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ENHANCING OCCUPATIONAL SAFETY AND HEALTH IN CONSTRUCTION MANUAL HANDLING OF LOAD:TEAM-LIFTING POSSIBILITY AND IMPACTS

[1]Adeyemi H. O., [2]David A. O., [1]Akinyemi O. O., [2]Opafola O.T. and [1]Adeyemi O. A.

[1]Department of Mechanical Engineering, Olabisi Onabanjo University, Ago-iwoye, Nigeria
[2]Department of Civil Engineering, Olabisi Onabanjo University, Ago-iwoye, Nigeria

**Corresponding Email: adeyemi.hezekiah@oouagoiwoye.edu.ng*

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ABSTRACT

Manual Handling of Load (MHL) is common to many job titles in the construction industry. It is one risk factor for many reported workers' ill-health and disabilities. This study evaluated the possibility and impacts of Team-work Practice (TwP) in MHL. Ten (10) building construction sites in South-Western Nigeria involving 125 workers in 6 job titles, were involved with special focus on concrete labourers(*ConL*) group. Structured questionnaire was used to measure the level and impacts of TwP. Measurement of task variables was carried out among *ConL* to determine performance of workers under One–person lifting (OpL) and Two-persons Team Lifting (TpTL) methods. One-way analysis of variance was used for data evaluation. 58% of the workers reported working in team. Among benefits narrated, solving problems together (74%), fast job completion (72%), work pressure distribution (55%) were common. Enhanced discipline (89%), reduced unsafe characters, better work conditions (63%), reduced risks taking (75%) were safety related benefits mentioned. There was no significant difference between the responses to TwP among *ConL* and three others (carpenters, bricklayers, bricklayers' assistants) ($p = 0.971, 0.952, 0.991$ respectively). Plumbers and labourers' groups recorded weak attitude to TwP. Performance of *ConL* when adopted as OpL was 88.4% and rated 99.5% when engaged TpTL. There were reductions in per lifting and lowering times with increased in the total work-volume. The study recommends development of a framework that seeks to include pairing of workers in MHL as a long term objective of promoting occupational safety and health in the construction industry.

Keywords:*Team-lift, construction, task, workers, safety*

INTRODUCTION

According to Safe Work Australia (2012), construction work is defined as any work carried out in connection with the construction, renovation, repair, maintenance, demolition among others. Workers in this industry do different activities each of which has its own dangers. One of the most important points of safety issues in the construction sites is that all working groups such as labourers, technicians, foremen are directly exposed to health risk of the work (Baradan and Usmen, 2006). Some authors reported that construction sites are the most dangerous workplaces where human injuries prevalence was very high (Tam *et al.*, 2004; Lee *et al.,* 2012; Hinze and Raboud, 1988). Occupational accidents in construction industry have negative impacts on workers' safety and health and on economics (Huang and Hinze, 2006; Pinto *et al.,* 2011). It was reported that the occurrence of work-related injuries and their costs in the construction industry were more than that of all other industries (Unsar and Sut, 2009).

Manual handling of loads (MHL) are popular in construction works and have contributed widely to most workers' reported injuries. According to European Agency for Safety and Health at Work (EASHW) (2007), MHL refers to the physical moving of load by lifting, shoveling, pulling, lowering, carrying, pushing or stacking. Some of the construction loads such as construction materials may include cement, stones, mortars, planks, irons, bricks, which are moved from storage or other location to a work station. There are several factors that make MHL hazardous and increase the risks of injury (Adeyemi *et al.,* 2013). For instance, the risk of back injury increases during lifting, carrying, pushing and pulling of loads. Most especially when the load is too heavy, difficult to grasp, unbalanced, unstable, difficult to reach, too strenuous, involves awkward postures or movements (EASHW, 2007)

To reduce injuries in load handling related tasks, some studies recommended team lifting as possible ergonomics measure. According to Eduardo (2008), teams may be used when task complexity exceeds the capacity of an individual and the job is stressful. Teams'practices are engaged in aviation, health care, financial sectors, engineering problem-solving tasks, manufacturing and others. Teamwork can be used to reduce the load on an individual performing a heavy lifting task and is particularly useful when an object is bulky and mechanical aids are not available (Sharp, 1997). It is hypothesized that team lifting may change trunk movements and subsequent spinal loading that would define risk of low back disorder (Marras, 1999). Biomechanical, psychophysical, and physiological stress tends to be reduced compared to the equivalent lifts and transfers performed by individuals. The stress associated with team lifting depends on a broad range of individual team member, load, task and environmental factors, which can interact in unexpected ways (Barrett and Dennis, 2005). Complicated tasks are simplified when people work as a team. According to Omid and Mehdi (2016), performance is the core of the substance for teams.

The costs of accidents and ill-health related to lifting operations among workers in Nigeria construction industry are immense and widely reported by same and other authors (Umeokafor, 2014; Adeyemi *et al.*, 2013; Auropean Agency for Safety and Health at Work, 2004; Ezenwa, 2001). This required additional efforts at providing more ergonomics measures to reduce to a tolerable level, the health and safety risks associated with the MHL. Hence a reason for the present study which aimed to study the possibility of adopting Team-work Practice (TwP) as an ergonomics measure to maximize occupational health and safety among workers in MHL jobs. The objectives were to assess the level and impacts of TwP among the different groups of workers and identify the various job titles where TwP was popular.

MATERIALS AND METHIODS

Ten (10) building construction sites located in Lagos and Abeokuta, the South-western Nigeria, together with 125 workers in 6 job titles (50 concrete laboureres (*ConL)*, 19 carpenters, 21 bricklayers, 13 bricklayers assistance, 12 labourers and 10 plumbers) were involved in the study.

A set of questionnaire related to information about subjects' experiences on the current job, job demand, level of teamwork possibility in their respective job titles, impact of TwP, TwP contributions to safety, impacts of TwP and others. The six (6) groups of workers considered were those of jobs that required lifting of one load or the other. They are, *ConL* (lifted, lowered and placed concrete), carpenters (worked with wood related task), bricklayers (set bricks), bricklayers' assistants (assisted bricklayers to lift bricks and cement mortars), labourers (lifted heavy loads, excavated trenches, performed clean-up tasks, provided labor support as required) and plumbers (installed, repaired and maintained pipes, fixtures and other plumbing equipment used for water distribution and waste water disposal).

Information regarding the level of TwP among the workers and its impacts on their work performance and safety was obtained from the subjects through interviews and with structured questionnaire. The content included among others, general information

about the subjects, work condition, level of team work possibility across the various job titles, benefits of TwP and team work contributions to safety. Respondents were asked to respond to the team work related questions on a five scale points (5 = strongly agreed, 4= agreed, 3= neutral, 2=disagreed, 1= strongly disagreed)

For reliability, personnel trained to make measurement in a standardized manner were involved in the measurement of variables in ConL' task category. Theworkers were divided into two categories of 25 each. The first group were made to lift the materials individually. Two(2) of the subjects in the second category were positioned one (1) at the origin to help lift the material together with the remaining 23 *ConL* and the other stationed at the load destination to lower same material with the 23 labourers. Three samples of one task cycle (lifting from origin to head, walking from the origin to destination, lowering the material from head to the work station (destination). The time required to carry out each stage of the tasks were recorded in seconds, using a wrist watch. The mass of the concrete with head-pan was measured in Kg, using a weighing scale. Total time to complete each cycle of the task in seconds, and the total amount of weight lifted in Kg, by each subject for 50 complete task cycleswere computed for each subjects.

Performance of *ConL* under TWP was determined using (1) (Sermin and Birol, 2010). Performance takes into account "time loss", which included any factor that lead to lifting materials in less than the maximum possible work pace.

$$\text{Workers' Performance} = \frac{\text{Actual Job Completion Time ?AJCT? - Time Losses(TL)}}{\text{Actual Job Completion Time (AJLT)}} \times 100 \quad ..(1)$$

Time loss was the difference between the planned job operation time (PJOT) and the AJCT. PJOT was the proposed time for completing a cycle of the job. As used in this study, PJOT was taken to be the time required to complete a cycle of the task by the fastest worker among all the subjects.

One-way analysis of variance (ANOVA) was used to determine whether there were any statistically significant differences between the means of responses to TwP among the six independent study groups. The Turkey post- hoc test which is generally the preferred test for conducting post hoc tests on a one-way ANOVA was used to ascertain the specific groups that differed.

RESULTS AND DISCUSSION

One hundred and twenty five (83%) (75 male and 50 females) out of the 150 workers that participated in the study completed the questionnaires out of which 50 ConL (females) were involved in the extended study. All subjects have spent not less than one year on the current job. The demographics of the workers are presented in Table 1.

Table 1: Demographic information for workers that participated in the study (Ntotal=125).

Descriptions	Workers		
	Mean	SD	Range
Age (years)	25.4	2.2	24-31
Duration of Employment/Operation	2.3	1.3	1-3

SD= Standard Deviation

Level of Teamwork possibility across the job titles

Figure1 shows the responses of respondents to whether working as a team may be possible in their various job titles. As shown in the figure, 88% confirmed that TwP was possible. 58% were presently working as team as more than 90% of this group mentioned that working as a team was effective in their respective job titles. 91% however reported to prefer working in a team to working alone.

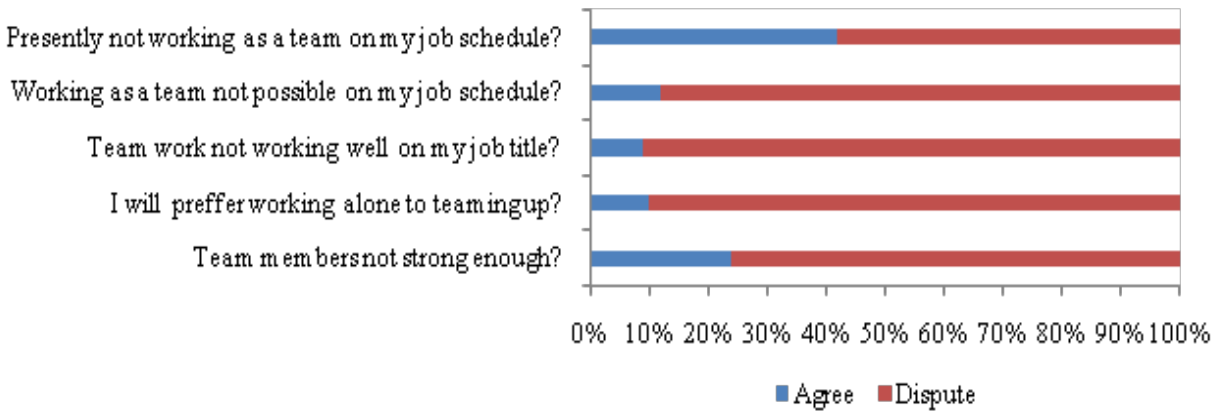

Figure 1: Response of workers to possibility of teamwork in their respective job titles.

Benefits of Team work practice

Among the workers who were involved in TwP, figure 2 shows the various benefits derived by the workers. Possibilities of solving problems together were among the highly reported (74%). Others included fastjob completion (72%), taking responsibility together for any shortcomings (66%) and the ability to, consult team leaders for advice (61%), distribute work pressures among other members (55%).

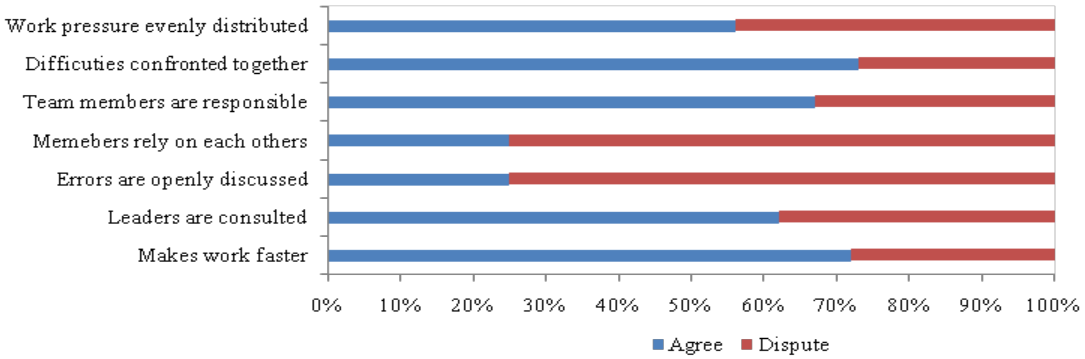

Figure 2: Reported benefits derived from Team-work practice.

From the Figure 2, 72.7% of the subjects mentioned that working as a team helped to fast track their works performance, 62.5% stated that leaders can be consulted in case of any problem. 54.5% mentioned that working as a team assisted them to handle difficult situations together. Other benefits mentioned included; reliance on others to do their job (23.9%), errors discussed openly (23.9%), work pressure evenly distributed (25.5%)

Reported workers team work attitudes to safety

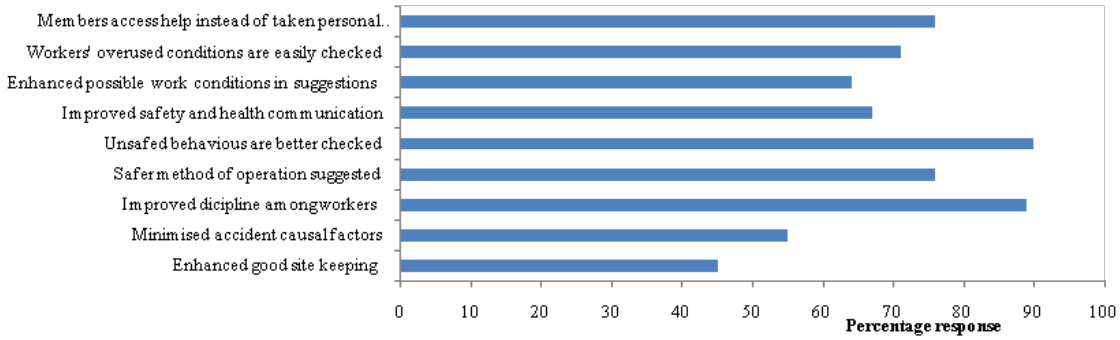

Figure 3: Impact of workers' team attitudes on safety.

From Figure 3, more than 89% reported to have witnessed improvement in workers' discipline and reduction in unsafe workers' behaviors respectively. Team work promoted better work conditions (63%) with suggestions of better work method. More than 75% reported asking for help from team members instead of taking risk capable of leading to job hazards. Therefore work stress/overuse conditions were reported (70%) minimized, accident causal factors reduced (56%) with improved safety communications (68%).

Table 2: Impacts of Team-lifting practice in cement placement tasks

Subjects	Load (Kg)	Lifting (Origin) (sec.)	Origin to Destination (min.)	Lowering (Destination) (Sec.)	AJCT (min.)	Total Mass Lifted (Kg)	Cost (N)
1	18 (22)	4.44(3.74)	15.03(14.67)	4.18(3.18)	23.65(21.59)	900(1100)	1,500(1,500)
2	20(23)	4.66(3.66)	16.03(15.07)	3.93(3.43)	24.62(22.16)	1000(1150)	1,500(1,500)
3	18(21)	5(4.5)	14.9(14.9)	3.04(3.04)	22.94(22.44)	900(1050)	1,500(1,500)
4	20(20)	4.02(4.12)	14.67(14.63)	3.12(3.02)	21.81(21.77)	1000(1010)	1,500(1,500)
5	19(19)	4(3.79)	15.07(15.07)	3.05(3.01)	22.12(21.91)	950(950)	1,500(1,500)
6	20(20)	4.76(3.76)	15.03(14.67)	3.25(3.25)	23.04(21.67)	1000(1050)	1,500(1,500)
7	17(22)	4.89(4.59)	16.03(15.07)	3.44(3.14)	24.36(23.1)	850(1100)	1,500(1,500)

8	18(23)	4.53(3.58)	14.9(15.03)	4.01(3.01)	23.44(21.57)	900(1150)	1,500(1,500)
9	16(21)	4.18(4.18)	14.37(16.03)	4.12(3.12)	22.67(23.33)	800(1050)	1,500(1,500)
10	18(20)	5.24(5.24)	15.07(14.67)	3.02(3.05)	23.33(22.93)	900(1000)	1,500(1,500)
11	20(21)	4.33(3.33)	14.9(15.07)	3.22(3.24)	22.45(21.62)	1000(1050)	1,500(1,500)
12	19(20)	4.77(4.79)	14.67(15.03)	3.12(3.11)	22.56(22.92)	950(1000)	1,500(1,500)
13	20(19)	4.56(4.51)	15.07(16.33)	3.54(3.50)	23.17(24.43)	1000(950)	1,500(1,500)
14	18(21)	4.23(3.23)	15.13(14.67)	3.26(3.26)	22.62(21.16)	900(1050)	1,500(1,500)
15	16(19)	3.88(3.28)	16.23(15.07)	3.54(3.49)	23.65(22.49)	800(950)	1,500(1,500)
16	17(22)	5.4(4.4)	14.9(14.96)	3.12(3.10)	23.42(22.48)	850(1100)	1,500(1,500)
17	19(20)	4.23(3.23)	14.67(14.63)	3.05(3.05)	21.95(20.31)	950(1000)	1,500(1,500)
18	20(19)	3.99(3.19)	16.03(15.07)	3.25(3.65)	23.27(21.51)	1000(950)	1,500(1,500)
19	18(20)	4.11(4.17)	14.9(14.67)	3.44(3.24)	22.45(22.08)	900(1000)	1,500(1,500)
20	20(21)	5.12(3.12)	14.67(15.07)	4.01(3.01)	23.8(21.2)	1000(1050)	1,500(1,500)
21	18(21)	4.07(3.57)	15.27(15.03)	4.12(4.00)	23.46(22.72)	900(1050)	1,500(1,500)
22	20(21)	5.01(4.01)	14.9(15.03)	3.02(3.09)	22.93(23.13)	1000(1050)	1,500(1,500)
23	19(21)	4.91(3.81)	14.67(14.9)	3.25(3.27)	22.83(21.96)	950(1050)	1,500(1,500)
24	20	4.78	15.07	3.44	23.29	1000	1,500(1,500)
25	17	4.12	15.03	4.01	23.16	850	1,500(1,500)
TOTAL	**18.6(19.04)**	**4.53(3.59)**	**15.08(13.85)**	**3.46(2.07)**	**23.08(20.41)**	**930(952)**	**37,500(37,500)**

x(y) where x = *ConL* in one –person lifting, y=*ConL* in two-persons lifting

From Table 2, the load lifted with OpL method was smaller than with TpTL. 20 Kg was the highest in the category of OpL as 23 Kg was recorded with TpTL. 21.81 seconds was the minimum time spent to complete a cycle of the task when the material was individually handled whereas 20.91 seconds was recorded as the minimum time to complete same task with TpTL. 1000 Kg was documented as the maximum lifted weight by an individual lifting alone as compared to 1100 Kg maximum weight notedwhen lifting in duo. For Samples 24 and 25, the records for the TpTL group were not available because the two subjects were positioned, one at the origin of load and the other at the work station to lift with the labourers and to lower same material respectively. Though a total number of 25 workers were involved in moving the material in the first category (OpL) and 23 subjects were involved in the actual lifting of material in the second group (TpTL), the same cost was incurred for the entire task (N37,500). However the quantity of work done, in terms of total weight lifted, was more in TpTL than OpL.

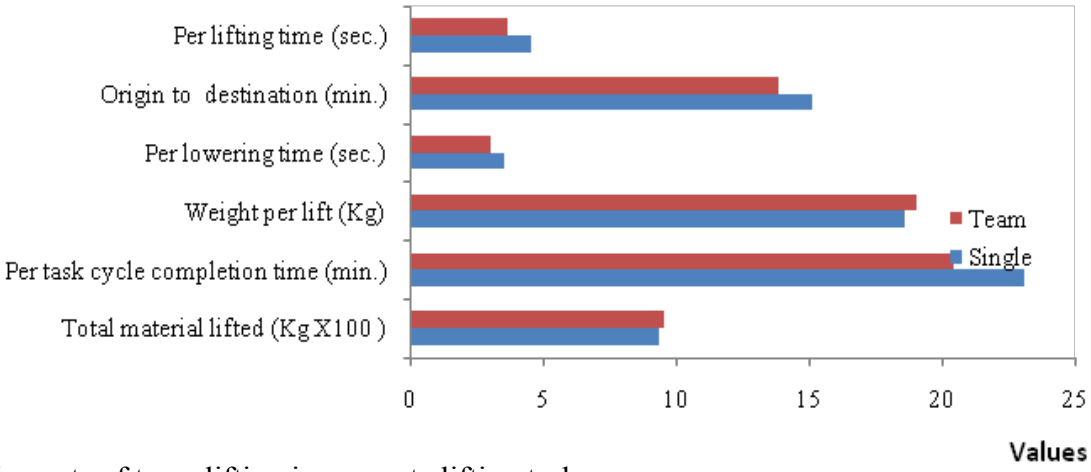

Figure 4: Impacts of team lifting in concrete lifting tasks

As shown in Figure 4, reduced lifting time was noted with task performance under TpTL. On the average, 4.53 seconds was used by OpL group to lift from the load origin to the head while 3.60 seconds was the time to perform the same task with TpTL. An OpL used 3.46 seconds to lower the material at the work station as against 2.97 seconds used with TpTL. Per-task-cycle completion time required 23.08 seconds while 20.41 seconds was needed to do the same with TpTL. Hence, there was 20% reduction in per lifting time, 14.2% reduction in per lowering time and an average of 11.6% reduction in the performance of a cycle task (lifting

material from the origin to head, walking from the origin to destination and lowering same material at the work station) using TpTL method. 9300Kg of concrete was lifted by an average worker with OpL while 9520 Kg was lifted by individual workers with TpTL. This resulted to increment of 2.4% in the entire work under TpTL intervention.

Estimation of performance of workers pre and post introduction of team lifting

Table 3: Estimation of performance of workersunder OpL and TpTL practices.

Factor	OpL	TpTL
Workers' Performance	$\frac{AJCT - TL}{AJCT} x100$ $= \frac{23.08 - 2.67}{23.08}$ $= 88.4\%$	$\frac{AJCT - TL}{AJCT} x100$ $\frac{20.41 - 0.10}{20.41}$ $= 99.5\%$

Table 3 shows the calculation procedures and the results of the workers' performances working as OpL and the effects of TpTL. The subjects' performancewith OpLwas calculated as 88.4%. This was rated 99.5% when TpTLwas adopted. Hence the performance of workers with TpTL was better than OpL.

Statistical Analysis

Oneway ANOVA analysis

The one-way analysis of variance determine whether there were any statistically significant differences between the means of responses to TwP among the six independent groups of construction workers as shown in Table 3.

Table 4: Descriptive statistic of all groups of workers involved in the study

Job Titles	No. of Subjects	Means	Std. Dev.	Std. Error
ConL	50	4.4545	.52223	.15746
Carpenters	19	4.2632	.56195	.12892
Bricklayers	21	4.6667	.48305	.10541
B. Assistants	13	4.4615	.51887	.14391
Other Laboureres	12	1.9000	.73786	.23333
Plumbers	10	2.7000	1.15950	.36667

5 = strongly agreed, 4= agreed, 3= neutral, 2=disagreed, 1= strongly disagreed

Table 4 shows that *ConL*, carpenters, bricklayers and bricklayer assistants all had their scores rated above 4.0 (4.4545, 4.2632, 4.6667, and 4.4615 respectively) which were strong agreement to TwP. However the plumbers and the labourers' groups recorded lower ratings below 3.0 (1.9000 and 2.7000 respectively). These signified declined responses to TwP among the groups. The output of the analysis shows that the significance value was 0.001 (i.e., p = .001). Therefore, there was a statistically significant difference in the responses of the subjects to TwP in the different job titles. The specific groups that differed were identified in the multiple comparisons(Table 5).

Post Hoc Tests for Multiple Comparisons

From Table 5, there were statistically significant differences between the groups as a whole. Difference occurred in the responses to TwP between the groups of plumbers and four others (*ConL*, carpenters, bricklayers, bricklayers' assistants) (p = 0.001), as well as between the Labourers and four others (*ConL*, carpenters, bricklayers, bricklayers' assistants) (p = 0.001). However, there were no difference between the responses to TwP in the groups of *ConL* and three others (carpenters, bricklayers, bricklayers' assistants) (p = 0.971, 0.952, 0.991 respectively). Hence the results show that the groups of *ConL*, capenters, bricklayers and bricklayers' assistance all adopted TwP unlike the plumbers and the labourers'groups.

Table 5: Post Hoc tests for multiple comparisons

Job Titles I	J	Mean Difference (I-J)	Std. Error	Sig.
MoCa	Carp	.19139	.24758	.971
	Brik	-.21212	.24322	.952
	BrAs	-.00699	.26771	.991
	Labr	2.55455*	.28553	.001
	Plumb	1.75455*	.28553	.001

Lifting and carrying loads occur frequently in building construction works and this associated with high reports and incidence rates of several injuries and work-disability (Henk *et al.,* 2012).Some workers in this category lift load considered to be more than there capacity. This leads to many musculoskeletal disorders prevalent among the group of workers

(Adeyemi *et al.,*2013). This study was an added efforts which assessed the possibility of team lifting as an administrative and /or personal ergonomics measure to reduce injury level in the work.

Slightly more than average numbers (58%) of the workers reported working as team deferent from adopting OpL in their various job titles. Most of the workers (88%) however confirmed that team lifting was possible in their respective job titles.Those who were involved in OpL may not have accessed the opportunity of using TpTL method. It was however clearly noted in the study that almost all the subjects (91%) preferred TpTL.

The possibilities of solving problems together, fast job completion, taking responsibility together and the ability to consult team leaders for relevant information about their jobs, distribution of work pressure among members, were the general common benefits stated to be associated with TwP. On safety related, discipline among workers, reduction in unsafe behaviors, suggestions of better work method, opportunity to seek for help instead of taking risk capable of leading to job hazards were reported. These reported merits associated with team lifting were in line with the reported view of Sharp *et al.* (1997) that teamwork can be useful at reducing the load, stress or injuries on an individual lifting load or performing a lifting task. In addition to safety and health related advantages with team work practices, as noted in this study, the ergonomics measure can lead to job completion shorter than adopting single-person lifting style. There were some levels of increments in the total weight lifted by each worker as a result of some levels of reductions recorded during each lifting attempt while using TpTL method.

Improved workers' safety, enhanced performance and quality of services were some of the techniques to measure effectiveness and benefits of ergonomic interventions. This was the case with team lifting measure considered in this study. The ergonomics lifting technique is a procedure and method that maybe typically instituted by both employers and the employees in construction industry which can significantly reduce daily exposures to hazards. Implementation of any ergonomics measure shows managements' commitment to workers' safety and health as a basis value. Its cumulative effectis a stronger safety culture for anyemployees that make up the most valuable asset. The managers should however note that there may be someextra labor cost involved with introduction of any ergonomics program. Sometimes there may be feeling of another person around out of necessity in the case of team lifting. However, the impacts of the measure extend well beyond the implementation costs.

Therefore the authors recommended development of a framework that will seek to include measures at promoting pairing of workers in construction works and other MHL manual material handlings tasks. Thiswill help to promote workers', quality service delivery and, occupational safety and health. Future research should further assess the impacts of team lifting on workers' performance and safety in other MHL tasks and clearly define the mechanisms for implementations among all the concerned stakeholders.

CONCLUSION

This study evaluated the possibility and impacts of team work practice (TwP) in manual handling of loads with special focus on cement concrete laborers (*ConL*). Majority of the workers opined that TwP was possible in their job titles. More than average in this category were already working at one level of constituted team or another. The possibilities of solving problems together, fast job completion, sharing responsibilities, distribution of work pressure among members were some of the general benefits mentioned and enjoyed with TwP. Among many impacts of TwP on safety promotion, discipline, reduced unsafe workers' behaviors, better work conditions, seeking for help instead of taking risk capable of leading to job hazards and minimizedwork stress/overuse conditions were among the commonly reported. There was no statistically significant difference in the responses of ConL, carpenters, bricklayers and bricklayers' assistance groups to TwP. However, TwP among the plumber and the labourers' groups of workers was not significant. Performance of workers using two-person team lifting (TpTL) method among the ConL group, was better than those with one-person lifting (OpL) technique. There were reductions in time spent on per lifting and per lowering of materials with TpTL which further reduced the total time spent on the whole job.The total volume of work done, in terms of total mass of materials lifted, using TpTL also increased.

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