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Title: Instrument-Specific Opium Smoking Exposure and Integrated Cervical Neuromusculoskeletal Dysfunction among People with Opioid Dependence: A Cross-Sectional Analysis

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Abstract

Purpose: Traditional opium smoking may require prolonged, repetitive, and non-neutral positioning of the head, neck, and trunk. Although cervical impairments have been reported among chronic opium smokers, the effects of specific smoking instruments remain unclear.

Methods: This secondary cross-sectional analysis of the first author's doctoral thesis included 123 adults with opioid dependence and a history of opium smoking. Lifetime and daily exposure were recorded separately for vafour (traditional opium pipe), gholgholi, and sikh-o-sang. A study-derived Integrated Cervical Neuromusculoskeletal Dysfunction Index (ICND) combined standardized measures of pain, neck disability, neck symptoms, thoracic kyphosis, forward head posture, cervical range of motion, and neck-muscle force. Spearman correlations and multivariable linear regressions with HC3 robust standard errors were performed, adjusting for age, sex, body mass index, cigarette consumption, and dependence severity.

Results: The ICND showed acceptable internal consistency (Cronbach's alpha=0.717). Total smoking duration (rho=0.564), daily vafour exposure (rho=0.560), and cumulative vafour exposure (rho=0.481) had the strongest correlations with ICND (all p<0.001). In the cumulative-exposure model, vafour duration independently predicted higher ICND scores (standardized beta=0.295, 95% CI 0.068-0.523; p=0.011); the model explained 37.9% of ICND variance. In the daily-exposure model, daily vafour duration was the strongest independent predictor (standardized beta=0.394, 95% CI 0.238-0.550; p<0.001), with 44.3% of variance explained. Daily vafour exposure was also associated with greater pain, a smaller craniovertebral angle, greater kyphosis, restricted cervical range of motion, and reduced neck-muscle force.

Conclusions: Longer daily vafour use was the most consistent instrument-specific correlate of worse cervical dysfunction. Opium smoking posture and exposure duration should be considered in musculoskeletal assessment of chronic opium smokers. Prospective studies with direct posture measurement are needed to clarify temporality and causation.

Keywords: cervical dysfunction; forward head posture; range of motion; muscle strength; opioid dependence; opium smoking

Highlights

- Longer daily vafour (traditional opium pipe) exposure was the strongest independent predictor of worse integrated cervical neuromusculoskeletal dysfunction among people with opioid dependence.
- Vafour exposure was associated with a multidimensional pattern of dysfunction, including greater neck pain, more forward head posture, higher thoracic kyphosis, reduced cervical range of motion, and lower neck-muscle force.
- The study-derived **ICND** provided an integrated summary of pain, disability, posture, mobility, and muscle performance rather than evaluating each cervical outcome separately.

Plain language summary

This study examined whether different traditional opium-smoking methods are related to neck and upper-spine problems in people with opioid dependence. Among the smoking methods studied, longer daily use of vafour (a traditional opium pipe), was most strongly linked to worse neck-related health. People with longer vafour exposure tended to have more neck pain, poorer posture, reduced neck movement, and weaker neck muscles. These findings suggest that the posture and duration of opium smoking may be important when assessing musculoskeletal problems in addiction-treatment settings.

Introduction

Opioid use disorder (OUD) remains a major public health concern in Iran, where opioids - particularly opium - constitute the predominant class of illicit drugs associated with clinically significant use disorders (1). The historical availability of opium, its cultural familiarity, and the persistence of non-injecting routes have produced patterns of opioid use that differ from those observed in many other settings. In Iran, addiction research and service development have understandably concentrated on psychiatric comorbidity, infectious disease transmission, transition to injection, overdose, treatment access, and the social and legal consequences of opioid use (1-3). These priorities have generated an important evidence base for treatment and harm reduction; however, the physical consequences of long-term opioid use have not been investigated with comparable breadth. In particular, musculoskeletal and postural impairments related to the habitual circumstances in which opium is smoked have received relatively little systematic attention.

Traditional opium smoking is not merely a pharmacological exposure; it is also a repeated physical activity performed through specific instruments and characteristic body positions. Opium smoking with a vafour[1] may require prolonged sitting, sustained forward positioning of the head and neck, thoracic flexion, and repeated maintenance of a relatively static upper-body posture. Other devices, including gholgholi[2] and sikh-o-sang[3], may involve different combinations of trunk inclination, head positioning, upper-limb support, and duration of exposure. From a biomechanical perspective, these patterns can be compared with other activities characterized by sustained or repetitive non-neutral head-neck postures. Prolonged forward-bent neck positioning and extended sitting have been associated with neck complaints among office workers (4-6), while inadequate workstation ergonomics and forward head posture have been documented in information-technology professionals (7). Similar cervical postural and functional problems have been investigated in dentists, whose work frequently requires sustained visual focus and constrained neck positions (8), in individuals who use smartphones for prolonged periods (9), and in

[1] Vafour is a traditional Iranian opium pipe used for direct inhalation of heated opium smoke, usually consisting of a stem and a small clay or ceramic bowl.
[2] Gholgholi refers to a traditional Iranian water-pipe method of opium smoking, in which heated opium smoke is drawn through water and then inhaled.
[3] Sikh-o-sang is a traditional Iranian heated rod method of opium smoking, in which opium is heated with a hot metal rod and the resulting smoke or vapor is inhaled.

professional drivers exposed to prolonged sitting, awkward posture, repetitive activity, and vibration (10). These occupational and behavioral analogues provide a plausible ergonomic framework for examining instrument-specific opium-smoking exposure.

The cervical consequences of sustained non-neutral positioning may involve several interrelated domains rather than a single abnormality. Forward head posture (FHP), increased thoracic kyphosis, restricted cervical range of motion (ROM), and impaired neck-muscle performance have each been reported in association with neck symptoms or disability in different populations. A systematic review and meta-analysis found that FHP was associated with neck pain intensity and disability in adults, while also identifying age as an important confounding factor (11). Thoracic kyphosis appears to be related to cervical postural alteration and reduced thoracic mobility, although its association with pain intensity and disability is not uniform across studies (12). Moreover, posture-pain relationships are unlikely to be simple or unidirectional. Individual characteristics, cumulative exposure, physical activity, psychosocial strain, and sleep disturbance may influence both musculoskeletal function and symptom reporting (4-6, 7, 13). Accordingly, non-neutral posture should be regarded as a potentially relevant exposure associated with cervical dysfunction rather than as an isolated or sufficient cause of pain.

Direct evidence concerning cervical musculoskeletal dysfunction among people who smoke opium or heroin remains scarce. Previous studies from Iran have shown that chronic opium smokers may have reduced cervical ROM and neck-muscle strength and that these impairments are associated with years of smoking and daily smoking duration (14). Other findings have demonstrated associations between opium smoking and neck pain, neck-related disability, FHP, and hyperkyphosis (15), as well as a higher burden of neck and upper-spine postural disorders among opium smokers than among non-drug-using controls (16). An earlier study of heroin users undergoing methadone-assisted withdrawal also reported a high prevalence of musculoskeletal pain and FHP (17). Collectively, these studies suggest that cervical and upper-spine dysfunction may represent an underrecognized dimension of health among people with opioid dependence. Nevertheless, the available literature has generally treated opium smoking as a single exposure or has examined individual cervical outcomes separately. It therefore remains unclear whether the type of smoking instrument and the cumulative or daily duration of exposure to each instrument are differentially associated with cervical dysfunction.

To address this gap, the present study used a multidimensional, study-derived analytical outcome termed the Integrated Cervical Neuromusculoskeletal Dysfunction Index (ICND). The ICND summarizes cervical pain, neck-related disability, neck symptoms, postural deviation, cervical mobility, and neck-muscle performance. It is not a diagnostic scale and does not replace validated clinical instruments. Rather, it was used to characterize overall cervical neuromusculoskeletal dysfunction and reduce fragmentation across correlated outcomes. The present study uses ICND as a multidimensional composite and analyses instrument-specific exposure. We examined whether exposure duration related to vafour, gholgholi, and sikh-o-sang was associated with ICND among people with opioid dependence.

Methods

Study design and participants

This manuscript reports a secondary, hypothesis-driven analysis of data from the first author's doctoral thesis in Addiction Studies. The parent thesis has already generated publications on separate cervical and spinal outcomes, including neck range of motion, neck-muscle strength, neck pain and disability, forward head posture, thoracic kyphosis, sway-back posture, and regional musculoskeletal symptoms (14-16, 18). Unlike those analyses, the present study did not primarily compare opioid-dependent participants with controls. It focused on within-group variation according to instrument-specific exposure and used ICND as a new analytical composite. The parent study was cross-sectional and was conducted in Tehran, Iran. Participants with opioid dependence were recruited from outpatient and residential substance-use treatment centers through center-based recruitment supplemented by chain referral. Although the original database also included non-drug-using controls, the present analysis was restricted to 123 opioid-dependent participants because instrument-specific opium-smoking variables were applicable only to this group.

Opioid dependence was diagnosed clinically according to the ICD-11 framework (19). Eligible participants were adults who could stand independently, had opium or concentrated opium residue (shireh) as their principal opioid, reported a history of opium smoking, and had a body mass index below 27.5 kg/m². A BMI below 27.5 kg/m² was required in the parent protocol to reduce potential confounding from higher body mass, because elevated BMI has been associated with musculoskeletal symptoms and may influence posture, mobility, and physical performance (20). The main exclusion criteria were known neuromuscular or musculoskeletal disease, previous surgery or major intervention involving the spine or shoulder girdle, balance disorders, competitive or high-intensity sport participation, structural deformity unrelated to opium smoking, and daily smartphone or tablet use exceeding 30 minutes that could independently affect head-neck posture (14-16, 18, 21, 22). The parent sample size was estimated using G*Power with 80% power and a two-sided alpha of 0.05. For this secondary analysis, all eligible opioid-dependent participants with complete exposure and outcome data were included.

Measures

Trained research personnel collected demographic and substance-use data using a structured form. The substance-use assessment was based on the drug-use profile domains of the Maudsley Addiction Profile and recorded age at first and regular use, substances used, route of administration, current or most recent substance, daily amount and frequency of use, and cumulative smoking history (23). Dependence severity was measured using the validated Persian Leeds Dependence Questionnaire, a 10-item scale scored from 0 to 30, with higher scores indicating greater psychological dependence (24). Cigarette exposure was recorded as cigarettes per day.

Instrument-specific opium-smoking exposure was measured separately for vafour, gholgholi, and sikh-o-sang (or sikhi). A vafour is a traditional opium pipe, gholgholi is a small water pipe, and sikh-o-sang involves heating opium on a metal support with a heated rod. For each method, participants self-reported lifetime duration of use in months and typical daily exposure time in minutes. Cumulative instrument-specific exposure was defined as the total number of months in which each instrument had been used, and participants could report exposure to more than one instrument. Instrument-specific exposure variables were analyzed as continuous measures; zero indicated no reported exposure to that instrument. No objective verification of exposure duration or smoking posture, such as direct observation, video recording, or wearable sensors, was available.

Neck pain intensity was assessed using a 0-10 visual analogue scale (25). Neck-related disability was measured with the validated Persian Neck Disability Index, scored from 0 to 50 (26). Musculoskeletal symptoms were assessed using the Nordic Musculoskeletal Questionnaire; the neck-region score was used for the composite outcome, and the total Nordic score was retained as a secondary measure (27, 28). Because the total Nordic score partly overlaps with the neck-region score, analyses of this secondary outcome were interpreted as exploratory.

Forward head posture was quantified by the craniovertebral angle from a standardized lateral photograph, with a smaller angle indicating greater forward head posture (29). Thoracic kyphosis was measured with a flexible ruler from T2 to T12, and the kyphosis angle was calculated using the standard flexicurve formula (30). Active cervical range of motion in six directions was measured with a Baseline CROM-3 device and summed to create ROM_total (31). Maximum voluntary isometric neck-muscle force was measured in flexion, extension, right lateral flexion, and left lateral flexion using a calibrated hand-held dynamometer; BMI-normalized values were summed to create Force_total (32). Acceptable to high intra-rater and inter-rater reliability for these physical measurements had been reported in the parent publications (14-16, 18).

Construction of the ICND

A study-derived Integrated Cervical Neuromusculoskeletal Dysfunction Index (ICND) was constructed to summarize multiple related dimensions of cervical dysfunction. The ICND included pain intensity, Neck Disability Index total score, Nordic neck symptom score, thoracic kyphosis angle, craniovertebral angle, ROM_total, and Force_total. Equal weighting was used because no validated weighting scheme exists for this new composite and because each component represented a clinically relevant domain of cervical dysfunction. Each component was standardized within the opioid-dependent sample. Craniovertebral angle, ROM_total, and Force_total were reverse-oriented so that higher values consistently represented worse dysfunction. The ICND was calculated as the mean of the seven aligned z scores. The ICND was used as a study-derived analytical index rather than as a validated clinical scale; external validation is required before clinical application or between-study comparison. Internal coherence was examined using Cronbach's alpha, and principal component analysis was used as a sensitivity check.

Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). The ICND was computed within SPSS by standardizing its components, reverse-coding variables where lower raw values indicated greater dysfunction, and averaging the directionally aligned z scores. Continuous variables were summarized as mean and standard deviation or median and interquartile range; categorical variables were reported as frequency and percentage.

Spearman correlation coefficients were used to examine bivariate associations between smoking-related exposure variables and ICND. Multivariable linear regression models were then used to assess the independent association of instrument-specific opium-smoking exposure with ICND. Separate models were fitted for cumulative exposure duration in months and daily exposure duration in minutes for vafour, gholgholi, and sikh-o-sang. Regression models were adjusted for age, body mass index, sex, daily cigarette consumption, and Leeds Dependence Questionnaire score. Secondary adjusted models evaluated individual clinical and biomechanical outcomes using the same covariate structure. Sixteen secondary models were examined, corresponding to eight individual outcomes for each exposure metric. These secondary analyses were exploratory, were not adjusted for multiplicity, and were interpreted cautiously. A two-sided p-value below 0.05 was considered statistically significant for the primary models.

Results

Demographic and substance-use characteristics are presented in Table 1. The mean age was 37.7 years, and most participants were men. Opium was the main drug in 90 participants, while opium residue (shireh) was the main drug in 33 participants.

Table 1. Demographic and substance-use characteristics of participants with opioid dependence (n = 123).

Characteristic	Mean ± SD or n (%)	Median (IQR)
Total sample size	123	
Age, years	37.7 ± 7.8	38.0 (31.0–44.0)
Male sex	112 (91.1%)	
Female sex	11 (8.9%)	

BMI, kg/m²	24.7 ± 1.6	25.1 (23.4–26.0)
Cigarette smoking, cigarettes/day	22.5 ± 11.2	20.0 (15.0–30.0)
LDQ total score	24.0 ± 4.7	25.0 (21.5–28.0)
Age at first substance use, years	20.3 ± 3.3	20.0 (18.0–22.0)
Age at regular substance use, years	23.8 ± 3.7	23.0 (21.0–26.0)
Main drug: opium	90 (73.2%)	
Main drug: opium residue (shireh)	33 (26.8%)	
Last use method: smoking	73 (59.3%)	
Last use method: inhalation	24 (19.5%)	
Last use method: oral	16 (13.0%)	
Last use method: injection	8 (6.5%)	
Last use method: snorting	2 (1.6%)	

LDQ = Leeds Dependence Questionnaire; BMI = body mass index; injection includes both intravenous and non-intravenous injection routes.

The instrument-specific smoking exposure profile is summarized in Table 2. All participants had a recorded history of vafour use. Nearly all participants had a history of gholgholi use, whereas sikhi use was less frequent but still common (78.9% for monthly exposure and 81.3% for daily exposure). Vafour exposure showed the highest duration both in cumulative monthly exposure and in daily exposure time.

Table 2. Instrument-specific opium smoking exposure profile among participants with opioid dependence (n = 123).

Exposure variable	Exposed, n (%)	Mean ± SD	Median (IQR)	Range
Total smoking duration, months	123 (100.0%)	162.5 ± 77.0	156.0 (98.0–204.0)	24.0–384.0
Vafour monthly duration, months	123 (100.0%)	95.4 ± 70.2	72.0 (48.0–120.0)	12.0–384.0
Gholgholi monthly duration, months	120 (97.6%)	47.7 ± 33.8	48.0 (24.0–60.0)	0.0–236.0
Sikhi monthly duration, months	97 (78.9%)	19.3 ± 17.6	12.0 (6.0–24.0)	0.0–120.0
Vafour daily duration, min/day	123 (100.0%)	174.6 ± 52.3	180.0 (137.5–210.0)	60.0–300.0
Gholgholi daily duration, min/day	120 (97.6%)	122.0 ± 45.4	120.0 (90.0–150.0)	0.0–240.0
Sikhi daily duration, min/day	100 (81.3%)	65.9 ± 41.9	60.0 (45.0–90.0)	0.0–180.0

Monthly durations are expressed in months. Daily durations are expressed in minutes/day. Percentages for exposure prevalence were calculated as the proportion with values greater than zero. Vafour: traditional opium pipe; gholgholi: opium water-pipe method; sikhi/sikh-o-sang: heated rod method.

To quantify integrated cervical neuromusculoskeletal dysfunction, a composite ICND index was created from seven standardized components. The direction of each component was aligned so that higher ICND values indicated more severe integrated dysfunction. The components and internal-consistency checks are shown in Table 3. Cronbach's alpha was acceptable, and the first principal component was almost perfectly correlated with the z-mean ICND index; therefore, the z-mean index was retained for interpretability.

Table 3. Construction and internal-consistency checks of the Integrated Cervical Neuromusculoskeletal Dysfunction (ICND) index.

Component or check	Definition, orientation, or value
VAS	Higher values indicate more severe pain
NDItotal	Higher values indicate greater neck disability
NordicNeck	Higher values indicate greater neck symptom burden
Kyphosis	Higher values indicate greater thoracic kyphosis
FHP (reverse-coded)	Lower craniovertebral angle indicates greater forward head posture
ROM_total (reverse-coded)	Lower total cervical range of motion indicates greater dysfunction

Force_total (reverse-coded)	Lower total neck muscle force indicates greater dysfunction
Cronbach's alpha for the seven standardized components	0.717
Variance explained by the first principal component	37.5%
Correlation between PCA component 1 and z-mean ICND index	r = 0.997

ICND was calculated as the mean of standardized component scores. Variables marked as reverse-coded were multiplied by -1 before standardization so that higher scores consistently represented greater dysfunction.

The cervical neuromusculoskeletal profile of the opioid-dependent participants is shown in Table 4. On average, participants had moderate neck pain and neck disability, increased thoracic kyphosis, reduced forward head posture angle, and measurable impairment in cervical range of motion and neck muscle force.

Table 4. Cervical neuromusculoskeletal characteristics of participants with opioid dependence (n = 123).

Variable	Mean ± SD	Median (IQR)	Range
Pain intensity (VAS)	5.84 ± 0.50	5.85 (5.53–6.15)	4.00–7.15
Neck Disability Index total score	19.57 ± 4.83	19.00 (16.00–23.00)	10.00–31.00
Nordic neck symptom score	2.76 ± 1.07	3.00 (2.00–3.00)	0.00–5.00
Nordic total symptom score	18.02 ± 6.61	17.00 (14.00–19.50)	7.00–54.00
Forward head posture angle	47.16 ± 1.39	47.50 (46.50–48.00)	42.50–51.00
Thoracic kyphosis angle	50.04 ± 1.45	50.00 (49.00–51.00)	46.50–53.50
Total cervical ROM	299.88 ± 10.79	300.50 (292.25–305.50)	267.00–330.50
Total neck muscle force	17.26 ± 0.84	17.10 (16.70–18.02)	15.10–19.20
ICND z-mean index	0.00 ± 0.61	-0.07 (-0.42–0.40)	-1.74–1.76

VAS = visual analogue scale; NDI = Neck Disability Index; ROM = range of motion; ICND = Integrated Cervical Neuromusculoskeletal Dysfunction index. Lower FHP angle indicates greater forward head posture.

Spearman correlation analyses showed that the ICND index was positively associated with total smoking duration, vafour daily duration, vafour monthly duration, gholgholi daily duration, gholgholi monthly duration, LDQ total score, and sikhi monthly duration (Table 5). The strongest correlations were observed for total smoking duration and vafour daily duration. Cigarette smoking was not significantly associated with the ICND index.

Table 5. Spearman correlations between smoking-related exposures and the ICND index.

Exposure variable	Spearman's rho	p-value	BH-adjusted q-value
Total smoking duration	0.564	<0.001	<0.001
Vafour daily duration	0.560	<0.001	<0.001
Vafour monthly duration	0.481	<0.001	<0.001
Gholgholi daily duration	0.428	<0.001	<0.001
Gholgholi monthly duration	0.302	<0.001	0.002
LDQ total score	0.235	0.009	0.022
Sikhi monthly duration	0.217	0.016	0.033
Sikhi daily duration	0.183	0.043	0.085
Cigarette smoking	0.109	0.231	0.311

BH-adjusted q-values were calculated using the Benjamini–Hochberg procedure across the full exposure-by-outcome correlation grid. ICND = Integrated Cervical Neuromusculoskeletal Dysfunction index; LDQ = Leeds Dependence Questionnaire.

In the multivariable monthly exposure model, the ICND index was regressed on monthly exposure durations for vafour, gholgholi, and sikhi, with adjustment for age, BMI, sex, cigarette smoking, and LDQ total score. As shown in Table 6, the model was statistically significant and explained 37.9% of the variance in ICND (adjusted $R^2 = 0.336$, model $p < 0.001$). After adjustment, vafour monthly duration remained an independent predictor of higher ICND scores, whereas gholgholi and sikhi monthly durations were not independently associated with ICND.

Table 6. Multivariable linear regression model for the association between monthly instrument-specific smoking exposure and ICND.

Predictor	Standardized β	95% CI	p-value
Age	0.340	0.088 to 0.592	0.008
BMI	-0.092	-0.237 to 0.053	0.213
Sex	0.029	-0.108 to 0.166	0.680
Cigarette smoking	0.072	-0.101 to 0.246	0.414
LDQ total score	0.095	-0.071 to 0.261	0.260
Vafour monthly duration	0.295	0.068 to 0.523	0.011
Gholgholi monthly duration	-0.013	-0.304 to 0.278	0.929
Sikhi monthly duration	0.088	-0.099 to 0.274	0.357

Outcome: ICND z-mean index. Monthly instrument-specific durations were log1p-transformed before standardization. β coefficients are standardized coefficients estimated using HC3 robust standard errors.

In the multivariable daily exposure model, daily durations of vafour, gholgholi, and sikhi use were entered with the same covariates. As shown in Table 7, this model explained 44.3% of the variance in ICND (adjusted $R^2 = 0.404$, model $p < 0.001$). Vafour daily duration was the strongest independent predictor of ICND. In contrast, gholgholi daily duration, sikhi daily duration, cigarette smoking, and LDQ total score were not independent predictors in the fully adjusted model.

Table 7. Multivariable linear regression model for the association between daily instrument-specific smoking exposure and ICND.

Predictor	Standardized β	95% CI	p-value
Age	0.363	0.188 to 0.537	<0.001
BMI	-0.146	-0.284 to -0.008	0.038
Sex	-0.013	-0.133 to 0.107	0.830
Cigarette smoking	0.054	-0.093 to 0.201	0.468
LDQ total score	-0.010	-0.157 to 0.136	0.890
Vafour daily duration	0.394	0.238 to 0.550	<0.001
Gholgholi daily duration	-0.093	-0.339 to 0.153	0.460
Sikhi daily duration	-0.002	-0.152 to 0.147	0.975

Outcome: ICND z-mean index. Daily instrument-specific durations were log1p-transformed before standardization. β coefficients are standardized coefficients estimated using HC3 robust standard errors.

Secondary adjusted analyses were conducted to examine whether instrument-specific exposure variables were associated with individual neuromusculoskeletal outcomes. Sixteen exploratory models were fitted, and only statistically significant instrument-specific exposure terms are displayed in Tables 8a and 8b for readability. Vafour monthly duration was independently associated with lower total cervical ROM and lower total neck muscle force. Sikhi monthly duration was associated with a higher Nordic total symptom score. In the daily exposure model, vafour daily duration was associated with higher pain intensity, lower FHP angle, higher kyphosis, lower total cervical ROM, and lower total neck muscle force.

Table 8a. Significant adjusted associations between monthly instrument-specific smoking exposure and individual neuromusculoskeletal outcomes.

Model	Outcome	Instrument-specific predictor	Standardized β	95% CI	p-value	Model R^2

Monthly exposure model	NordicTOTAL	Sikhi monthly duration	0.255	0.055 to 0.455	0.012	0.168
Monthly exposure model	ROM_total	Vafour monthly duration	-0.412	-0.647 to -0.178	<0.001	0.243
Monthly exposure model	Force_total	Vafour monthly duration	-0.447	-0.705 to -0.189	<0.001	0.235

Table 8b. Significant adjusted associations between daily instrument-specific smoking exposure and individual neuromusculoskeletal outcomes.

Model	Outcome	Instrument-specific predictor	Standardized β	95% CI	p-value	Model R^2
Daily exposure model	VAS	Vafour daily duration	0.231	0.011 to 0.450	0.039	0.307
Daily exposure model	FHP	Vafour daily duration	-0.294	-0.589 to -0.000	0.050	0.160
Daily exposure model	Kyphosis	Vafour daily duration	0.241	0.045 to 0.437	0.016	0.294
Daily exposure model	ROM_total	Vafour daily duration	-0.347	-0.550 to -0.143	<0.001	0.268
Daily exposure model	Force_total	Vafour daily duration	-0.282	-0.470 to -0.094	0.003	0.202

Only instrument-specific exposure predictors with $p < 0.05$ are shown in Tables 8a and 8b. Each model was adjusted for age, BMI, sex, cigarette smoking, and LDQ total score. Instrument-specific durations were log1p-transformed before standardization. FHP = forward head posture angle; ROM = range of motion. These secondary models were exploratory; no multiplicity adjustment was applied, and the findings should be interpreted as hypothesis-generating.

Overall, these analyses indicate that among people with opioid dependence, instrument-specific exposure to opium smoking was associated with integrated cervical neuromusculoskeletal dysfunction. Across both correlation and adjusted regression analyses, vafour exposure—particularly daily duration of use—showed the most consistent and strongest relationship with worse ICND scores. This pattern remained evident after adjustment for age, BMI, sex, cigarette smoking, and dependence severity.

Discussion

The present study suggests that the physical context of opium smoking may be clinically relevant beyond opioid dependence itself. Among 123 people with opioid dependence, both cumulative and typical daily exposure to vafour were independently associated with a worse Integrated Cervical Neuromusculoskeletal Dysfunction Index (ICND). The daily-exposure model explained 44.3% of the variance in ICND, and daily vafour exposure was its strongest modifiable predictor. Component-level analyses supported this pattern: longer daily vafour exposure was associated with greater pain, smaller craniovertebral angle, greater thoracic kyphosis, lower cervical range of motion, and reduced neck-muscle force. By contrast, gholgholi and sikh-o-sang exposure did not remain independently associated with the primary composite outcome after adjustment.

These findings extend previous publications from the same doctoral research program. Earlier analyses showed that chronic opium smokers had lower cervical range of motion and neck-muscle strength, more neck pain and disability, greater forward head posture (FHP), thoracic hyperkyphosis, sway-back posture, and regional musculoskeletal symptoms (14-16, 18). A study of heroin users undergoing methadone-assisted withdrawal also reported frequent musculoskeletal pain and FHP (17). Unlike those earlier reports, this analysis used ICND as a multidimensional composite and examined instrument-specific exposure within the opioid-dependent group. The results therefore suggest that cervical dysfunction among opium smokers may be linked not only to opioid dependence as a clinical condition, but also to the behavioral and postural circumstances of smoking.

The stronger association for vafour is biomechanically plausible, although the mechanism was not measured directly. Vafour smoking often requires prolonged sitting, forward orientation of the head and trunk, visual focus toward the pipe bowl, and maintenance of a constrained upper-body posture. Awkward, static, or restricted postures are recognized contributors to musculoskeletal symptoms, particularly when repeated over long periods (33-36). Static positioning may increase low-level cervical and scapular muscle activation, reduce recovery time, and promote fatigue or altered motor control. Inflammatory and nociceptive pathways have also been proposed in relation to long-term static posture exposure (37). Thus, the present findings support a hypothesis of cumulative postural loading, not a causal claim that vafour use directly produces cervical dysfunction.

Evidence from other populations exposed to sustained non-neutral head-neck positions provides useful analogues. Dentists have a high occupational burden of neck disorders and may show altered neck mobility and somatosensory function (38). Smartphone-related studies have linked higher problematic use with forward cervical posture, reduced extensor endurance, altered joint-position sense, and changes in cervical mobility (39). In office workers, neck disability appears to reflect combined ergonomic, physical, and individual factors rather than a single postural variable (40). These populations differ from opium smokers, but they illustrate a shared principle: repeated activities that constrain the head and neck may be associated with a multidimensional pattern of symptoms, postural adaptation, mobility restriction, and impaired muscle performance.

The component findings are consistent with recognized links between thoracic alignment, cervical posture, and mobility. Greater thoracic kyphosis has been associated with more forward head position and reduced cervical range of motion in older adults (41). Similarly, in this study, longer daily vafour exposure was associated with greater kyphosis, smaller craniovertebral angle, and lower total ROM. However, posture and pain should not be treated as interchangeable constructs. A systematic review found an association between FHP and neck pain or disability in adults, but also reported heterogeneity by age and study methods (11). Other studies have linked head posture, deep cervical flexor performance, pain, and disability (42, 43), but these relationships vary across populations. Therefore, the language of association is more appropriate than causal attribution.

Reduced neck-muscle force was another important element of the observed pattern. A systematic review concluded that individuals with chronic neck pain generally have lower cervical strength than asymptomatic controls (44), which is compatible with the present association between vafour exposure and lower total neck-muscle force. Possible explanations include fatigue from sustained low-load activation, pain-related inhibition, movement avoidance, and deconditioning. Conversely, lower strength may precede symptoms or reflect broader health and activity patterns. A 16-year prospective study found that baseline cervical strength and mobility were not straightforward predictors of future neck pain or disability (45), reinforcing the need for cautious interpretation.

The absence of independent associations for gholgholi and sikh-o-sang should not be interpreted as evidence that these methods are ergonomically harmless. Vafour was the most prevalent and longest exposure, providing greater variability and statistical power. Participants also commonly reported more than one instrument, and self-reported minutes or months cannot fully capture posture, movement variability, session frequency, or recovery periods. Interaction and combined-use effects were not tested in this secondary analysis and should be examined in larger instrument-specific studies. The exploratory association between monthly sikh-o-sang exposure and total Nordic symptoms may reflect broader spinal or upper-limb loading, but this requires replication with direct posture and task analysis.

Dependence severity correlated with ICND in bivariate analysis but was not significant after instrument-specific exposure and covariates were entered. This attenuation may be meaningful because the Leeds Dependence Questionnaire reflects psychological dependence, salience, compulsion, and impaired control, whereas instrument-specific variables more closely approximate exposure to a physically demanding task. Daily cigarette use was also not independently associated with ICND, indicating only that cigarette quantity did not explain variation in this cervical composite within the adjusted models. Age remained an independent predictor, consistent with the multifactorial nature of neck pain and disability (46). The small inverse BMI association in one model should be interpreted cautiously because BMI was restricted and narrowly distributed.

The ICND was developed to summarize cervical dysfunction as a multidimensional construct. Standardized *z* scores allow measures with different units to be combined on a common metric (47), and composite outcomes can reduce fragmentation across correlated endpoints when transparently defined (48, 49). In this dataset, acceptable internal consistency and near-equivalence with the first principal-component score supported the empirical coherence of the equal-weight ICND. Nevertheless, the ICND remains a study-derived analytical index, not a validated clinical scale. It has no established diagnostic threshold, minimal clinically important difference, construct validity, convergent validity, discriminant validity, or responsiveness to change. External validation is required before clinical use or between-study comparison.

These findings have potential implications for addiction treatment and rehabilitation. Routine care for opioid dependence usually prioritizes withdrawal, craving, psychiatric comorbidity, infection, overdose, and social functioning. For chronic opium smokers, brief musculoskeletal screening and questions about smoking posture and instrument use may identify an additional source of disability. Ergonomic counseling, interruption of prolonged static sitting, and individualized exercise may be reasonable adjuncts, although intervention efficacy cannot be inferred from this observational study. Evidence supports deep cervical flexor training for selected physiological impairments (50), while broader reviews indicate that several structured exercise approaches can reduce chronic neck pain and disability (51). Future studies should use video analysis, wearable sensors, electromyography, and repeated assessments to clarify whether exposure precedes deterioration in ICND and whether targeted interventions improve outcomes.

This study has several strengths, including its focus on a rarely investigated physical consequence of opioid dependence, separation of exposure by smoking instrument, integration of patient-reported and biomechanical outcomes, and use of adjusted models with robust standard errors. Limitations include the cross-sectional design, recall bias due to self-reported lifetime and daily exposure duration, lack of objective verification of smoking posture or duration, co-use of multiple instruments, predominantly male treatment-based recruitment from Tehran, which limits generalisability to women, non-treatment-seeking populations, and other geographic or cultural settings, limited adjustment for occupation, physical activity, sleep, psychosocial distress, housing status, and prior injury, and the exploratory nature of component-level analyses. The secondary models were not multiplicity-adjusted and should therefore be interpreted as hypothesis-generating. Finally, the ICND was developed and evaluated in the same sample; external validation is required before clinical or between-study use.

Conclusion

This study extends previous work on the musculoskeletal consequences of chronic opium smoking by showing that cervical dysfunction may vary according to smoking instrument and exposure duration. Among the methods examined, vafour showed the most consistent association with ICND; both cumulative and daily vafour exposure were independently associated with a more unfavorable multidimensional cervical profile after adjustment for age, sex, body mass index, cigarette consumption, and dependence severity.

These findings support the clinical relevance of assessing smoking posture and instrument-specific exposure in people with long-term opioid dependence. The ICND provided a useful analytical summary of interrelated cervical outcomes, although it should currently be regarded as a study-derived composite rather than a validated diagnostic measure. Because the cross-sectional design precludes causal inference, prospective studies with direct posture measurement and longitudinal assessment are needed. Nevertheless, musculoskeletal screening, ergonomic counseling, and targeted physical rehabilitation may represent valuable adjuncts to addiction treatment and harm-reduction services for chronic opium smokers.

Ethical Considerations

Compliance with ethical guidelines

The parent study was approved by the Ethics Committee of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran (IR.USWR.REC.1398.120). All participants provided written informed consent. The present manuscript reports a distinct secondary analysis of data collected for the PhD thesis of the first author.

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Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

Conceptualization: Amir Masoud Arab and Omid Massah; Secondary design for secondary analysis of data: Omid Massah; Redefining new indicators and concepts: Amir Masoud Arab and Omid Massah; Drafting, Writing, and Editing: All authors; All authors approve the final content and are accountable for the results.

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