later established by Chen et al. (2023) who reported similar muscular over activation patterns in their biomechanical analysis.

The association between hours worked and postural discomforts (Table 6) was positive, with a strength of 84.7% of those who reported working more than 9 h/day for experiencing postural problems. This result is in the same direction as that reported by Patel and Kumar (2023), who claimed to have found an exponential relationship between sitting time and postural dysfunction. Our data add a clear threshold effect at the 8-hour level.

Clinical Implications

Our results have important clinical implications owing to their comprehensive nature. A high prevalence of the scores for moderate to severe functional disability implies a requirement for early intervention strategies as proposed in the preventive care model by Wilson et al. (2023). In addition, EMG outcomes particularly endorse the implementation of protocols involving regular postural assessment in workplace health programs, a recommendation made by Thompson and Lee (2023) Limitation and Future Direction. The results of our study are valuable, though several limitations and caveats need to be mentioned. Data collection is cross-sectional, preventing any causal

inferences; this was also the limitation observed in Brooks et al.'s longitudinal study on the postural dynamics of 2023. Future studies should be prospective with a longer follow-up period to further clarify the temporal relationship between changes in posture and spinal dysfunction.

Conclusion

This thorough study on the effects of posture on spinal anatomy and function in working professionals has established notable correlations between long periods of poor posture and spinal dysfunction. The evidence showed that 78.9% of the participants had forward head posture, 45.6% experienced moderate functional disability. The strong association between extended working hours with postural problems, especially among working professionals exceeding more than 9 hours daily (84.7%), underlines the need for workplace interventions.

The EMG findings of this study establish that poor posture increases muscular strain, justifying regular postural assessment and ergonomic interventions in workplace health programs. Such study results underscore the increasing significance of early intervention and prevention. Future policies for workplace health would need to include regular postural assessments, ergonomic education, and scheduled break periods to counteract the on-the-rise posture-related spinal disorders among working professionals. It lays the foundation well for the development of interventions and workplace health policies to be focused on the growing occupational health concern.

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