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An experimental investigation on postural risks in floor mopping

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MOTIVATION

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- Around **90% of the cleaning professionals' experience musculoskeletal disorders (MSDs).**
- The working **environment**, the ergonomic **design** of the equipment and **posture** adopted by cleaning personnel's greatly **influences the workload.**
- **Control over working environment** while cleaning is **challenging**. Hence, from the designer's perspective, design modifications in tools/equipment are prioritized.
- **Data on precise range of motion (ROM)** of different body joints involved in various cleaning methods are essential for any design modifications.

2021.*Spring-Cleaning-Without-Back-Pain.Jpg*. [image] Available at: <https://atlantaspineinstitute.com/spring-cleaning-without-back-pain/> [Accessed 2 January 2021].

OBJECTIVE

- To investigate the **awkward body posture** adopted in floor mopping by **push and figure-of-eight** methods.

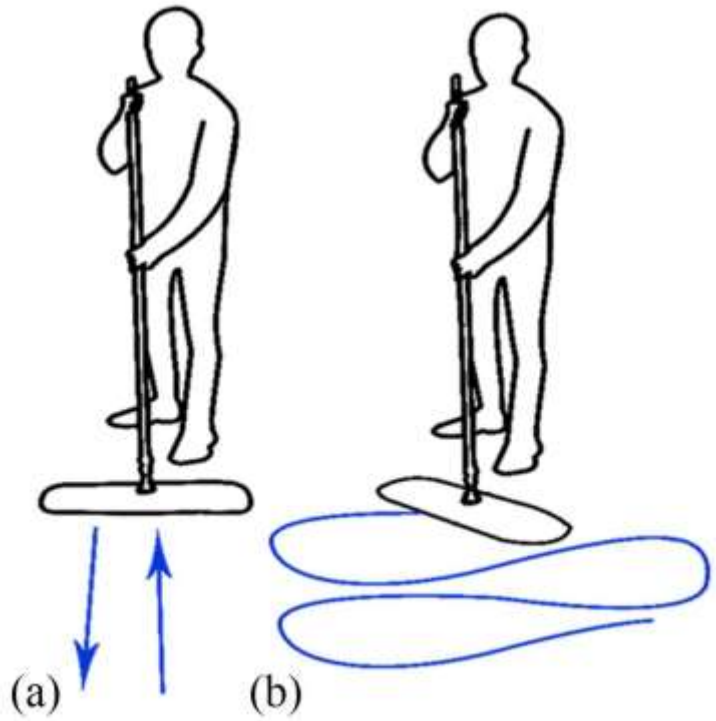

Fig. 1 Mopping methods (a) push (b) figure-of-eight

METHODOLOGY

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- **Experiments were performed under two laboratory set-ups-**

  1. To find the **joint angle variation** of various **hand joints** for Push and figure-of-eight mopping technique using six-dimensional electromagnetic sensors.
  2. To find the **postural risk** using **Rapid Upper Limb Assessment** (RULA) while recording extreme positions of awkward postures involved during mopping through motion cameras.

- **Participants**: **3 mopping professional** each in **5^{th} , 50^{th} and 95^{th} height categories** according to Indian Anthropometry data.

- Demographic and anthropometry data collected

- A **cleaning mop** having straight rod, model Roots EZE, Taara Hygiene Enterprises, India has been used in the mopping tasks.

METHODOLOGY

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Experiment 1: Measurement of hand joint angle variations

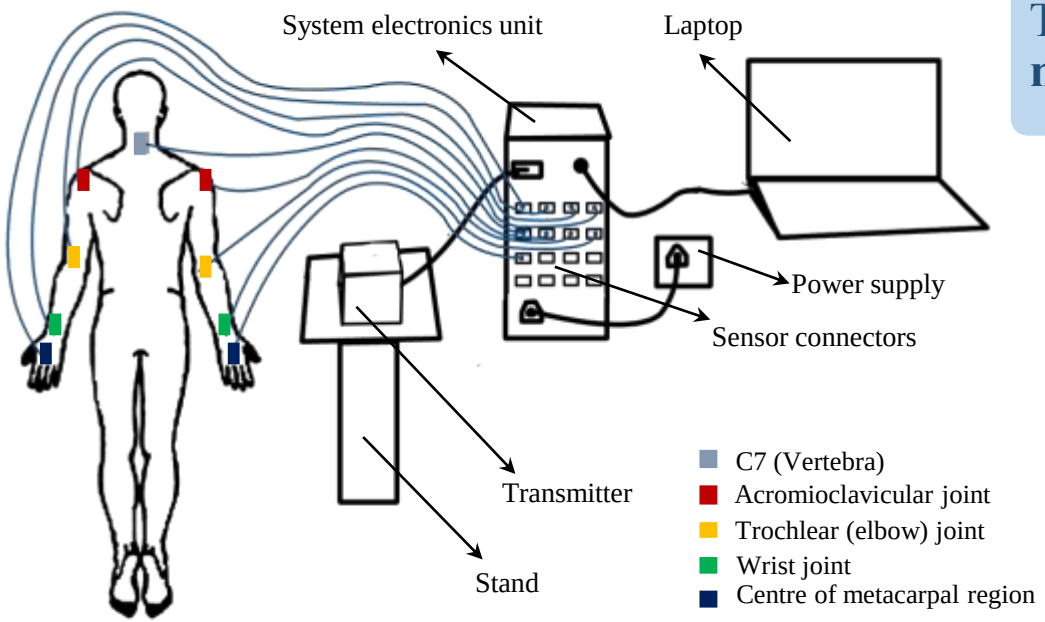

Fig. 2 Equipment setup of ETS showing sensor positions

To avoid electromagnetic interference, **metallic rod replaced** with PVC pipe

10 trials of mopping performed by each participants for **each mopping method**

Continuous positional data of participants **hand joints recorded** using electromagnetic tracking system**(ETS)**.

Positional data **processed in MATLAB** 2016 to **get angular variation** of wrist, elbow and shoulder joint

Maximum and minimum joint angle calculated for all the trials and **mean range of angular variation** was calculated

Experiment 2: Recording dynamic motion during mopping

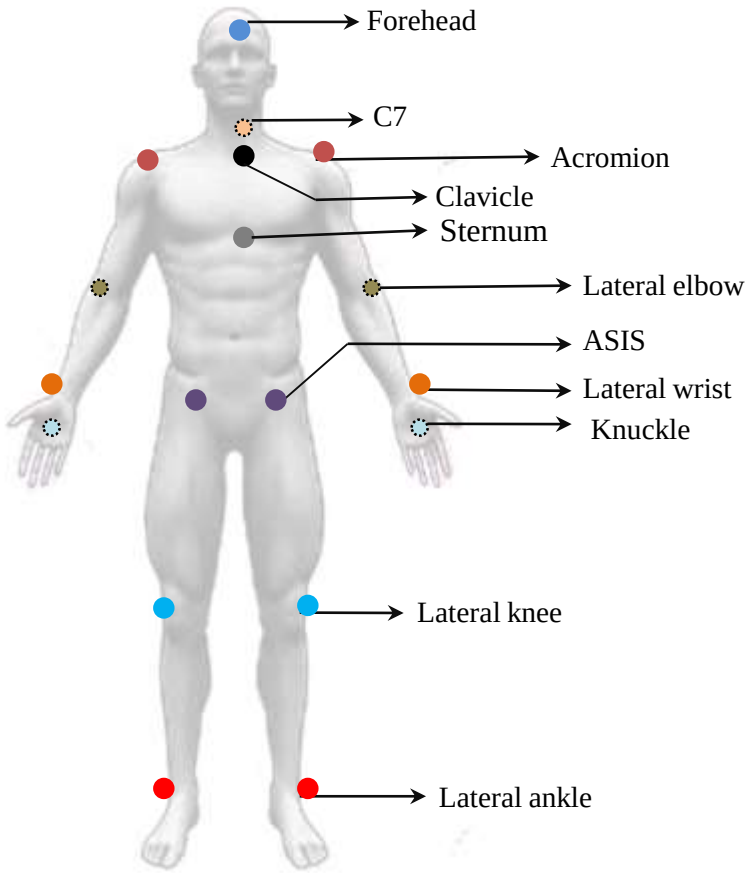

Fig. 3 Placement of retroreflective markers on various landmark of body

Continuous dynamic movement of mopping professional captured in **Optical motion capture laboratory environment**.

18 retroreflective markers mounted on various body anatomical landmarks

Marker movement recorded for **3 trials of mopping in each mopping method**

3D gait model **scaled** to make model **subject specific** and **dynamic motion** of mopping activity **simulated** in OpenSim 4.0 environment

Posture adopted for each trial divided **into 7 prime positions to identify extreme postures**

Mean of maximum RULA score calculated for all the trials and compared

RESULTS AND DISCUSSION

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- **6 out of 9** selected participants were female.

- **Avg. Age:** 23.3 years (±1.699)
  Avg. Height: 1.6m (±0.11)

Table 1 Demographic data of mopping professionals

Variables	Number of participants	Percentage (%)
BMI (kg/m^2)		
<18.5	1	11.11
18.5-25	6	66.66
25-30	2	22.22
Literacy level		
Illiterate	1	11.11
Primary school	4	44.44
High School	4	44.44
Work experience		
≤1 year	1	11.11
1-2 years	3	33.33
2-3 years	4	44.44
3-4 years	1	11.11

RESULTS AND DISCUSSION

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Variation of joint angles

- Angular variation of **wrist** and **shoulder** **joints** in **push mopping** method is **lower** as compared to figure-of-eight method
- **Elbow** joint shows **increased** range of angular variation in **push method** than figure-of-eight
- For the **hand placed at the top of the mop handle**, an **increased** angular range of **wrist and shoulder joints** are observed with an **increase in height** of mopping professionals in **push mopping technique**

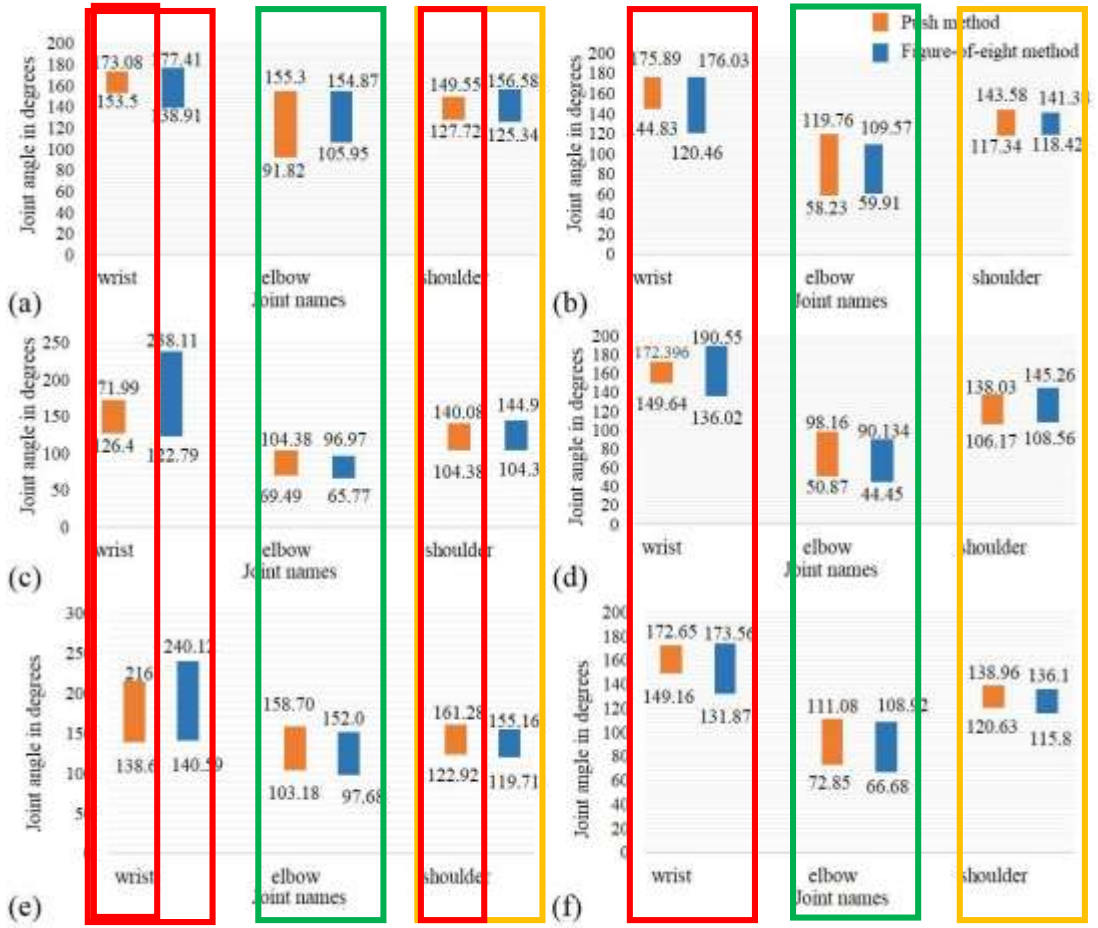

Fig. 4 Range of joint angles of wrist, elbow and shoulder during mopping with participant's hand on (a) (c) (e) upper position and (b) (d) (f) lower position of mop handles respectively for 5th, 50th and 95th percentile heights.

RULA analysis

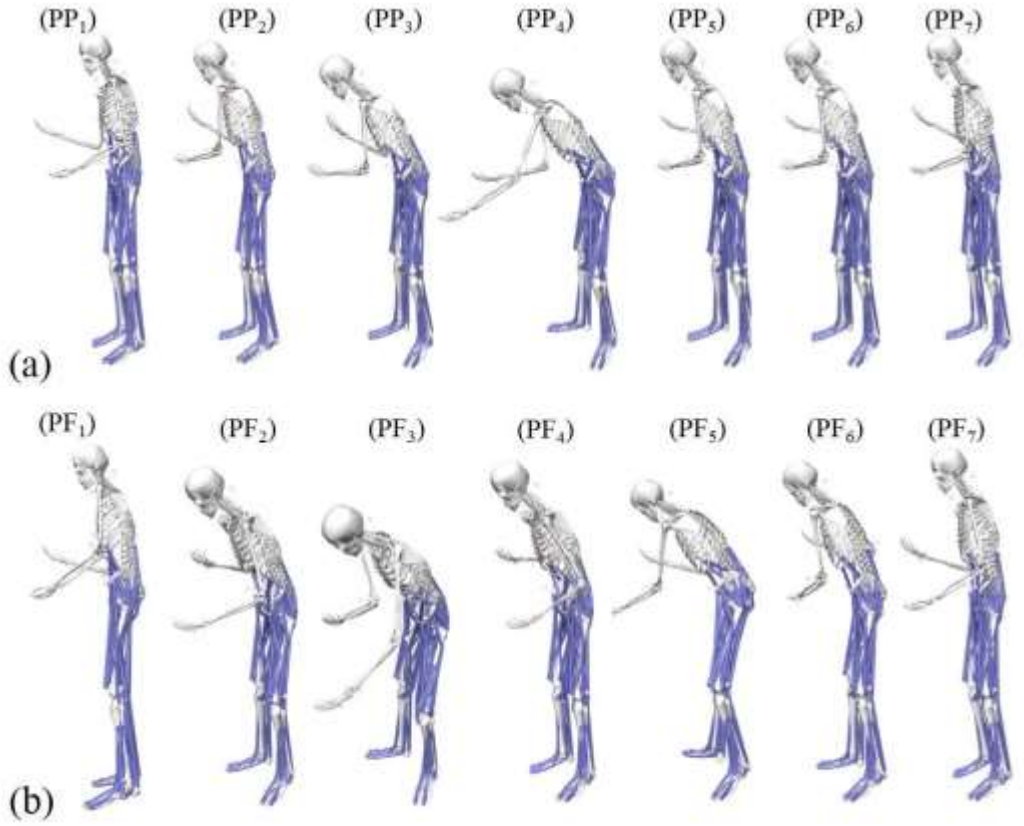

Fig. 5 Array of postures showing the sequential movement in mopping activities using (a) push (PP1 to PP7) and (b) figure-of-eight (PF1 to PF7) methods. (PPi: Posture in push method PFi: Posture in figure-of-eight method; i: index from 1 to 7)

RESULTS AND DISCUSSION

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Table 2 Comparison of RULA score and risk index for participants of height 5th, 50th and 95th percentile performing mopping by push and figure-of-eight methods

Height percentile	**Push method**			**Figure-of-eight method**		
	Mean RULA Score (SD)	Risk Index (SD)	Risk Level	Mean RULA Score (SD)	Risk Index (SD)	Risk Level
5th	4.8 (±0.5)	1.602 (±0.17)	Low to medium	6.6 (±0.58)	2.198 (±0.19)	High to very high
50th	4.6 (±0.55)	1.54 (±0.19)	Low to medium	6.4 (±0.89)	2.13 (±0.295)	High to very high
95th	5.0 (±0)	1.67 (±0)	Medium	6.5 (±0.58)	2.165 (±0.19)	High to very high

- The RULA score for **push technique** lies between 4 to 5: **low to medium risk**
  figure-of-eight lies between 6 to 7: **medium to high risk**
- Highest RULA score in push method (5.0) < Lowest score in figure-of-eight method (6.4): indicating **high risk in figure-of-eight**

CONCLUSION

- This research confirms that **mopping professionals** are **highly susceptible to postural loads / discomfort**
- Result shows **less postural load** in Push mopping technique
- For future investigation, a **swiveling head with an optimum bend** at the top and provision of an **offset at the farthest end of the mop handle** with proper ergonomic mediations are **suggested** to achieve improved posture and lessen risk level in mopping task.

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THANK YOU