Study on Correlation Between Hotel Cleaners' Musculoskeletal Pain and Cleaning Pose by RULA (Upper Limb Assessment) and MSDs Checklist: Using Hot Spring Hotels and Motels in Taiwan as Examples

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Abstract: Information of hotel cleaners' musculoskeletal pain can be acquired by subjective survey on patients. The ultrasonic waves and X-ray examination can reveal the parts of muscular trauma, bones and joints, and fracture. Medical instruments can recognize the situation musculoskeletal pain and related treatment and recovery will be offered. However, after pain is relieved, hotel cleaners often experience musculoskeletal pain again. Hot Spring Hotels and Motels in employment caused by the cleaners will reduce the manpower supply shortage, the impact of manpower supply chain management (SCM) performance. Hence, it is necessary to find the causes of their musculoskeletal pain. Does cleaning pose cause hotel cleaners' musculoskeletal pain? It is an important research topic. Hence, this study probed into the correlation among hotel cleaners' working pose, force and musculoskeletal pain by RULA (Upper Limb Assessment). The MSDs Checklist revealed the risk factors of cleaning as the reference for medical personnel's diagnosis and treatment. This study treated hot spring hotel and motel cleaners as the subjects. According to the results, based on the correlation between hotel cleaners' musculoskeletal discomfort and RULA, subjective discomfort of neck, body and upper arm is significantly related to score of RULA. A comparison of hot spring hotel and motel cleaners' work situations showed that when cleaning hot spring pools and bathtubs, the scores of different poses in RULA vary significantly. This is due to different designs of hot spring pools of hot spring hotels and Jacuzzis of motels. The cleaners may easily have musculoskeletal discomfort due to excessive force and bad poses. This study suggests using long brushes to improve bad poses and excessive force. According to the analytical result of MSDs, regarding raising mattress and changing bed sheet and bedspread, compared to hot spring hotels, motels are more dangerous. Regarding cleaning of bathtubs and hot spring pools, hot spring hotels are more dangerous than motels. The findings of this study can serve as reference for hotels to improve work process or for medical personnel to enhance diagnosis and treatment.

Keywords: Hot spring hotel and motel cleaners, MSDs checklist, musculoskeletal pain, rapid upper limb assessment (RULA), supply chain management (SCM).

1. INTRODUCTION

Tourists are increasing year by year in Taiwan. Hotel cleaners have heavy and frequent works, and tend to encounter musculoskeletal pain. After they receive medical treatment, and the pain is relieved, with heavy and highly repetitive works, they experience musculoskeletal pain again. Does cleaning pose cause hotel cleaners' musculoskeletal pain? It is an important research topic.

Regarding the research on hotel cleaners' musculoskeletal pain, many scholars have proposed the views. Krause *et al.* [1] investigated room cleaners of hotels in U.S. According to the research, 63% suggested that they had low back discomfort. 43% had neck discomfort and 59% had upper limb discomfort.

NIOSH [2] assessed work process of room cleaners in hotels of the U.S. and developed the statistical result of different studies, such as low back, shoulders and neck and upper limb discomfort.

Frumin *et al.* [3] conducted questionnaire survey on 3564 room cleaners of 87 unions of hotel industry in the U.S. and demonstrated that 32% had body discomfort, 22% had upper limb discomfort and 19% had leg discomfort.

Chyuan *et al.* [4] explored hotel room cleaners' work characteristics and musculoskeletal discomfort. Based on the result, as to musculoskeletal pain, shoulders and neck are the highest (78.8%), the following are wrist/finger (66.2%) and low back (62.6%).

Wu *et al.* [5] studied the risk factors of hotel housekeepers' musculoskeletal situations. The research was based on subjective survey and supported by observation of work and human factor checklist. The findings can help lower housekeepers' occupational musculoskeletal pain.

Chen *et al.* [6] probed into highly frequent hotel cleaners' musculoskeletal discomfort. As to musculoskeletal discomfort in hot spring hotels, low back and waist are 61.11%, shoulders are 60.56% and necks are 53.33%. As to musculoskeletal discomfort in motels, shoulders are 56.8%, low back and waist are 52.8% and necks are 47.20%.

Regarding correlation between hotel cleaners' musculoskeletal pain and cleaning pose, this study will adopt RULA (Upper Limb Assessment) to explore correlation between hotel cleaners' working pose and force and musculoskeletal plain and through MSDs Checklist, it will find the risk factors of cleaning in hotel industry to serve as reference for medical personnel's diagnosis and treatment of musculoskeletal pain.

2. MATERIALS AND METHODS

2.1. Materials

This study selected 12 hot spring hotels and 8 motels in Taiwan with intention to receive the survey in 2010. It included 20 highly frequent room cleaners of hotel industry. It recorded the work process of 5 kinds of housekeeping by videos. Finally, it filled them in RULA and MSDs Checklist [7]. Data of discomfort of musculoskeletal pain were provided by IOSH100-H510 of Institute of Labor, Occupational Safety and Health, Ministry of Labor [7] in 2011. 5 kinds of housekeeping includes raising mattress, changing bed sheet and bedspread, cleaning bathtub and hot spring pool and cleaning sink, wall and toilet.

2.2. Methods

2.2.1. Rapid Upper Limb Assessment (RULA)

By RULA, this study tries to find if hotel cleaners' cleaning pose matches standard human factor engineering. Before using RULA, it recorded cleaners' different cleaning situations and poses by digital video camera and assessed cleaners' force. The researcher calculated and obtained total scores of RULA by checklist and conducted feasible actions. RULA action analysis and calculation principle by McAtamney and Corlett [8, 9]:

A. Arm and wrist analysis of cleaning:

1. Step1 (situation of upper arm)+ Step2 (situation of forearm) + Step3 (situation of wrist pose) + Step4 (twisting of wrist)=Step5(hand and wrist checklist, as shown in Table **A**)

2. Step5 (hand and wrist checklist)+ Step6(score of muscular capacity) + Step7(weight loading) =Step8(scores of hand and wrist)

B. Neck, body and leg analysis of cleaning:

3. Step9 (score of neck pose)+ Step10(score of body pose) + Step11(score of leg) =Step12(checklist of neck, body and leg, as shown in Table **B**)

4. Step12 (scores of neck, body and leg)+ Step13(score of muscular capacity) + Step14(score of leg) =Step15(scores of neck, body and leg)

C. Total score of RULA of cleaning:

By comparing Step8 (calculation of scores of hand and wrist) and Step15 (scores of neck, body and leg) with Table **C**, we obtain total scores. Actions are shown in Table **1**.

In order to compare hot spring hotel and motel cleaners, this study will adopt Mann-Whitney U method (M-W method) to find two samples and their difference. M-W method will be introduced below.

2.2.2. Mann-Whitney U Method (M-W Method)

It is similar to T-test with population and it is suitable for test of two groups of samples (hot spring hotel and motel cleaners. Do they have the same median from the same population? Are they from the same population? Does the population of two samples have the same variance?

Through Mann-Whitney U method, it examines the difference of RULA of hot spring hotel and motel cleaners. M-W method action analysis and calculation principle by Mann and Whitney [10], Fay and Proschan [11] .

2.2.3 MSDs Checklist

We analyze the result of video recording and adopt MSDs Checklist provided by Institute of Labor, Occupational Safety and Health, Ministry of Labor. Through MSDS Checklist, we calculate the risk factors of Table **A**, **B** and **C**. MSDs Checklist method action analysis and calculation principle by Baron *et al.* [12], Armstrong *et al.* [13] and Hagberg *et al.* [14].

3. RESULTS

After data collection and analysis, through RULA, this study will analyze means and action level percentages of two groups of samples (cleaners of hot spring hotels and motels) and correlation and difference between hot spring hotel and motel cleaners' musculoskeletal discomfort and RULA. Means of two groups (hot spring hotel and motel cleaners) are shown in Table **2**. RULA action level percentage is shown in Table **3**. Correlation between hot spring hotel and motel cleaners' musculoskeletal discomfort and RULA is in Tables **4** and **5**. Difference between hot spring hotel and motel cleaners' musculoskeletal discomfort and RULA is in Table **6**. Application result of MSDs Checklist on hot spring hotel and motel cleaners' musculoskeletal discomfort is shown from Tables **7-13**.

4. DISCUSSION

According to result of Table **3**, after comparing action level difference of hot spring hotel and motel cleaners by RULA, this study realizes that regarding raising mattress and changing bed sheet and bedspread, action level of hot spring hotels is (AL2-3) and action level of motels is (AL2-3). As to cleaning of bathtubs and hot spring pools, action level of hot spring hotels is (AL2-3) and action level of motels is (AL2-3). As to cleaning of sink, action level of hot spring hotels is (AL1-2), and that of motels is (AL1-2). As to cleaning of wall, action level of hot spring hotels is (AL1-2) and action level of motels (AL1-2). Regarding cleaning of toilet, action level of hot spring hotels is (AL2) and that of motels is (AL2).

Table 1. Action level of working pose of RULA.

Action Level (AL)	AL1	AL2	AL3	AL4
Total Scores	**1-2**	**3-4**	**5-6**	**7**
Actions	Action level is acceptable	In-depth investigation and improvement if necessary	In-depth investigation and improvement recently	Immediate improvement

McAtamney and Corlett [8,9]

Table 2.   Mean of RULA scores of cleaners' works.

Items of Work	Hotels	1	2	3	4	5	6	7	8	Total Score
		Score of Arm	**Score of Forearm**	**Score of Wrist**	**PART A**	**Score of Neck**	**Score of Body**	**Score of Leg**	**PART B**	**Check-list C**
Raising mattress and changing bed sheet and bed-spread	Motel	3.88	3	3	5.58	3	2.88	2	4.88	5.88
	Hot spring hotel	3.92	3	3	5.25	3	2.92	2	4.92	5.92
Cleaning bathtub and hot spring pool	Motel	2.13	3	2.13	5.13	2.13	2.13	2	3.33	4.25
	Hot spring hotel	2.92	3	2.92	5.92	2.92	2.92	2	3.92	5.83
Cleaning sink	Motel	2.13	1	2	2.13	2.13	2	1	2.1	2.1
	Hot spring hotel	2.1	1	2	2.1	2.1	2	1	2.1	2.1
Cleaning wall	Motel	3.13	1.13	1.13	2.25	2.13	2	1	2.13	2.13
	Hot spring hotel	3.583	1.583	1.583	3.167	2.083	2	1	2.083	2.667
Cleaning toilet	Motel	2.88	2	2	2.88	2.88	2.88	2	4.75	3.88
	Hot spring hotel	2.917	2	2	2.917	2.917	2.917	2	4.833	3.917

Table 3.   RULA action level percentages of hot spring and motel cleaners.

Action Level	Raising Mattress and Changing Bed Sheet and Bedspread		Cleaning Bathtub and HOT Spring Pool		Cleaning Sink		Cleaning Wall		Cleaning Toilet	
	Hot Spring Hotel Cleaners	Motel Cleaners	Hot Spring Hotel Cleaners	Motel Cleaners	Hot Spring Hotel Cleaners	Motel Cleaners	Hot Spring Hotel Cleaners	Motel Cleaners	Hot Spring Hotel Cleaners	Motel Cleaners
(AL1)	0	0	0	0	91.66%	87.5%	91.66%	87.5%	0	0
(AL2)	0	0	16.67%	87.5%	8.34%	12.5%	8.34%	12.5	100%	100%
(AL3)	100%	100%	83.33%	12.5%	0	0	0	0	0	0
(AL4)	0	0	0	0	0	0	0	0	0	0

Table 4.   Correlation between hot spring hotel cleaners' musculoskeletal discomfort and RULA.

| Items of Work | Parts | Result | Statistics of RULA Scores | | Chi-square Test Value | P Value | Significance Level | Test result |
			RULA Value >2	RULA Value >2				Significant Difference
Raising mattress and changing bed sheet and bedspread	Neck	Comfort	1	4	23.76	0.00	*	Yes
		Discomfort	6	1				
	Body	Comfort	0	5	15.09	0.00	*	Yes
		Discomfort	2	5				
	Upper arm	Comfort	0	5	12.75	0.00	*	Yes
		Discomfort	1	6				
Cleaning bathtub and hot spring pool	Neck	Comfort	1	4	14.62	0.0001	*	Yes
		Discomfort	0	7				
	Body	Comfort	1	4	14.62	0.0001	*	Yes
		Discomfort	0	7				
	Upper arm	Comfort	1	4	14.62	0.0001	*	Yes
		Discomfort	0	7				
	Wrist	Comfort	1	3	11.55	0.0007	*	Yes
		Discomfort	1	7				
Cleaning sink	Neck	Comfort	5	0	12.75	0.0004	*	Yes
		Discomfort	6	1				
	Upper arm	Comfort	5	0	12.75	0.0004	*	Yes
		Discomfort	6	1				
Cleaning wall	Neck	Comfort	4	1	14.62	0.0001	*	Yes
		Discomfort	7	0				
Cleaning toilet	Neck	Comfort	0	5	12.75	0.0004	*	Yes
		Discomfort	1	6				
	Body	Comfort	1	4	14.62	0.0001	*	Yes
		Discomfort	0	7				
	Upper arm	Comfort	1	4	14.62	0.0001	*	Yes
		Discomfort	0	7				

Note: *Represents a significant level<0.05

Result of Tables **4** and **5** shows hot spring hotel and motel cleaners' current musculoskeletal discomfort. Based on result of correlation between cleaners' musculoskeletal discomfort and RULA, subjective discomfort of neck, body and upper arm is significantly associated with scores of RULA.

Based on result of Table **6**, regarding difference between hot spring hotel and motel cleaners, this study adopts Mann-Whitney U method and T test and it demonstrates that as to cleaning bathtubs and hot spring pools, two methods show the difference. As to cleaning of wall, T test shows difference and Mann-Whitney U method does not. Finally, as to raising mattress and changing bed sheet and bedspread and cleaning sink and toilet, two methods do not show difference.

According to Tables **7** and **13**, MSDs Checklist shows low scores of risk factors in Table **C**. We thus conduct general assessment by total risk factors of Table **B** and Table **C**. Scores of time/risk factors of Work 1 (Table **A**) are calculated by total working hours of Work 1 in Table **A** /risk factors of Table **A**. Since Work 3~Work 5 do not show any risk factors, we only explore Work 1 and Work 2 in Table **A** and **B** + **C**. As to Work 1 of Table **A** of raising mattress and changing bed sheet and bedspread, this study demonstrates that motels are more dangerous than hot spring hotels.

Table 5.   Correlation between motels cleaners' musculoskeletal discomfort and RULA.

Items of Work	Parts	Result	Statistics of RULA Scores		Chi-square Test Value	P Value	Significance Level	Test Result
			RULA Value >2	RULA Value>2				Significant Difference
Raising mattress and changing bed sheet and bedspread	Neck	Comfort	0	1	16.75	0.00	*	Yes
		Discomfort	1	6				
	Body	Comfort	1	3	16.13	0.00	*	Yes
		Discomfort	1	3				
	Upper arm	Comfort	0	1	16.75	0.00	*	Yes
		Discomfort	1	6				
	Forearm	Comfort	0	2	17.56	0.00	*	Yes
		Discomfort	1	5				
Cleaning bathtub and hot spring pool	Neck	Comfort	1	0	16.75	0.00	*	Yes
		Discomfort	6	1				
	Body	Comfort	4	0	20.42	0.00	*	Yes
		Discomfort	3	1				
	Upper arm	Comfort	1	0	16.75	0.00	*	Yes
		Discomfort	6	1				
Cleaning sink	Neck	Comfort	1	0	16.75	0.00	*	Yes
		Discomfort	6	1				
	Upper arm	Comfort	1	0	16.75	0.00	*	Yes
		Discomfort	6	1				
Cleaning wall	Neck	Comfort	1	0	16.75	0.00	*	Yes
		Discomfort	6	1				
Cleaning toilet	Neck	Comfort	0	1	16.75	0.00	*	Yes
		Discomfort	1	6				
	Body	Comfort	1	3	20.42	0.00	*	Yes
		Discomfort	0	4				
	Upper arm	Comfort	0	1	16.75	0.00	*	Yes
		Discomfort	1	6				

Note: *Represents a significant level<0.05

Table 6.   Difference between hot spring hotel and motel cleaners' cleaning of bathtubs and hot spring pools and RULA.

Items	T Test	P Value	Significance	M-W Method	P Value	Significance
Score of upper arm	-5.498	0.00	Yes	10	0.002	Yes
Score of wrist	-5.270	0.00	Yes	9	0.003	Yes
Score of neck	-5.498	0.00	Yes	10	0.002	Yes
Total score of RULA	-5.270	0.00	Yes	9	0.003	Yes

Table 7.   Basic information analysis of hotel cleaners.

Category		Hot Spring Hotel	Motel
Number of Employees		12	8
Working hours (hours)	Work 1	3.98 hours	3.125 hours
	Work 2	2.42 hours	2.5 hours
	Work 3	1.32 hours	1.875 hours
	Work 4	1.06 hours	1.25 hours
	Work 5	1.21 hours	1.25 hours
	Total working hours	10 hours	10 hours

Table 8.   Table A analysis of hotel cleaners' cleaning.

Table A		Hot Spring Hotel	Motel
Number of Employees		12	8
Scores	Work 1	7.50	9
	Work 2	5.67	4
	Work 3	0	0
	Work 4	0	0
	Work 5	0	0
	Average	13.17	13

Table 9.   Table B analysis of hotel cleaners' cleaning.

Table B		Hot Spring Hotel	Motel
Number of Employees		12	8
Scores	Work 1	6.33	7
	Work 2	3.33	5
	Work 3	0.00	0
	Work 4	0.00	0
	Work 5	0.00	0
	Average	9.67	12

Table 10.   Table C analysis of hotel cleaners' cleaning.

Table C		Hot Spring Hotel	Motel
Number of Employees		12	8
Scores	Work 1	2.67	2
	Work 2	0	0
	Work 3	0	0
	Work 4	0	0
	Work 5	0	0
	Average	2.67	2

Table 11.   Total average of Work 1 of Table B+C.

Total Average of Work 1 of Table B+C		Mean of Category A	Mean of B Category
Number of Employees		**12**	**8**
Scores	Table B Work 1	7	7
	Table C Work 1	2	2
	Total average of Work 1 of Table B+C	9	9

Table 12.   Total average of Work 2 of Table B+C.

Total Average of Work 2 of Table B+C		Mean of Category A	Mean of B Category
Number of Employees		**12**	**8**
Scores	Table B Work 2	3	5
	Table C Work 2	0	0
	Total average of Work 2 of Table B+C	3	5

Table 13.   Total average of Work 1 and 2 in Table A , B and C.

Scores of time/risk factors	Mean of Category A	Mean of B Category
Number of employees	**12**	**8**
Work 1 (Table A)	53.16%	34.72%
Work 2 (Table A)	42.29%	62.5%
Work 1 (Table B +Table C)	46.54%	34.72%
Work 2 (Table B +Table C)	73.56%	50%

As to Work 2 of Table **A** of cleaning bathtub and hot spring, hot spring hotels are more dangerous than motels.

CONCLUSION

Based on analysis of RULA, for motels and hot spring hotels, the work which requires in-depth investigation and improvement is raising mattress and changing bed sheet and bedspread. Action level is (AL2-AL3). As to cleaning bathtub and hot spring pool, action level of motels and hot spring hotels is (AL2-AL3) and it should be further studied. According to correlation between hotel cleaners' musculoskeletal discomfort and RULA, subjective discomfort of neck, body and upper arm is significantly associated with scores of RULA. By comparing hot spring hotel and motel cleaners, we realize that as to cleaning hot spring pool and bathtub, scores of poses of RULA are significantly different. It might be due to different designs of hot spring pool of hot spring hotels hot spring pool and Jacuzzi of motels. The cleaners tend to have excessive force and bad poses and it cause musculoskeletal discomfort. We suggest improving bad poses and excessive force by long brushes.

Based on analysis of MSDs checklist, as to Work 1 of Table **A** of raising mattress and changing bed sheet and bedspread, motels are more dangerous than hot spring hotels. Regarding Work 2 of Table **A** of cleaning bathtub and hot spring pool, hot spring hotels are more dangerous than motels. Based on on-site visit, in highly frequent hotel industry, 2 or 3 sections are arranged for cleaning. As to arrangement of cleaners, each section includes 4~5 cleaners. On average, each cleaner cleans 20~30 rooms, and the workload is higher than common hotels.

This study suggests that when cleaners' salaries are based on cases, long brushes can be used to clean hot spring pool and Jacuzzi. It will avoid the musculoskeletal discomfort of low back and waist. When cleaners receive monthly wages, we suggest that besides long brushes which avoid musculoskeletal discomfort of low back and waist, rest hours or manpower can be increased. As to low back and waist, future researchers can adopt KIM analysis. Findings of this study can serve as reference for improvement of work process in hotels or medical personnel's diagnosis and treatment.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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