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Ergonomic Risk Assessment of Kitchen Workers: Cornell Musculoskeletal Discomfort Questionnaire and Manual Lifting Analysis

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ABSTRACT

Aims: This study provides a comprehensive ergonomic assessment in a kitchen, combining subjective and objective measures.

Method and Materials: In this cross-sectional study, kitchen staff completed the Farsi version of the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). Hierarchical Task Analysis (HTA) broke down tasks to identify key physical demands. Manual handling tasks were evaluated using the National Institute for Occupational Safety and Health (NIOSH), the Washington Industrial Safety and Health Act (WISHA), the Key Indicator Methods (KIM), and the Manual Handling Assessment (MAC). Cohen's Kappa (κ) assessed inter-method agreement.

Findings: The CMDQ revealed the highest discomfort in the lower back region (11.33 ± 8.38) and right shoulder (11.00 ± 5.62). Objective tools identified several tasks as high risk: the Rice Cook's handling of 50kg rice containers (NIOSH Lifting Index (LI)=3.4; KIM Score=56, Risk Level 3) and 40kg rice strainers (NIOSH LI=5.48; KIM Score=132, Risk Level 4), and the Stew Cook's preparation of food in 30kg pans (NIOSH LI=3.56; KIM Score=41, Risk Level 2). Inter-method agreement (κ) was moderate to good between WISHA and NIOSH (κ=0.4942) and between MAC and KIM (κ=0.5170). NIOSH showed fair agreement with KIM (κ=0.2540) and slight agreement with MAC (κ=0.1960). WISHA's agreement with MAC and KIM was very subtle (κ=0.0837 and κ=0.1143, respectively).

Conclusion: kitchen tasks pose significant ergonomic risks, aligning with reported lumbar and shoulder discomfort. The varied agreement among MMH tools emphasizes the value of a multi-method approach for comprehensive risk assessment. Ergonomic interventions like load reduction and workstation adjustments are recommended.

Keywords: Musculoskeletal disorders, Lifting, National Institute for Occupational Safety and Health (NIOSH), Ergonomics

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Introduction

Cooking in institutional kitchens entails preparing large volumes of food under tight deadlines, imposing both physical and mental demands that lead to high rates of Work-Related Musculoskeletal Disorders (WRMSDs) among cooks [1-3]. These disorders reduce productivity, increase absenteeism, and healthcare costs [4-6]. Poor posture, reported in 76% of Iranian workers, is a key contributor to WRMSDs [7].

Cooks endure prolonged standing, repetitive motions, and handling heavy loads, all of which increase the risk of Low Back Pain (LBP) and other musculoskeletal issues [8]. Previous studies confirm these hazards, identifying significant risk factors in hospital kitchens [9], high LBP prevalence among food-industry workers [10], and classifying many food preparation tasks as high-risk [3, 11]

This study employs Hierarchical Task Analysis (HTA) (Figure 1)to break down kitchen tasks and identify hazards [12]. It uses the validated Farsi version of the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) to measure symptom frequency and severity [13, 14]. Between 2010 and 2020, manual-handling assessments in Iran frequently used National Institute for Occupational Safety and Health (NIOSH), Key Indicator Methods (KIM), 3D Static Strength Prediction Program (3DSSPP), Liberty Mutual Material Handling Tables (SNOOK Tables), Washington Industrial Safety and Health Act (WISHA), and Manual Handling Assessment (MAC) methods to quantify ergonomic risks in demanding settings like institutional kitchens [15].

The WISHA Lifting Calculator assesses manual lifting by scoring load weight, frequency, vertical distance, and posture, flagging tasks above risk thresholds [16]. NIOSH's Lifting Equation computes a Recommended Weight Limit (RWL) and Lifting Index (LI > 1 indicates risk) based on geometric and task parameters [17]. KIM evaluates repetitive manual handling by scoring force, posture, frequency, and duration to yield an overall risk level [18]. MAC uses color-coded charts of load, posture, and frequency to rapidly identify risk in dynamic environments [19].

This study will assess on-site manual handling among kitchen cooks in Tehran, integrating HTA, the Farsi CMDQ, and multiple ergonomic tools (NIOSH, WISHA, KIM, MAC, SNOOK) to comprehensively evaluate physical strain and inform interventions for reducing WRMSDs.

Method and Materials

This descriptive, observational, cross-sectional study was conducted over two weeks on full-time kitchen staff working 8 hours/day, 6 days per week. Jobs were analyzed into tasks and subtasks using the HTA method.

After identifying the body part with the highest CMDQ score in SPSS 27, manual handling conditions were evaluated using observational tools, including the WISHA Lifting Calculator, NIOSH Lifting Equation, MAC, and KIM.

To quantify the correlation between the risk scores from these four methods, Cohen's kappa coefficient (κ) was calculated in SPSS 27. The analysis used LI values for WISHA and NIOSH and total score values for MAC and KIM. The observed WISHA LI was calculated as the recorded load divided by the permissible weight. All numeric metrics were then coded into low, moderate, or high ordinal risk categories based on established cut-points(Eynipour et al.'s method [20]):

WISHA: Risk was categorized as low risk for an LI < 1, moderate risk for 1≤LI<1.5, and high risk for LI≥1.5.

NIOSH: Risk was categorized as low risk for LI≤1, moderate risk for 1<LI≤3, and high risk for LI>3.

MAC: Risk was categorized as low (0–4), moderate (5–12), and high (13–20).

KIM: Risk was categorized as low (<10), moderate (10–50), and high (≥50).

Findings

Given that the entire population of six full-time kitchen staff was assessed, the CMDQ was used as an initial screening tool to cross-validate against objective measures. The study population consisted of six kitchen staff members, each with at least 1 year of experience. The group was predominantly male (83.3%), with 50% aged 31-40. Notably, none of the participants engaged in regular exercise (100%), half were current smokers, and two-thirds were classified as overweight or obese.

Using HTA, all kitchen tasks were broken down into hierarchical subtasks, and the duration and object weight were recorded for each. As an example, Figure 2 shows the dishwasher HTA, where Plan 0 outlines sub-goals (tasks 1–4) and their corresponding stepwise operations.

According to the CMDQ (Farsi version), the lower back had the highest mean discomfort score (11.33±8.38) reported among the kitchen staff. Following this, other body parts with high discomfort scores included the right shoulder (11.00±5.62), left shoulder (9.67±5.71), right foot (9.00±5.97), and left foot (8.00±5.97). The discomfort scores for the upper back, right wrist, and left wrist were 6.50±5.94, 5.17±7.46, and 4.67±7.73, respectively. In contrast, several body parts reported no discomfort, including both forearms, the hip, and both lower legs.

The agreement in risk categorization between the tools was assessed using Cohen's Kappa (κ), as shown in **Error! Reference source not found.**. A moderate to good agreement was found between WISHA and NIOSH (κ=0.4942) and between MAC and KIM (κ=0.5170). NIOSH showed fair agreement with KIM (κ=0.2540) and slight agreement with MAC (κ=0.1960). The agreement between WISHA and both MAC and KIM was very subtle, though statistically significant.

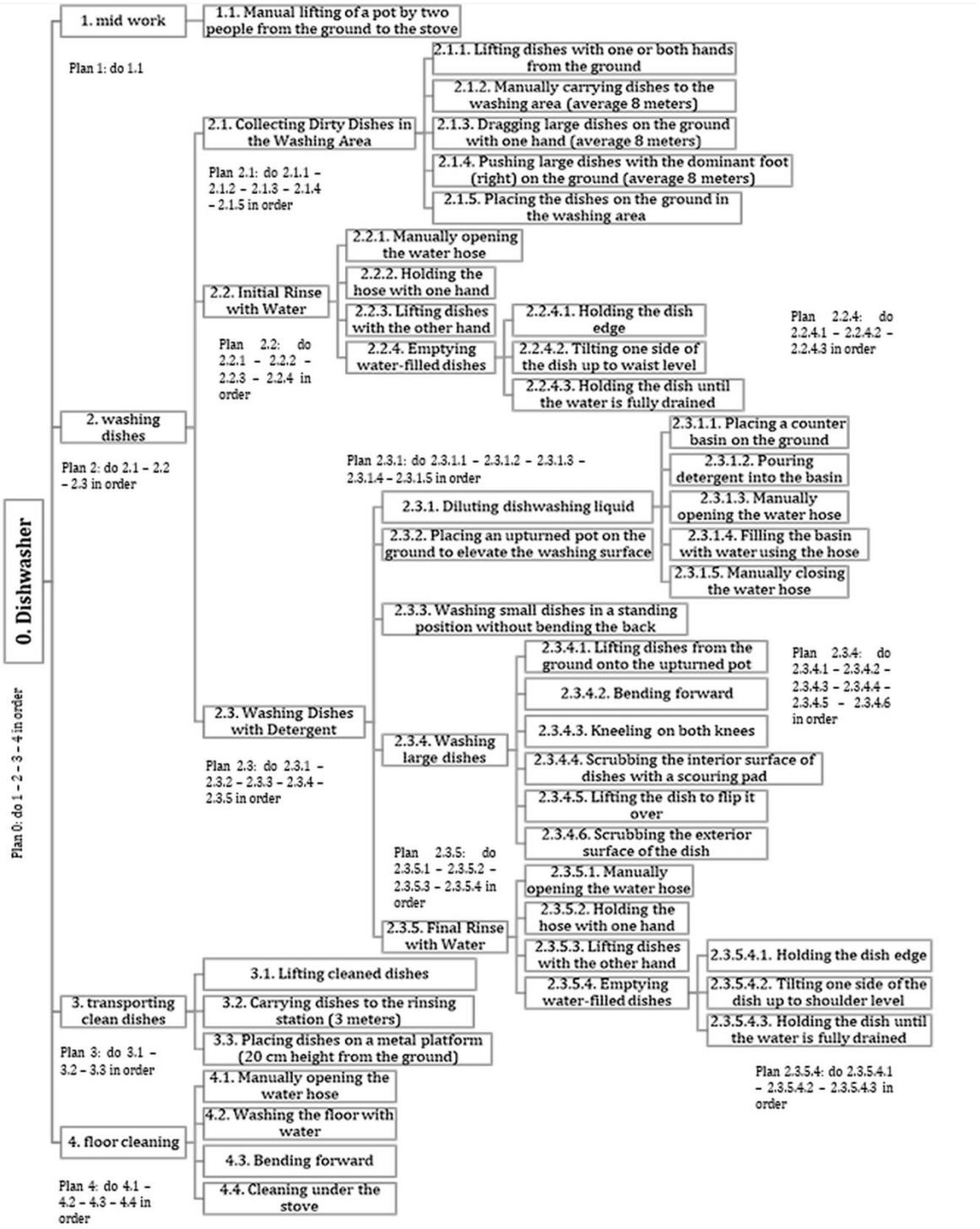


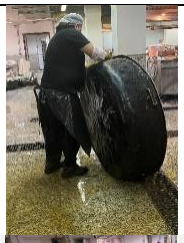
Figure 1) Dishwasher Hierarchical Task Analysis (HTA)

Table 1) Cohen's Kappa (κ) Coefficients for Inter-Method Agreement in Risk Categorization

Pairwise Comparison	Kappa (κ)	p-value	Interpretation of Agreement
WISHA vs. NIOSH LI:	0.4942	< 0.0001	Moderate to Good
WISHA vs. MAC:	0.0837	0.0155	Very Slight
WISHA vs. KIM:	0.1143	0.0039	Very Slight
NIOSH LI vs. MAC:	0.1960	< 0.0001	Slight
NIOSH LI vs. KIM:	0.2540	0.0002	Fair
MAC vs. KIM:	0.5170	< 0.0001	Moderate to Good

As summarized in Table 2, for the dishwasher, washing 14 kg pans was rated as high-risk by NIOSH (LI=1.82 and 1.97) and MAC (Score=14, Red). For the rice cook, handling a 50 kg Rice container and a 40 kg rice strainer yielded high-risk scores across all methods, with NIOSH LIs of 3.4 and 5.48, respectively, and a KIM score of 132 (Risk Level 4) for the strainer task. Serving rice from a 50 kg pot was also identified as high-risk (NIOSH LI=5.58; KIM Score=109). Similarly, the Stew Cook's preparation and serving of food in 30 kg pans were rated as high-risk by NIOSH (LI=3.56 and 3.05) and MAC (Score=16, Red). In contrast, lighter tasks, such as the assistant cook packaging 5 kg baskets, were rated as safe or low-risk.

Table 2) summarizes the results of the manual handling risk assessments

JOB	Task	Photo	Objects (weight-Kg)	NIOSH		WISHA		MAC		KIM	
				RWL	Lifting index	Adjusted weight limit (Kg)	MSD's risk level	Total score	MSDs risk level	Total score	MSDs risk level
Dishwasher	Gathering dirty dishes at the washing station		Pan (14)	8.4	1.66	15.5	Safe	10	A = AMBER	26	2
	Initial washing of dishes with water		Pan (14)	7.7	1.82	13.95	Hazardous	14	R = RED	26	2
			Pan (8)	7.7	1.04	15.5	Safe	10	A = AMBER	23	2
	final washing of dishes with water		Pan (14)	7.1	1.97	13.17	Hazardous	14	R = RED	26	2
			Pan (8)	7.1	1.13	15.5	Safe	10	A = AMBER	23	2
	Moving washed dishes		Pan (14)	8.4	1.66	15.5	Safe	10	A = AMBER	26	2
Rice cook	Retrieving rice from the storage		Rice sack (10)	4.9	2.04	11.1	Safe	11	A = AMBER	48	2

	Rinsing rice		plastic container filled with water and rice (50)	14.7	3.4	28.3	Hazardous	17	R = RED	56	3
	Initial cooking of rice		Aluminum ladle filled with rice (5)	4.3	1.17	11.1	Safe	11	A = AMBER	44	2
			Rice strainer containing rice (40)	7.3	5.48	20.3	Hazardous	19	R = RED	132	4
	Steaming rice		Strainer filled with cooked rice (7)	6.1	1.14	11.1	Safe	8	A = AMBER	47.5	2
	Serving rice		pot containing rice (50)	9	5.58	22.5	Hazardous	18	R = RED	109	4
Stew cook	Frying chicken		Strainer filled with fried chicken (9)	6.7	1.35	15.3	Safe	12	A = AMBER	24	2
	Preparation of cooked food		Pan filled with fried chicken (30)	8.1	3.56	18	Hazardous	16	R = RED	41	2
	Serving launch		Pan filled with fried chicken (30)	9.8	3.05	18	Hazardous	16	R = RED	41	2
Multi-task cook	Preparation of fried eggplant		Tray filled with fried eggplant (10)	7.1	1.41	18	Safe	10	A = AMBER	22.5	2
	Preparing hamburger		Pan lid filled with hamburgers (10)	8.5	1.17	18	Safe	9	A = AMBER	20	2
Assistant cook	Packaging		The basket containing 40 packaging containers (5)	18.8	0.26	31.5	Safe	6	A = AMBER	16.5	1

Discussion

The findings revealed a high rate of discomfort, particularly in the lower back and shoulders, which was consistently validated by the objective risk assessments. For instance, the hazardous scores assigned by NIOSH, MAC, and KIM to the high-load tasks of the rice and stew cooks—such as handling 30-50 kg pans and containers—directly corroborated their self-reported pain. The high incidence of LBP (CMDQ score 11.33 + 8.38) aligns with previous research, such as Mehrparvar's report of a 44.6% in the food industry, confirming the demanding nature of this occupation.

A key aspect of this research was evaluating the inter-method agreement for risk categorization using Cohen's Kappa. The WISHA and NIOSH lifting indices showed moderate-to-good agreement (κ = 0.4942). This level exceeds the "fair agreement" reported by Asadi et al. [21] and may be attributed to our use of a three-tiered risk categorization. The MAC and KIM tools also demonstrated moderate to good agreement (κ=0.5170), consistent with Eynipour's findings and suggesting that these tools converge on similar classifications despite their different methodologies.

Similarly, the agreement between MAC and KIM in the present study was moderate to good (κ = 0.5170). This aligns with Eynipour, who also reported a moderate Kappa value (κ=0.667) for MAC/KIM agreement. This indicates that these tools often converge on similar overall risk classifications, despite MAC's visual nature and KIM's detailed multi-factor input. The NIOSH LI exhibited fair agreement with KIM (κ = 0.2540) in this study. While Rostami et al. [22] reported 71% overall agreement in risk estimates between the two, our "fair" agreement suggests that KIM's broader consideration of factors such as posture, frequency, and duration may lead to divergences in categorization compared to NIOSH's primary focus on biomechanical load.

The present study found only slight agreement between the NIOSH LI and MAC when risk was categorized (κ = 0.1960). This contrasts sharply with the "perfect agreement" (κ = 1.00) reported by Eynipour. The perfect agreement found by Eynipour is unusually high and might be specific to their dataset, whereas our lower, though statistically significant, value suggests more divergence. This discrepancy could be influenced by the distribution of task difficulties in our sample, as noted by Zargarzadeh et al [23], Ergonomic tools may show less consistency for moderately demanding tasks, and Zargarzadeh also characterized MAC as one of the "least conservative" tools, which might lead it to categorize functions at a lower risk level than NIOSH. Finally, the agreements involving the categorized WISHA LI with MAC (κ=0.0837) and KIM (κ=0.1143) were very slight, indicating limited practical concordance despite being statistically significant. This low agreement could again reflect the specific characteristics of the tasks assessed or the "least conservative" nature of the WISHA tool.

Conclusion

This ergonomic assessment confirmed significant musculoskeletal risks among university kitchen workers, with objective tools validating subjective discomfort reports. An analysis of inter-method agreement revealed varied concordance: moderate to good for WISHA/NIOSH (κ=0.4942) and MAC/KIM (κ=0.5170), but only slight to fair for other pairings. This divergence shows that tools weigh risk factors differently, reinforcing the value of a multi-faceted assessment approach. These results provide an evidence base to guide targeted interventions and inform the selection and interpretation of ergonomic tools in similar settings.

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Authors' Contribution

MN, as the Main Researcher, conceived and designed the study, performed the data analysis, and wrote the initial draft of the manuscript. SA as Subsidiary Researcher conducted the Methodology and was responsible for writing the Introduction. OA

supervised the entire project and wrote the Discussion. All authors have read and approved the final version.

Conflicts of Interest

None declared by authors

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Before the study, all participants were provided with a full explanation of the research objectives and procedures. Written informed consent was obtained from each participant, and they were explicitly informed of their right to withdraw from the study at any time without consequence. The methodology was entirely non-invasive, consisting only of standard observational ergonomic assessments and the administration of a validated discomfort questionnaire. To ensure confidentiality, all participant data were anonymized and reported in aggregate, such as mean discomfort scores and demographic percentages.

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