Applied Mechanics and Materials Vols 465-466 (2014) pp 1160-1164 *Online: 2013-12-19*
© (2014) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/AMM.465-466.1160

Development of Questionnaire for Assistive Device Design in LPG Cylinder Handling

Al Amin, M.S.[a], Nuradilah, Z.[b], Isa, H.[c], Nor, A.M[d], Febrian. I[e], and Taufik[f]

Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, 76100, Durian Tunggal, Melaka, Malaysia

[a]alamin@utem.edu.my, [b]dilah_zahri@yahoo.com, [c]isa@utem.edu.my, [d]akramin@utem.edu.my, [e]febrian@utem.edu.my, [f]taufik@utem.edu.my

Keywords: Liquefied Petroleum Gas (LPG) cylinder, manual handling, health effect, assistive device

Abstract. In Malaysia, Liquefied Petroleum Gas (LPG) is filled in a heavy steel cylinder and it is widely used for cooking purpose. Due to its dimensions and mass, the delivery men exposed to ergonomics risk factors associated with excessive force that can lead to injury to the back and the shoulders. There are assistive devices can be used to aid the delivery men; however, those devices are not efficient to transport the LPG cylinder to non-elevator apartments. Based on this reason, this study develops a questionnaire to determine design requirements of the assistive device for LPG cylinder handling. Structured interview using questionnaire survey was conducted among 25 delivery men. Based on the questionnaire survey, 76% of the delivery men required an assistive device that is safe, motorized, and push oriented for LPG cylinder handling. This study concluded that the developed questionnaire is reliable to determine design requirements of the assistive device for LPG cylinder handling.

Introduction

Liquefied Petroleum Gas (LPG) cylinder is widely used for cooking purpose in household and restaurant. The mass of filled LPG cylinder for domestic usage is ranged between 30 kg to 34 kg; meanwhile the empty LPG cylinder weighted from 16 kg to 20 kg [1, 2]. The diameter of LPG cylinder is 33 cm and its height is 61 cm. When a delivery man delivers or replaces the LPG cylinder, he will handle the delivery process manually such as lifting and pushing. For example, the delivery man uses a trolley to transfer the LPG cylinder from the transporter to the house. In the case of non-elevator apartment, the delivery man has to hold and lift the LPG cylinder to transfer it from the ground level to the upper levels. Thus, the workload for the delivery man to handle or carry the LPG cylinder using stairs is greater than the floor with no gradient [3].

Since the LPG cylinder is heavy and bulky, the delivery man tends to experience sprains and strains injuries in the neck, shoulders, back, arms and knees. The delivery man usually experience strains once they first exposed to risk of handling the heavy loads; however, repeated exposure to the risk may cause they suffer continuous injuries such as weaken joints, pinch nerves, inflame tissues, damage muscles and in worst case scenario may result in chronic illnesses [4]. According to the 2012 Liberty Mutual Workplace Safety Index, overexertion which includes injuries related to excessive manual handling shows the highest rank that causes disabling injury [5]. It seems that overexertion is obviously caused by heavy workloads.

In recognition the importance of LPG cylinder handling, an effective assistive device is required to reduce the risk of injury for the delivery man. The most immediate and useful solutions are trolleys and carts which can avoid the need for carrying loads over distances [6]. However, there is an argument stated that the existing manual materials handling devices do not overcome the problem of mishandling the task [7]. This is due to little attention paid to ergonomics aspects in the design of the trolleys and carts [6]. Based on this reason, it is important to determine the design requirements of the trolley and cart from the delivery men so that the device can be designed properly, effective and safe for the purpose of LPG cylinder handling. Thus, the present study takes this opportunity to develop a questionnaire with the aim to determine information on the current

All rights reserved. No part of contents of this paper may be reproduced or transmitted in any form or by any means without the written permission of Trans Tech Publications, www.ttp.net. (ID: 136.186.1.81, Swinburne University, Hawthorn, Australia-18/05/15,00:16:04)

practice in LPG cylinder handling. Besides, the questionnaire is used to determine the delivery men's requirements regarding assistive device for LPG cylinder handling.

Questionnaire Development

There were six stages in developing the questionnaire. In stage one, the information and relevant questions to be asked in the questionnaire were obtained through literature review and on site observation at several stores. Based on literature review, this study decided the contents and design of the questionnaire such as demographic information, types of questionnaire either open-ended questions or closed-ended questions, and body parts symptom survey. Additionally on site observation provides an outlook of the working operation practiced by the delivery men.

In stage two, the information was discussed in a mini workshop which involved a team of experts from different fields of study. During the discussion, this study decided to construct the questionnaire into five sections. Section A consists of demographic questions which include age, height, weight and body mass index of the delivery men. Section B focuses on the operation and job description. This section identifies the working activities performed by the delivery men such as working hours, the process involved when delivering the LPG cylinder, the advantages and disadvantages of the current method of LPG cylinder handling. Section C asks the health effects experienced by the delivery men through body parts symptom survey, adopted from the established questionnaire [8]. Additionally, section D of the questionnaire concentrates on safety issues on the current operation. This section requires the delivery men to state the cause and effect of their involvement in the accident at the workplace. Section E is an improvement section which covers on the requirements needed by the delivery men to design future assistive device. The questions consist of the price, handling technique, device system and safety features.

Stage three focuses on performing pilot study on the questionnaire draft which involved 15 delivery men who were transporting the LPG cylinder to non-elevator apartments. To ensure the questionnaire able to acquire reliable information, this study applied face-to-face interview with the delivery men. Stage four proceeds with validating and improved the questionnaire draft. The Cronbach's alpha value obtained from reliability test is 0.8456. Thus, it shows that the questionnaire draft had greater internal consistency and no modification on the questionnaire draft is required. In stage five, an actual survey was performed involving 25 delivery men. Finally, another reliability test was performed for the final developed questionnaire. Types of question being used in the questionnaire are multiple choice questions and Likert Scale. Fig.1 shows the process flow of questionnaire development.

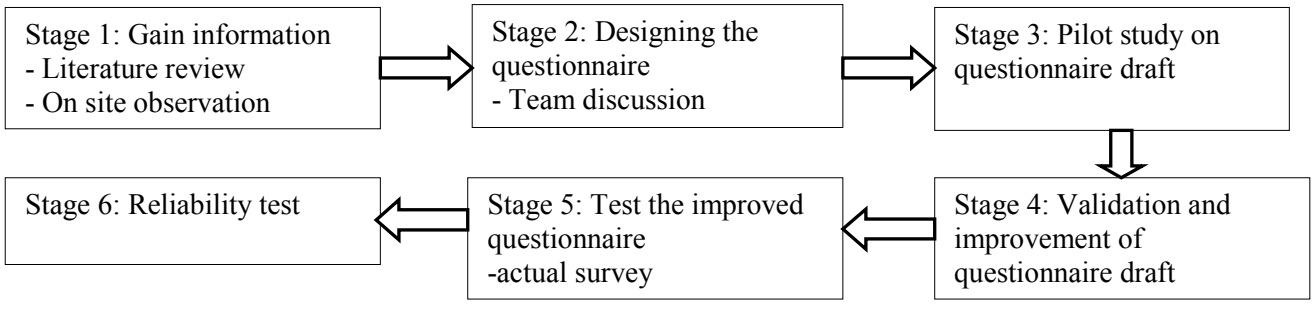

Fig.1: Questionnaire development process

Results and Discussion

The demographic information of the delivery men is shown in Table 1.

Table 1: Demographic information of the delivery men

Age (years)			Body mass (kg)			Body height (m)		
Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
24	33	45	60	73	86	1.60	1.68	1.83

Most of the delivery men were delivered the LPG cylinder to non-elevator apartments. Hence they need an assistive device to aid them to transport the LPG cylinder from the ground to the upper levels. Out of 25 delivery men, 40% of them reported that they used a trolley but it was limited only to the ground floor. The delivery men claimed that their job involved lowering and lifting from the store floor to the transporter. Furthermore, holding and transferring activity occurred whenever the delivery men carried the filled LPG cylinder to the destination. The same activity occurred when the delivery men brought down the empty LPG cylinder to the transporter and return to the store. It was found that the delivery men delivered about 21 LPG cylinders to the customers with the frequency of 13 times per day. 76% of the delivery men were transporting the LPG cylinder by using a motorcycle, thus, the average cycle time required to complete each delivery is 34 minutes. This is due to a motorcycle can load the maximum of three LPG cylinder compared to a lorry, which able to load more LPG cylinders. Hence the motorcycle required longer delivery times.

This study found that there were advantages and disadvantages of the current method of handling and transporting the LPG cylinder. 68% of the delivery men found that the current method was easier as their movement is not limited, but, this action resulted in adverse health effects. In addition, they felt that using the trolley or any other aids might slower their task [6]. The disadvantage of the current method is energy consuming. Since the entire delivery men managed to carry the LPG cylinder on the shoulder during up and down the stairs, it leads to more energy consuming. It has been proven that shoulder load carriage associated with higher heart rate and oxygen uptake [9].

While handling the LPG cylinder, 92% of the delivery men experienced discomfort in the lower back, 84% and 80% of them felt discomfort in the neck and the upper back respectively. Meanwhile, 60% of the delivery men claimed discomfort in the right shoulder, 8% of them experienced discomfort in the left shoulder and 28% of the delivery men experienced discomfort in the both shoulders. Results are illustrated in Fig. 2. The reason why the delivery men experienced discomfort in their body parts is due to lifting and holding the LPG cylinder. The delivery men tend to move and transfer the heavy cylinder in a poor posture which can cause them to experience stress in the contact area. This practice leads to injury to the musculoskeletal system [10]. In addition, working with loads required to be carried upstairs may result in physiological burden [3]. In fact, 60% of the delivery men have been involved in accidents while handling the LPG cylinder. Out of which, 36% of them experienced slip and 32% of them involved falling. Due to the accidents, 52% of them had back pain injuries. The main causes of the accidents are due to the carelessness of the delivery men and physical disabilities.

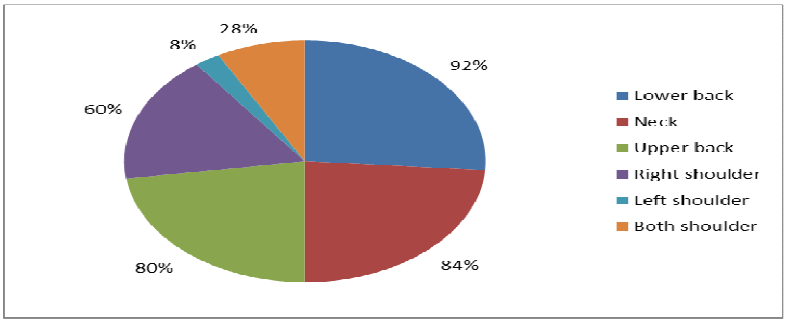

Fig.2 : Complaint on discomfort in the body parts among the delivery men

Besides, the information on requirements of the delivery men provides an insight into the whole future design and manufacturing operation of the LPG cylinder handling device [11]. Based on this survey, 36% of the delivery men preferred to have a device with a reasonable price. 76% of them would like to have a motorized device, 72% wanted the device that is light. This is important because a light device enables the delivery men to operate and mobilize the device efficiently and do not disrupt their movements while handling the LPG cylinder. As for safety and injury prevention, more than 60% of the delivery men proposed that the assistive device should be equipped with a lock and brake. Fig. 3 shows the pushing handling technique, motorized and lock

safety features obtained the highest score. The delivery men preferred to have pushing device due to less physical demand required. Furthermore, in the case of climbing the stairs, motorized device can be useful and provides lessen manual labor. Since the device is motorized, safety features such as lock is needed.

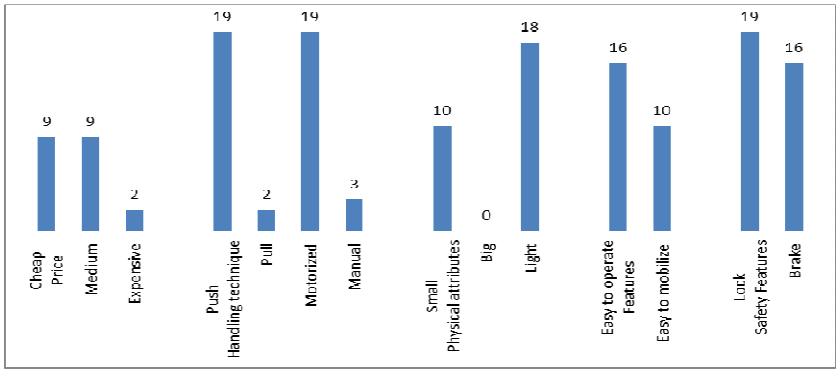

Fig. 3: Requirements for future assistive device

Reliability Measures

The reliability of the questionnaire is tested using Cronbach's alpha (α) as shown in Table 2. Cronbach's alpha is used to determine the internal consistency or average correlation of items in a survey in order to measure its reliability [12]. In this study, the value of Cronbach's alpha is 0.7302. Nine factors such as cheap, expensive, push, pull, motorized, manual, small, easy to mobilize and easy to carry obtained reliabilities above 0.7. The closer the Cronbach's alpha coefficient to value 1.0 means that the greater the internal consistency of the item in the scale or the question [13]. Meanwhile, there are factors such as light, easy to operate, safety lock and brake obtained value in the range 0.6 to 0.7. From the rules of thumbs, if the value is 0.9, the internal consistency is excellent, 0.8, the consistency is good, 0.7 is acceptable, 0.6 is questionable and less or equal to 0.5 is poor internal consistency [14].

Table 2: Reliability measures using Cronbach's alpha (α) for the surveyed requirements

No.	Requirements	Cronbach's alpha (α)
1	Cheap	0.71552
2	Expensive	0.74331
3	Push	0.70016
4	Pull	0.75629
5	Motorized	0.73125
6	Manual	0.73166
7	Small	0.73178

No.	Requirements	Cronbach's alpha (α)
8	Light	0.67165
9	Easy to operate	0.68833
10	Easy to mobilize	0.71305
11	Easy to carry	0.71587
12	Safety lock	0.68353
13	Brake	0.67950

Conclusion

This study has developed a questionnaire to survey information and requirements from the delivery men regarding future design of assistive device for the purpose of delivering the LPG cylinder to non-elevator apartments. Based on a pilot study among 25 delivery men, this study identified that design criteria such as push handling technique, motorized, light and safety should be incorporated in the design of the LPG cylinder handling. Furthermore this study concluded that the developed questionnaire has shown a reliable tool to identify the requirements of delivery men regarding the design of LPG cylinder handling device. Further research work is required to transform the delivery men requirements into technical specifications of the LPG cylinder handling device.

Acknowledgement

The authors would like to thank the Universiti Teknikal Malaysia Melaka (UTeM) for funding this project under university short term research fund (PJP/2012/FKP (7D)/S1126).

References

[1] Information on http://www.mymesra.com.my/ Petronas Dagangan Berhad.

[2] F.F.M.Saad, The design and development of warning device for low pressure LPG tank (Universiti Teknikal Malaysia Melaka, 2009)

[3] M.K. Chung, Y.J. Lee, I. Lee and K.I. Choi, Physiological workload evaluation of carrying soft drink beverage boxes on the back. Applied Ergonomics 36 (2005)p.569-574.

[4] J.I.Wilson, A.Perez, L.Connor, C.Elmore, D.Padilla, R.Rivera, A.Smith and M.Nephew, Education Support Professionals: Repetitive stress injuries handbook. National Education Association (2004).

[5] Information on www.libertymutual.com / Research institute.

[6] K.Mack, C.M. Haslegrave and M.I. Gray, Usability of manual handling aids for transporting materials. Applied Ergonomics Vol 26(1995) p.353-364.

[7] J.C.Woldstad and D.B.Chaffin, Dynamic push and pull forces while using a manual material assist device. IIE Transaction 26 (1994)p.77-87.

[8] I.Kuorinka, B.Jonsson, A.Kilbom, H.Vinterberg, F.Biering-Sorensen, G.Andersson and K.Jorgensen, Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics 18(3)(1998)p.233-237.

[9] S.J. Legg, T. Ramsey and D.J. Knowles, The metabolic cost of backpack and shoulder load carriage. Ergonomics 35(9) (1992).

[10]S.S. Chowdhury, J. Boricha, S. Yardi, Identification of awkward postures that cause discomfort to Liquid Petroleum Gas workers in Mumbai. Indian J. Occup. Environ, Med 16 (2012)p.3-8.

[11]E.S. Jaiswal, A Case study on Quality Function Deployment (QFD). IOSR Journal of Mechanical and Civil Engineering 3(6)(2012)p.27-35.

[12]J.R.A.Santos, Cronbachs's Alpha: A tool for assessing the reliability of scales. Journal of Extension 37(2)(1999).

[13]J.C.Nunnally, Psychometric Theory (2nd edition). (McGraw Hill Publications, New York,1978).

[14]J.A.Gliem and R.R.Gliem, Calculating, interpreting and reporting Cronbach's Alpha reliability coefficient for Likert-type scales. Midwest Research to Practice in Adult, Continuing and Community Education, 2003.

4th Mechanical and Manufacturing Engineering
10.4028/www.scientific.net/AMM.465-466

Development of Questionnaire for Assistive Device Design in LPG Cylinder Handling
10.4028/www.scientific.net/AMM.465-466.1160