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Validity of Upper Limb Risk Assessment Method for Assessing Work-Related Upper Limb Disorders at Workplace

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ABSTRACT

This paper examines the construct validity of the newly developed observational tool called Upper Limb Risk Assessment (UPLIRA) tool for assessing work-related upper limb disorders (WULDs). Hence, this study aims to establish the validity of the UPLIRA tool. The construct validity for the UPLIRA method was verified using the known-groups technique by comparing two different groups of office workers (n = 70) and cashiers' workers (n = 56). The Mann-Whitney test was used to compare the socio-demographic characteristics of these two groups and to evaluate the validity by comparing the questionnaire answers from the respondents. The construct validity shows that statistically significant for the 69% items of UPLIRA ($\rho < 0.05$). It shows that the UPLIRA assessment provided a good indication of work-related upper limb disorders (WULDs) which might be reported as pain or discomfort in the upper body region. These results support that UPLIRA tool is valid instrument to measure exposure risk factors of the WULDs in industrial settings and epidemiological studies.

1. Introduction

Psychometrics properties assessment on the ergonomics measurement method being developed is important to validate the measurement tools to ensure it can be used in ergonomics risk management. Ergonomics measurement method with good psychometric properties value indicates that it can be widely used by researchers [1]. Validity is the property of an instrument that involves the instrument measures what it is designed to measure [2]. This is particularly so in the development of observational methods as the psychometric testing are critical especially in exploring the relationship between ergonomics risk factors and the health effects particularly those involving musculoskeletal disorders (MSDs) [3-5]. Pen and paper observational method is mostly used to assess working postures because there is simple to learn and use [6-8]. There are many existing methods for assessing work-related upper limb disorders (WULDs) however, some of the methods which have been developed are not extensively tested due to infrequent assessment of psychometric studies

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[5,9,10]. Poor characteristic of observational assessment tools due to inadequately tested on its reliability and validity studied contributes to the inconsistent and inaccurate measurements [11]. In addition, the lack of reliable and valid observational assessment tools can lead to significant challenges in ergonomics measurement settings [10,11]. It is essential to prioritize the development and testing of these tools to ensure that they provide accurate and consistent measurements that can inform effective decision-making. Upper Limb Risk Assessment (UPLIRA) method intends to be a comprehensive method, regardless of the weakness or limitations of the previously compared methods, which also pursue the same purpose that is to evaluate WULDs. Therefore, this research paper was to establish the validity of the new technique of the observational method which is called UPLIRA tool during the development process.

2. Methodology

2.1 Upper Limb Risk Assessment (UPLIRA) Tool

The UPLIRA was developed to assess the exposure to risk factors of WULDs in the workplace. The UPLIRA assessment consists of four main risk factors which have been discovered related to upper limb disorders (ULDs) which are physical, psychosocial, work organizational and individual risk factors. The physical risk factors involved the five main body regions such as neck, shoulders, elbows, wrists and back. It has a scoring system and action levels which provide a guide to the level of risk and the need for action to conduct more detailed assessments.

2.2 Study Design and Data Collection

In this study, a new observational method was developed. The validity of UPLIRA method was assessed using construct validity. The construct validity for the UPLIRA method was verified using the known-groups technique by comparing the group of cashier workers to the group of office workers. Differences in results obtained between these groups of workers would demonstrate that they performed different occupational activities [12,13]. Office workers and cashiers normally use their upper body parts during work. The work tasks performed by cashiers include scanning, packaging and handling receipt while office workers performed activities such as key-in data, writing letters, dealing with telephone and email enquiries, creating and maintaining filing systems, scheduling and attending meetings, keeping diaries and arranging appointments. The sample of two occupational groups to assess construct validity was chosen based on the guideline for sample size decision [14]. 56 from a population of 65 workers were chosen as cashiers whereas 70 from a population of 85 of office workers were chosen. The total sample size is 126. According to Gravetter *et al.,* [15], it was stated that a sample size larger than 30 and less than 500 is appropriate for most research. In addition, when samples are broken into sub-samples (different jobs), a minimum sample size of 30 for each category is necessary [15].

Data collection was conducted by the researcher at the subjects' workplace during the workday. Each task was directly observed using the UPLIRA checklist. The observation of the workplace was carried out using a video camera (Nikon Coolpix A100) for recording and capturing tasks of the job. During the assessment, the work parameter assessed including physical factors such as angle of body postures and repetition (neck, shoulders, elbows, wrists and back) were approximately taken from the video recording as well as the workplace environment such as lighting, temperature and noise level. The equipment used in assessing cashiers' and office workers' risk factors includes a weighing scale that was used to measure the weight of the load, goniometer used to measure posture, a lux meter to measure lighting and a sound level meter to measure noise. During recess time, workers

underwent a structured interview using the UPLIRA method. The workers were asked about the psychosocial, work organizational and individual risk factors.

2.3 Data Analysis

The Mann-Whitney test was used to compare the socio-demographic characteristics of these two groups and to evaluate the validity by comparing the questionnaire answers of cashier (n = 56) and office workers (n = 70). The dependent variable in this study is such as neck flexion, neck extension, shoulder extension and others, meanwhile for independent variable are referring to the two different group (the distribution of scores for Group 1 – 'Cashier workers' group and Group 2 – 'Office workers'). The level of significance adopted for statistical significance was ρ < 0.01 [16]. The statistical analysis was performed using Statistical Package for Social Sciences (SPSS) Version 20 and Microsoft Office Excel (Version 2013) database.

3. Results

3.1 Description of the Sample

The known-groups technique of construct validity was used to evaluate two different employee groups (office workers and cashiers). Comparison of sociodemographic characteristics and descriptive analysis of two different groups of office workers (n = 70) and cashiers (n = 56) are shown in Table 1. A significant difference was found between age and working experience (p = 0.001) for both workers in the sectors demonstrating different characteristics regarding age and working experience. The Mann-Whitney test value for gender between cashiers and office workers was p = 0.05 and demonstrated that these two groups had similar characteristics regarding gender. The Mann-Whitney test indicated values of acceptance of the null hypothesis (p-value > 0.01). The majority of participants (51.4%) of office workers were male and female (48.6%) with mean value of 2.93 (SD = 0.709) and age between 20 to 56 years old whereas for cashiers, the majority were female (66.7%) and male (33.3%) with mean value of 2.09 (SD = 0.668) as well as age ranging between 19 to 40 years old. The mean value for working years is 2.34 (SD = 1.214) with 38.6% of office workers to have been working for 6-10 years. Most of the cashiers had lower than 5 years of working experience (77.2%) with mean value of 1.25 (SD = 0.474).

Table 1
Descriptive analysis and comparison of demographic data of the two groups, office workers (n = 70) and cashier workers (n = 56)

Variables	Office Workers (n=70)	Cashier Workers (n=56)	p-value*
	Mean (SD)	Mean (SD)	
Age	2.93 (0.709)	2.09 (0.668)	0.001
Gender: Male (%)	51.4	33.3	0.050
Female (%)	48.6	66.7	
Working Experience (Years)	2.34 (1.214)	1.25 (0.477)	0.001

Note: * Mann-Whitney test

3.2 UPLIRA Final Score and Action Level for Cashier and Office Workers

The result of UPLIRA final score and action level for cashier and office workers shown in Table 2. For cashier sector, about 56 respondents was involved in the analysis of using UPLIRA pen and paper checklist. The tasks involved for cashier were grasping, scanning and sorting items. The results

showed that the minimum final score for cashier task was between 43 and the maximum final score was 50. The highest score with 31 (55.4%) respondents was rated as had low risk level and the range of score are 43-50 while the action level stated that the changes may be needed. Whereas 25 (44.6%) respondents were rated as had medium risk level with the final score was range between 51 and 64 and further investigation required for the action level. For office sector, 70 office workers were recruit. Workers from office areas performed work predominantly in a sitting position, using computers and telephones throughout the day. The minimum of final score for office workers was 34 and the maximum final score was 55. 60 (85.7%) respondents were rated as having low exposure level with range of final score between 34 and 50 and further investigation was required. Another 10 (14.3%) respondents were rated as having medium risk level and change may be needed as suggested for the action level.

Table 2
UPLIRA final score and action level (n = 126)

Exposure Level	Action Level	Cashier Workers (n = 56)			Office Workers (n = 70)		
		Frequency	Percentage (%)	Range of score	Frequency	Percentage (%)	Range of score
Low	Change may be needed	31	55.4	43-50	60	85.7	34-50
Medium	Further investigation required	25	44.6	51-64	10	14.3	51-55
High	Further investigate required urgently	0	0	0	0	0	0

3.3 Comparison between the UPLIRA Scores from Workers in Cashier and Office Sectors

The assessment of construct validity using the known-groups technique included a comparison between cashiers and office workers. This technique consists of identifying differential results during the application of an instrument on contrasting groups [17]. Two distinct groups of employees, office workers and cashiers were compared. The Mann-Whitney test was used to evaluate construct validity comparing the answers in the UPLIRA questionnaires of employees from office workers to cashiers. The level of significance adopted for statistical significance was $p < 0.05$. A high degree of construct validity is obtained when the scores of dissimilar groups are very different on items that are of relevance to one group but not the other [12].

The results in this study demonstrated that most items in the questionnaire were different between the groups. A significance difference was found between these groups with 78% of physical risk factors items. This was expected as physical requirements for cashiers as their tasks are different from those involved in the office. However, shoulders extension, shoulders flexion/extension repetition, shoulders abduction, shoulders abduction/adduction repetition, shoulders medial rotation, shoulders lateral rotation, force repetition, vibration and lighting level obtained similar scores in both groups. Cashiers recorded the angle of 0° to 20° for shoulders extension whereas 61 office workers recorded the same angle during the assessment. Meanwhile, for shoulders flexion/extension repetition, most of the cashiers and office workers recorded a reading of 15-20 repetition of shoulders. Therefore, the value of $p = 0.313$. 54 out of 70 office workers experienced 30° to 90° in shoulders abduction posture compared to cashiers with 40 workers who experienced similar postures angle that led to $p = 0.141$. The same characteristics also contributed to insignificant difference for shoulders abduction/adduction repetition, shoulders medial and lateral rotation, force repetition, vibration and lighting level. The physical risk factors items confirmed the expected results since office workers primarily perform their activities sitting down and the tasks involve writing and

typing. Cashiers however, perform dynamic activities using more range of muscle. These activities often involve scanning items, collecting payment and packaging groceries. Table 3 shows the comparison between the UPLIRA scores from office workers and cashiers in terms of physical risk factors section.

Table 3
Comparison between the UPLIRA scores from office workers (n = 70) and cashier workers (n=56) for physical risk factors section

UPLIRA Items	Sub-items	Office Workers (n=70)	Cashier (n=56)	ρ-value*
		Mean (SD)	Mean (SD)	
A1. Neck	▪ Flexion	2.59 (0.551)	2.45 (0.570)	0.036
	▪ Extension	0.00 (0.000)	1.66 (0.721)	0.000
	▪ Flexion/extension repetition	2.51 (0.583)	2.46 (0.538)	0.003
	▪ Lateral bending	1.13 (0.378)	1.20 (0.401)	0.018
	▪ Lateral bending repetition	1.41 (0.577)	1.63 (0.776)	0.020
	▪ Rotation	2.33 (0.631)	2.25 (0.720)	0.042
	▪ Rotation repetition	2.73 (0.448)	2.59 (0.426)	0.025
A2. Shoulders	▪ Flexion	1.80 (0.604)	2.00 (0.426)	0.030
	▪ Extension	1.13 (0.337)	1.25 (0.437)	0.081
	▪ Flexion/extension repetition	1.63 (0.594)	1.73 (0.587)	0.313
	▪ Abduction	1.91 (0.474)	1.79 (0.494)	0.141
	▪ Adduction	1.93 (0.729)	1.57 (0.568)	0.006
	▪ Abduction/adduction repetition	1.61 (0.666)	1.61 (0.679)	0.922
	▪ Medial rotation	1.87 (0.509)	1.96 (0.538)	0.331
	▪ Lateral rotation	1.84 (0.581)	1.79 (0.706)	0.509
	▪ Medial/Lateral rotation repetition	1.66 (0.657)	1.66 (0.695)	0.036
A3. Elbows	▪ Flexion	1.77 (0.423)	1.88 (0.334)	0.009
	▪ Flexion repetition	1.86 (0.572)	1.82 (0.690)	0.000
	▪ Pronation deviation	1.74 (0.440)	1.64 (0.483)	0.007
	▪ Supination deviation	0.00 (0.000)	1.64 (0.483)	0.000
	▪ Pronation/supination repetition	2.09 (0.654)	2.04 (0.808)	0.043
A4. Wrists	▪ Flexion	2.26 (0.652)	1.80 (0.519)	0.000
	▪ Extension	1.80 (0.604)	2.16 (0.626)	0.002
	▪ Flexion/extension repetition	2.49 (0.654)	2.27 (0.700)	0.011
	▪ Ulnar deviation	2.31 (0.603)	2.29 (0.594)	0.017
	▪ Radial deviation	2.30 (0.622)	2.29 (0.594)	0.010
	▪ Ulnar/radial deviation repetition	2.27 (0.721)	2.46 (0.571)	0.001
A5. Back	▪ Flexion	1.76 (0.523)	1.71 (0.731)	0.014
	▪ Extension	0.00 (0.000)	1.50 (0.539)	0.000
	▪ Flexion/extension repetition	2.59 (0.496)	1.64 (0.616)	0.020
	▪ Lateral bending	1.79 (0.562)	1.32 (0.508)	0.000
	▪ Lateral bending repetition	2.10 (0.783)	1.29 (0.530)	0.000
	▪ Rotation	1.56 (0.629)	2.13 (0.715)	0.000
	▪ Rotation repetition	2.23 (0.641)	2.39 (0.679)	0.022
B. Force	▪ Force	1.00 (0.000)	1.71 (0.456)	0.000
	▪ Force repetition	2.93 (0.259)	1.00 (0.000)	0.684
C. Vibration	None	1.04 (0.204)	1.00 (0.000)	0.428
D. Temperature	None	1.91 (0.830)	1.63 (0.885)	0.036
E. Noise Level	None	1.86 (0.546)	2.36 (0.699)	0.000
F. Lighting Level	None	1.34 (0.478)	1.23 (0.426)	0.177

Note: * Mann-Whitney test

The value of mean (SD) for cashiers was mostly higher than that of office workers. Previous studies found that supermarket or grocery store workers have more tendencies to have repetitive hand movements compared to office workers [18,19]. During data collection, it was found that office workers normally do not engage in work that requires back extension, elbows supination deviation and neck extension. Office workers are more likely to work in a seated position (sitting down) and usually use hand and wrists in flexion or extension posture whereas majority of cashiers work in an upright position (standing up). From the result obtain so far, the observer found that the mean values for cashier and office workers were different. This is because the different in the range of work task. In addition, the lighting level items were found to be insignificant because the lighting only related to visual symptoms. Therefore, the lighting condition was important for reduction of visual discomfort for computer work [20].

Table 4 shows the result of comparison between the UPLIRA scores from office workers and cashiers for psychosocial risk factors section. 'Lack of support from supervisors and co-workers', 'difficulty to keep up with work', 'high level of attention and concentration', 'unplanned overtime/shift work', 'enough training and information to carry their job' and 'satisfied with the job or not' demonstrated the most significant ($p < 0.05$) differences between the mean scores of office and cashier groups. During the interview session with office workers, several factors that contributed to work stress were found. This included high level of attention and concentration, mean = 2.61 (SD = 0.546), sudden changes in workload, mean = 2.20 (SD = 0.791) and frequent tight deadlines, mean = 1.84 (SD = 0.754). A study from Sharifi *et al.,* [21] found that deadlines, job handovers and conflicts at the workplace are psychosocial items that lead to work stress. Moreover, job dissatisfaction, high job demands, high workload and lack of support from superiors and co-workers were suggested as risk factors for ULDs [22-25]. Other studies found that the interaction among psychosocial factors, ergonomic postures and the complex individual response to the workplace factors refer to the individual's work style, which is how an individual performs his/her job tasks [26-29].

Table 4
Comparison between the UPLIRA scores from office workers (n = 70) and cashier workers (n=56) for Psychosocial risk factors section

UPLIRA Items	Office Workers	Cashier	p-value*
	Mean (SD)	Mean (SD)	
G1. Lack of support from supervisors and co-workers	1.40 (0.668)	1.75 (0.769)	0.005
G2. Difficult to keep up with their work	1.93 (0.621)	1.80 (0.699)	0.033
G3. Frequent tight deadlines	1.84 (0.754)	2.00 (0.831)	0.288
G4. High level of attention and concentration	2.61 (0.546)	2.80 (0.401)	0.041
G5. Unplanned overtime/shift work	1.04 (0.204)	1.63 (0.776)	0.000
G6. Enough training and information to carry their job	1.40 (0.600)	1.09 (0.288)	0.001
G7. Sudden changes in workload	2.20 (0.791)	1.80 (0.796)	0.007
G8. Satisfied with job or not	1.60 (0.689)	1.57 (0.628)	0.930

Note: * Mann-Whitney test

Table 5 shows the comparison between the UPLIRA scores from office workers and cashiers for work organizational risk factors section. The results demonstrated that 'the requirement to work hard' and 'wage incentives' had the most significance difference. A workplace that lacks civility and respect can lead to emotional exhaustion among staff, greater conflicts and job withdrawal [30]. Hayatuddin [31] found that the emotional management of female students at the Institute of Higher Education is in good condition and this emotional management has an impact on their studies.

Table 5
Comparison between the UPLIRA scores from office workers (n = 70) and cashier workers (n = 56) for work organizational risk factors section

UPLIRA Items	Office Workers	Cashier	p-value*
	Mean (SD)	Mean (SD)	
H1. How often your job required to work hard?	2.57 (0.650)	1.18 (0.386)	0.000
H2. How often you can use the skills from your previous experience and training?	1.51 (0.631)	1.68 (0.741)	0.013
H3. Relationship between other employees	1.57 (0.672)	1.32 (0.636)	0.242
H4. How often company give wage incentives?	1.70 (0.645)	1.77 (0.831)	0.867

Note: * Mann-Whitney test

Table 6 shows the comparison between the UPLIRA scores from office workers and cashiers for individual risk factors section. The results demonstrated that there were no significance differences ($p > 0.05$) between the mean score of office and cashier groups. However, the study found that smokers were 1.97 times more likely to experience back pain as compared to non-smoking colleagues. In addition, the significance of individual characteristics and organizational effects in explaining the mental health and job satisfaction of employees [32,33].

Table 6
Comparison between the UPLIRA scores from office workers (n = 70) and cashier workers (n = 56) for individual risk factors section

UPLIRA Items	Office Workers	Cashier	ρ-value*
	Mean (SD)	Mean (SD)	
I1. Smoking	1.54 (0.943)	1.29 (0.680)	0.164
I2. Had any on the job accidents from previous 6 months?	1.00 (0.000)	1.00 (0.000)	1.000
I3. Within the past 12 months, the amount of work is limited by any disability	1.00 (0.000)	1.00 (0.000)	1.000

Note: * Mann-Whitney test

4. Conclusions

Upper Limb Risk Assessment (UPLIRA) was developed to provide a method of screening the working task quickly for exposure to the physical, psychosocial, work organizational and individual risk factors. In order to established UPLIRA method, the construct validity was tested using known-groups technique by comparing two different groups sectors which are cashier and office workers. The construct validity shows that statistically significant for the 69% items of UPLIRA ($p < 0.05$). It shows that the UPLIRA assessment provided a good indication of work-related upper limb disorders (WULDs) which might be reported as pain or discomfort in the upper body region. These results support that UPLIRA tool is valid instrument to measure exposure risk factors of the WULDs in industrial settings and epidemiological studies. Next research may be required to corroborate these testing results from a larger data set from different job settings at different industries.

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