Original Research

Assessment of the Effect of Work Condition Variables on Work Outcome in Blue-Collar Job using Objective Research Technique

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Abstract
The work condition variables' significance in achieving the organizational objective in the blue-collar jobs is proportionate to appropriate implementation and management of ergonomics principles for productivity and occupational risk factors reduction. This study adopted an objective research approach in assessing the effect of working condition variables in the material manual handling task of a blue-collar job. The data analyzed in this study were obtained from 624 male participants within the working-class age of 20-39 years through the instrumentation of a JKBK solar powered pedometer and a digital professional (LCD) stopwatch in Abeokuta, South-Western Nigeria. The data analysis showed that the participants' endurance time has a negative correlation with work rate but significantly and positively correlated with productivity at a *p*-value of less than 0.05. The independent *t*-tests analyses carried out on the work posture, load mass, handling height, loading and offloading, and lifting and lowering modalities considered disclosed $p < 0.05$ – significant in all cases. This study recommended load split into lesser load mass for work processes that involve awkward work posture, high handling height, loading and offloading, and lifting and lowering for a heavy load to increase productivity, work rate, and endurance time.

Keywords - Productivity; Musculoskeletal injury; Work condition variable; Lifting; Material manual handling

INTRODUCTION

The work processes in almost all occupations involve performing one form of manual task or the other. Carrivick et al. [1] defined manual handling as any work process or activity that requires the worker to use or exert force in lifting, lowering, pulling, pushing, carrying, moving, holding, or restraining a person, an animal or object. The above job operations involved in material manual handlings sum up the diverse widespread of physically demanding occupational work activities in the manufacturing and construction industries in most developing nations of the world. The material manual handling operations in these nations involve inanimate objects without mechanical devices [1-3]. Occupational injury, especially those resulting from manual handling, is a primary burden to society, organizations, and the sufferers themselves. Among the work health problems that are estimated to affect millions of workers worldwide every year, musculoskeletal disorders (MSD) represent one of the most widely spread and the most expensive work-related health problems witnessed in developed and developing countries [4]. Studies have shown the significance of musculoskeletal disorders in the world of work as absenteeism, morbidity, disability, loss of time, financial burden, sick leave, and work-related injuries [5-11].

Research works in different professions in Nigeria showed that high prevalence of work-related musculoskeletal disorders in the workers is associated with work conditions variables [12-24]. The significance of working condition variables in achieving the organizational aim, especially in blue-collar jobs, is commensurate with appropriate implementation and management of ergonomics principles for productivity and occupational risk factors reduction [13, 14, 25, 26]. The steps involve proper job evaluation and specifications, identification of work-related risk factors, implementation, and adherence to the safe work processes in the work environment [26]. The work conditions variables are in three categories: physical, organizational, and psychosocial [27-33]. The primary occupational risk factors in the working conditions variables that affect the physical demands for work characteristics include force, magnitude, contact stress, work posture, duration, and repetition. The primary risk factors are often aggravated by the secondary risk factors (workplace environmental conditions, work organization characteristics, work station layout, objects handled properties) that manifest into one form of occupational hazard [34].

Musculoskeletal dysfunction is a fundamental health challenge that is widespread, particularly among blue-collar workers who perform repetitive jobs in the public and private sectors where heavy material handling tasks and repetitive activities proliferate [35]. Edlich et al. [36] and Hoozemans et al. [37] showed a significant connection between manual handling and musculoskeletal injuries. Da Costa and Vieira [38] revealed that repetitiveness in excess, heavy lifting, and awkward body postures concerning work is the biomechanical risk factors reported in most cases having WMSD causation attributes. Understanding the connection among comfort, health, safety, and productivity and the verse knowledge of the effectual application of ergonomic in the workplace, both employer and employee can be sensitive to potential visual stress that can affect all areas of performance [39]. Analyzing the effect of work condition variables on an individual in physically demanding jobs can be inferred from such an individual's productivity, the work rate of job handling, and muscular endurance within the limits of the required maximal effort without injury. Reducing the incidence of musculoskeletal dysfunction could be more effective than many other approaches, which tend towards the enhancement of workers' quality of life and consequently maintain and improve workers' performance [40]. The variation in the incidence rates of MSD in different work environments and study location is clearer from its multi-factorial causes viewpoint [41]. Several studies in this research area have made suggestions through their investigations on suitable interventions to prevent job-related health and safety issues in some specific workforce, especially in work-related musculoskeletal disorders. The various research approaches employed by researchers in addressing work-related musculoskeletal injuries found in the literature include engineering redesign, worker selection programs, work hardening, risk assessments, work shift, modification of the loads, the design of objects handled, lifting techniques, workplace layout, task design, and training [1, 36, 42-59].

First, this study was conceived on the principle that some job work environment may not be restructured or changed to lower the physical work demands while still maintaining the optimum performance level of a worker and without work-related musculoskeletal injury [42]. The second was that works training does not effectuate into practice in material manual handlings operations in the work environment [36, 44, 57]. Therefore, this work adopted an objective research approach in assessing the effect of working conditions variables on work outcome in material manual handling prevalent in the blue-collar job.

MATERIALS AND METHOD

Figure 1 is the flowchart of the research process in this study.

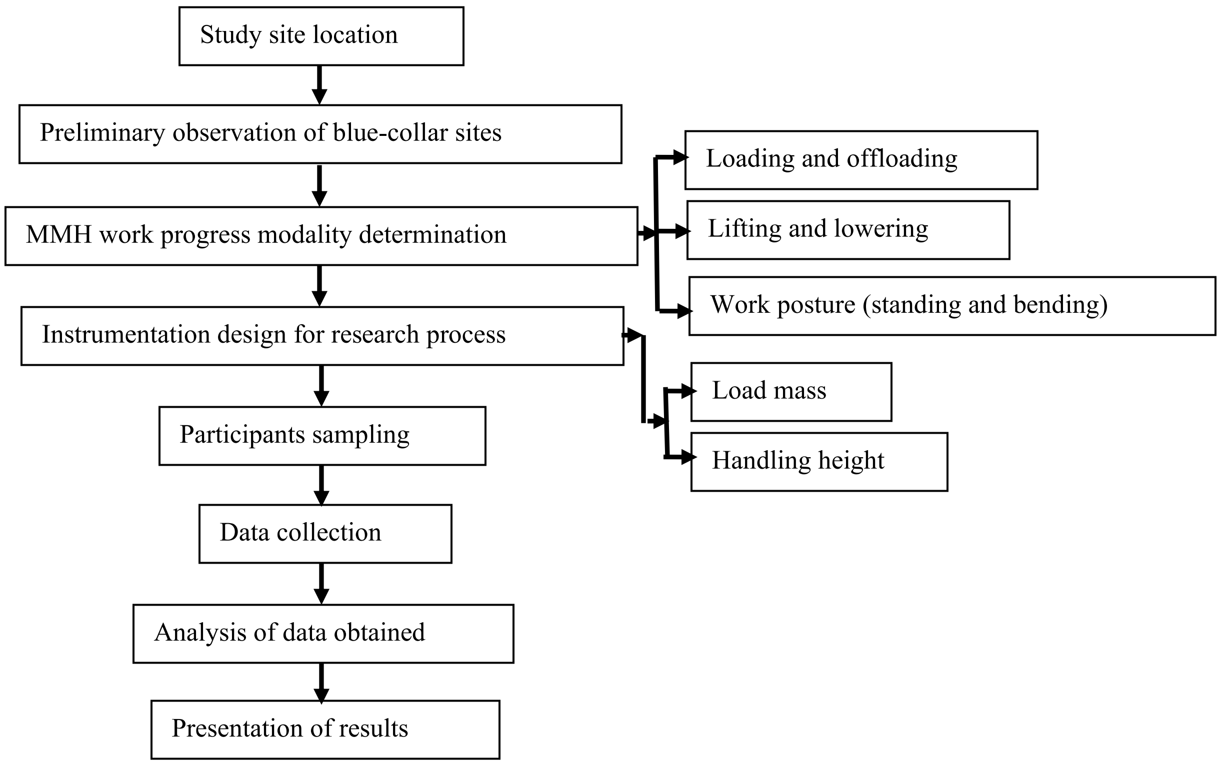

FIGURE 1
SEQUENCE OF THE RESEARCH PROCESS

The targeted study population for this study was male workers within the working-class age of 20-39 years. The number of persons who participated in this study was six hundred and twenty-four (624) persons in Abeokuta, South-Western Nigeria. The peculiarity of the material manual handling for the physical work activity for load capacity relevant in the work environment such as block industries, warehouse, construction sites, and water packaging factories is a single load size but repeated job sequence of operations during every task cycle. The material manual handling operation adopted for the blue-collar job environment using the objective research techniques considered for working condition variables in this study were lifting, lowering, and carrying/transferring. The specific in the materials manual handling encountered in the work environment assessed in this study is the variability of the load mass and the handling height. The MMH operations considered the numbers of each type of mass load count (productivity), endurance time, and work rate. Preliminary observation of materials manual handling jobs that involved load capacity revealed that where workers handle the variable load, there is no fixed time pattern for handling, thereby making the handling work rate also a variable factor. Material manual handling operation, in some cases, requires the worker to exert a larger force less frequently or a smaller strength more often for a given work rate. For all the work cases, the researcher ensured that the overall workload of the participants does not cause excessive fatigue. The instrumentation design for the objective assessment in this study was the following;

i. JKBK solar-powered pedometer of EG-029 (Cielo international Mumbai, Maharashtra), the operation of the portable solar-powered digital pedometer, is for detecting the motion of the participants. The pedometer was hanged at the waist of each of the participants during the work process investigation. The functional specifications of the pedometer applicable for use in this study device are stepping range count (0 - 99999) and distance range count (0 – 99.999 km). The pre-calibrated ranges of applications are for the step length and weight capacity of 30 – 120 cm and 30 – 150 kg, respectively.

ii. A digital professional (LCD) stopwatch of model PC-396 (Shenzhen super deal Co, Ltd, China) was used for recording the duration of the time interval for the work characteristics during the physical work activity assessment.

The derived different handling height and load mass for the MMH work peculiarity conditions considered were;

i. Lifting the mass of 20 kg from the ground to a height of 1.2 m
ii. Lifting the mass of 20 kg from the ground to a height of 2.2 m
iii. Lifting the mass of 10 kg from the ground to a height of 1.2 m
iv. Lifting the mass of 10 kg from the ground to a height of 2.2 m
v. Transferring 20 kg masses on the same level at a standing height
vi. Transferring 20 kg masses on the same level while bending
vii. Transferring 10 kg masses on the same level at a standing height
viii. Transferring 10 kg masses on the same level while bending
ix. Lowering 20 kg mass from a height of 2.2 meters to the ground.
x. Lowering 20 kg mass from a height of 1.2 m to the ground.
xi. Lowering 10 kg mass from a height of 2.2 meters to the ground.
xii. Lowering 10 kg mass from a height of 1.2 m to the ground.
xiii. Lift and movement (Loading and offloading model) using 10 and 20 kg masses

The heights and load mass used were guided by the measured average handling heights and load masses handled in the block industries, warehouses, construction sites, and water packaging factories' work environment. Each participant engaged in the thirteen randomly selected experimental conditions until exhaustion. The number of materials handled and the time it took were noted and registered for each participant's productivity, work rate, and endurance time.

The data obtained from the work processes were summarized using descriptive statistical analysis. The descriptive statistical analysis included measures of location and variability such as mean, range, standard deviation, standard mean error and percentile. Inferential statistical analysis was used to determine whether there is a statistical difference in the following work condition variables; work posture (standing and bending), load mass (10 and 20 kg), handling height (1.2 and 2.2 m), loading and offloading, lifting, and lowering. The Inferential statistical analyses conducted were independent samples t-test and correlation analysis at a significant level of 0.05.

RESULT AND DISCUSSION

I. Material manual handling evaluation through the load lifts handling work condition variable

The descriptive statistical analysis of the task characteristics in the MMH evaluated through the productivity (n), work rate (load handled per min), and endurance time (s) (the maximum length of time during which an individual is capable of lifting a given load at a given frequency continuously [60] for the various lifting handling methods and the load masses are presented in Table I. Table I shows that the maximum average mean of the load mass count was recorded when lifting and moving to offload (LMOL) job operation involving 10 kg load mass. The work outcome for the LMOL could be attributed to the change of posture during the load handling activities as the LMOL load handling method involved lift, carry and move, bend, and drop. The lifting and move to offload (LMOL) job operation is also a work in the direction of gravity that needed less resistance and strength to overcome the weight of the load mass. The movement involved during the LMOL gave some stress relief to the participants. The to and fro movement gave the participant relief and enhanced effectiveness and productivity. Therefore, the change of posture involved in LMOL increased the endurance time to which the participant handled the work. The highest work rate expressed as load mass handled per min was recorded against the job operations during handling 10 kg load mass at a work handling height of 1.2 m (GtW). The result recorded against GtW could be attributed to closeness and relatively less weight of the load.

TABLE I
DESCRIPTIVE STATISTICAL ANALYSIS OF THE LOAD LIFTS HANDLING METHODS

Load (kg)	Variables	Load handling	Mean ± SD	SEM	Range	Percentiles (Th)				
						5	25	50	75	95
10	Productivity	GtW	93.28 ± 29.14	1.17	131.00	50.00	71.25	89.00	114.00	149.00
		GtS	87.49 ± 28.25	1.13	133.00	34.25	69.25	90.00	109.00	128.00
		WtG	109.43 ± 48.56	1.94	178.00	38.00	68.00	108.00	150.00	188.00
		StG	94.39 ± 49.08	1.96	178.00	22.00	58.00	88.00	130.00	190.00

		SLTS	47.43 ± 7.06	0.36	36.00	37.00	42.00	47.00	53.00	60.00
		SLTB	42.21 ± 6.30	0.32	31.00	33.00	37.00	42.00	47.00	53.00
		LMOL	124.76 ± 24.09	1.22	126.00	76.00	112.00	129.00	140.00	160.00
		LML	111.06 ± 21.48	1.09	112.00	67.00	101.00	115.00	126.00	140.00
	Work rate	GtW	2.12 ± 0.61	0.02	4.42	1.14	1.74	2.12	2.39	3.25
		GtS	2.63 ± 2.55	0.10	31.07	0.51	1.24	2.04	3.21	6.34
		WtG	2.87 ± 1.05	0.05	8.43	1.77	2.26	2.66	3.13	4.65
		StG	2.00 ± 1.62	0.08	13.74	0.73	1.21	1.58	2.09	5.27
		SLTS	1.69 ± 1.01	0.05	5.40	0.80	1.10	1.49	1.80	4.30
		SLTB	1.30 ± 0.19	0.01	1.00	1.00	1.19	1.30	1.40	1.60
		LMOL	1.16 ± 0.16	0.01	0.85	0.93	1.03	1.14	1.28	1.41
		LML	1.73 ± 0.36	0.02	1.91	1.19	1.47	1.68	2.02	2.34
	Endurance time	GtW	3009.79 ± 935.22	37.44	4525.00	1601.50	2271.75	2927.50	3685.00	4622.25
		GtS	2683.48 ± 1082.40	43.33	5690.00	936.00	1920.50	2607.00	3419.00	4621.00
		WtG	2195.01 ± 884.61	44.79	4307.00	665.60	1623.25	2193.50	2776.50	3841.90
		StG	3636.69 ± 1837.64	93.05	9307.00	1340.85	2318.25	3280.50	4517.50	7252.30
		SLTS	2135.57 ± 962.82	48.75	4785.00	579.15	1442.25	2054.00	2705.25	3833.10
		SLTB	2046.11 ± 610.35	30.91	3085.00	1221.00	1554.00	1974.00	2491.00	3180.00
		LMOL	6716.06 ± 2061.28	104.38	11282	3390.4	5091	6765.5	8195	10180.5
		LML	4017. 63 ± 1141.11	57.78	5835	2479	3096	3894.5	4850	6050.4
20	Productivity (n)	GtW	41.91 ± 22.20	1.12	76.00	10.55	22.00	42.00	60.00	80.00
		GtS	36.53 ± 11.25	0.57	49.00	17.00	28.00	38.00	46.00	53.00
		WtG	50.64 ± 19.29	0.98	84.00	19.00	36.00	49.00	65.00	82.45
		StG	44.77 ± 19.81	0.79	89.00	13.00	31.00	44.00	56.00	80.75
		SLTS	41.22 ± 5.27	0.21	33.00	33.00	37.00	41.00	45.00	50.00
		SLTB	36.69 ± 4.69	0.19	29.00	29.00	33.00	37.00	40.00	45.00
		LMOL	47.43 ± 7.06	0.36	36.00	37.00	42.00	47.00	53.00	60.00
		LML	42.21 ± 6.30	0.32	31.00	33.00	37.00	42.00	47.00	53.00
	Work rate (Load handled per min)	GtW	0.94 ± 0.69	0.04	3.37	0.19	0.41	0.73	1.41	2.28
		GtS	0.64 ± 0.31	0.02	1.92	0.20	0.43	0.60	0.79	1.24
		WtG	1.04 ± 0.76	0.04	12.83	0.33	0.68	0.95	1.29	1.84
		StG	0.94 ± 0.21	0.01	1.37	0.65	0.81	0.92	1.05	1.31
		SLTS	1.25 ± 0.98	0.04	6.10	0.625	0.80	0.90	1.30	3.20
		SLTB	1.46 ± 1.13	0.07	5.40	0.60	0.80	1.00	1.50	4.30
		LMOL	2.07 ± 2.80	0.11	17.56	0.43	0.54	0.75	2.5	8.33
		LML	0.91 ± 0.21	0.01	1.5	0.7	0.8	0.9	1	1.3
	Endurance time (sec)	GtW	3633.62 ± 1165.52	59.02	6025.00	1869.10	2764.75	3553.00	4471.25	5652
		GtS	3891.67 ± 1300.65	65.86	5640.00	1947.60	2752.50	3880.50	4892.75	6080.85
		WtG	2568.99 ± 1063.45	42.57	6257.00	1172.00	1658.00	2504.00	3403.25	4309.00
		StG	1821.65 ± 1767.04	70.74	7357.00	0.00	0.00	1772.00	3058.00	5176.25
		SLTS	2586.09 ± 1046.80	41.91	5081.00	745.50	1845.50	2628.00	3353.00	4262.25
		SLTB	2084.75 ± 935.93	37.47	4202.00	535.00	1320.00	2122.00	2771.25	3611.50
		LMOL	4953.17 ± 1367.32	69.24	7625	2795.45	3915	4949	5922.5	7151.8
		LML	2903.99 ± 724.26	36.67	4214.00	1686.40	2409.00	2902.50	3373.00	4140.50

GtW - Ground to 1.2 m; GtS - Ground to 2.2 m; WtG - 1.2 m to Ground; StG - 2.2m to Ground; SLTS - Same Level Transfer Standing; SLTB - Same Level Transfer Bending; LML - lifting and move to load; LMOL - lifting and move to offload

II. Effect of endurance time on productivity

The implication of an individual's endurance time on productivity was analyzed using correlation analysis. Table II shows that there is a positive and significant (p = 0.00) correlation between endurance time and productivity for a load mass of 10 kg. However, the reverse was observed for a load mass of 20 kg. The correlation coefficient, r-value, recorded between endurance time and productivity for the load mass of 20 kg, was -0.112 significant at p = 0.03. The analyzed data showed that the maximum length of time during which the participants' load lifting capability increases translate to the productivity under 10 kg load mass capacity. This result means that the productivity of the participants continuously in the work process increase with the endurance time when the load mass is less. For a productive long working time, there is a need for the reduction of load mass.

TABLE II
CORRELATION BETWEEN ENDURANCE TIME AND PRODUCTIVITY

Load mass (kg)	No of participants	*r*-value	*p*-value
10	624	0.454*	0.00
20	390	-0.112*	0,03

* Correlation is significant at the 0.05 level (2-tailed)

III.Effect of Endurance Time on Work rate

The relationship between endurance time and work rate was investigated using bi-variant correlation analysis to determine if there is any difference or similarity in how two variables change for the value obtained from the participants. Table III shows that the maximum length of time during which the participants' load lifting capability decreases is inverse to the workload handled per time under each of the load mass capacity considered. The "*r*" values for the correlation analysis were -0.527 and -0.585 for 10 kg and 20 kg load masses, respectively, which were significant at $p = 0.00$ (Table III). This result means that the work rate at which the participants continuously lift the load decrease with the endurance time. For a longer working time, there is a need that the work rate is reduced for a longer period of load lift handling. The observation in this study agreed with Genaidy and Asfour (1989) that endurance time is inversely proportional to work rate in load handling.

TABLE III
CORRELATION BETWEEN ENDURANCE TIME AND PRODUCTIVITY

Load mass (kg)	No of participants	*r*-value	*p*-value
10	624	-0.527	0.00
20	390	-0.585	0,00

*. Correlation is significant at the 0.05 level (2-tailed).

IV. Independent Sample T-test Analysis between Lifting and Lowering at 1.2 m and 2.2 m Handling Heights on Work Outcome

The independent-sample t-test showed that the mean value for productivity during the lifting load mass of 10 kg job operations to a height of 1.2 m was statistically significantly lower (Mean = 93.28±29.14, SEM = 1.13) when compared to the mean value during the lowering job operations (Mean ± SD = 109.43 ± 48.56, SEM = 1.94) at *p*-value less than 0.05. At the height of 2.2 m, the mean value for productivity was 87.49±28.25, which was lower than the lower job operation (94.39±49.08) at the same height but not significant (Table IV). For work rate measured by the number of materials handled in a minute (load handled per min), the mean values of the work rate at 1.2 m and 2.2 m heights were statistically significantly lower than the lower operations (Table IV). The dependency of the participant's muscle or muscle group in the repetitive operation in handling the load masses over a while without fail through the engagement of their maximal force at a particular work rate assessed showed variation in the mean values between the lifting and lowering job operations. For a load mass of 10 kg, the average mean value for endurance time of 2195.01 ± 884.61s was recorded during the lifting operation, whereas it was 3009.79 ± 935.22s through a height of 1.2 m which was statistically higher when compared with the lowering operation (Mean = 2195.01 ± 884.61, SEM = 44.79). The endurance time took a similar trend at the height of 2.2m as the statistical mean for lifting operation was lower (Mean = 2683.48 ± 1082.40, SEM = 43.33) as compared with the mean of the lowering operation (Mean = 2683.48 ± 1082.40, SEM = 43.33). The work outcome variables used, productivity, work rate and endurance time, in the analysis of the lifting and lowering job operation at 1.2 m and 2.2 m handling heights using a load mass of 20 kg showed that the groups' means of the lifting and lowering job operation are significantly different but for endurance time at the handling height of 2.2 m. The statistical significance was observed at *a p*-value of less than 0.05 (Table IV). From the result in this study, it can be inferred that the demands on the worker for productivity, the work rate of job handling, and endurance are higher during the lifting job operation than the effects of lowering job operation. This result could be due to the strength needed to overcome the mass of the load and work against gravity during the lifting operations.

TABLE IV
INDEPENDENT SAMPLE T-TEST FOR LIFTING AND LOWERING JOB OPERATIONS

escriptive statistics						T-test result		
Load mass	Variable	Lift height	N	Mean ± SD	SEM	*t*	df	*p*-value
10 kg	Productivity	GtW	624	93.28 ± 29.14	1.17	-13.27	623	0.00
		WtG	624	109.43 ± 48.56	1.94			
		GtS	390	87.49 ± 28.25	1.13			0.48
		StG	390	94.39 ± 49.08	1.27	-0.71	623	
	Work rate	GtW	624	2.12 ± 0.61	0.02			0.00
		WtG	624	2.87 ± 1.05	0.05	-9.38	389	
		GtS	390	2.63 ± 2.55	0.10			0.00
		StG	390	2.00 ± 1.62	0.08	5.44	389	
	Endurance time	GtW	624	2195.01 ± 884.61	44.79			0.00
		WtG	624	3009.79 ± 935.22	37.44	12	389	
		GtS	390	2683.48 ± 1082.40	43.33			0.00
		StG	390	3636.69 ± 1837.64	93.05	-8.36	389	
20 kg	Productivity	GtW	390	41.91 ± 22.20	1.12			
		WtG	390	50.64 ± 19.29	0.98	-11.97	389	0.00
		GtS	390	36.53 ± 11.25	0.57			0.00
		StG	390	44.77 ± 19.81	0.79	-8.09	389	
	Work rate	GtW	390	2.36 ± 1.73	0.09			
		WtG	390	1.41 ± 0.82	0.04	-2.21	389	0.03
		GtS	390	1.41 ± 0.82	0.04		389	0.00
		StG	390	1.71 ± 1.23	0.06	62.47		
	Endurance time	GtW	390	1453.35 ± 466.21	23.61			
		WtG	390	3201.8 ± 836.6	42.36	6.18	389	0.00
		GtS	390	2840.63 ± 949.38	48.07		389	0.32
		StG	390	2914.64 ± 1344.19	68.07	11.71		

GtW - Ground to 1.2 m; GtS - Ground to 2.2 m; WtG - 1.2 m to Ground; WtS- Ground to 2.2 m;

V. Independent Sample T-test Analysis between 10 kg and 20 kg Load Masses Work Variables on Work Outcome

In Table V, the mean score for the load mass of 10 kg productivity was 93.28 ± 29.14, and that of 20 kg was 41.91 ± 22.20 for lifting from ground to 1.2 m. The average mean values obtained for the 10 and 20 kg mass showed that half of the productivity of 10 kg mass productivity was higher than the productivity of the 20 kg load mass. The variation was found to be significant at a *p*-value of less than 0.05. An independent *t*-test analysis between work outcomes measured using the work rate for the load mass variables (10 and 20 kg) showed that the number of 10 kg load mass handled per minute was significantly higher than the 20 kg load mass. Independent *t*-test analysis of the endurance time in executing the work between the load mass variables of 10 and 20 kg was found to be significant, $t(389) = -15.07$, $p < 0.05$ (Table 5). The assessment carried out to determine if it was better to handle small loads frequently or large loads infrequently showed that the higher capacity of the load mass affects the work rate and the endurance time, reflecting in the productivity as the participants handle lighter loads at a greater work rate.

It, therefore, necessitated that in a work situation where the load can be split, such should be adopted as material manual handling of lesser load mass in this study grants higher productivity, the work rate of job handling, and endurance time.

TABLE V
INDEPENDENT SAMPLE T-TEST FOR 10 KG AND 20 KG LOAD MASS VARIABLES

Descriptive statistics					T-test result		
Handling heights (m)	Variable	Load mass (kg)	Mean ± SD	SEM	*t*	df	*p*-value
1.2	Productivity	10	87.49 ± 28.25	1.13			0.00
		20	41.91 ± 22.20	1.12	30.51	389	
	Work rate	10	2.12 ± 0.61	0.02			0.00
		20	0.94 ± 0.69	0.04	24.77	389	
	Endurance time	10	3009.79 ± 935.22	37.44			0.00
		20	3633.62 ± 1165.52	59.02	-13.93	389	
2.2	Productivity	10	93.28 ± 29.14	1.17			
		20	36.53 ± 11.25	0.57	36.12	389	0.00
	Work rate	10	2.63 ± 2.55	0.10			
		20	0.64 ± 0.31	0.02	15.69	389	0.00
	Endurance time	10	2683.48 ± 1082.40	43.33			
		20	3891.67 ± 1300.65	65.86	-15.07	389	0.00

VI. Independent Sample T-test Analysis between 1.2 m and 2.2 m Handling Heights on Work Outcome

The analysis on the impact of handling height on the outcome of work variable conducted using the independent t-test between working heights of 1.2m and 2.2 m heights showed higher productivity at a handling height of 1.2m (Mean = 93.28 ± 29.14, SEM = 29.14) compared to the productivity work outcome value at a handling height of 2.2 m (Mean = 87.49 ± 28.25, SEM = 28.25) (Table 6) at *p*-value = 0.00. Since the p-value obtained is less than 0.05, it is considered significantly different. The independent t-test analysis on the work rate outcome variables used to determine whether there is a certainty that work rate at the work handling height of 1.2 m was statistically different from the work handling height of 2.2 m showed that the work rate at 1.2 m work handling height had statistically higher mean values (Mean ± SD = 2.63 ± 2.55, SEM = 2.55) compared to 1.2 m work handling height (Mean ± SD = 2.12 ± 0.61, SEM = 0.61). The variation of the work rate outcome at the two work handling heights was significant at a confidence level of $p < 0.05$ (Table 6). In Table 6, the endurance time for the material manual handling had a mean score of 3009.79s at a work handling height of 1.2 m and 2683.48 at work a handling height of 2.2 m. The standard deviation for the work handling height of 1.2 m was 935.22s which varied from the value of 1082.4 sec obtained for the standard deviation for the work handling height of 2.2 m. The independent t-test analysis between the two work handling heights, 1.2m, and 2.2m, was significant, $t(623) = 5.56$, $p < 0.05$ (Table VI). This physical work activity carried out using the 10 kg and 20 kg load mass observation similar results in the productivity, work rate, and endurance time. The significant difference between the work outcome variable of 1.2m and 2.2 m work handling heights showed that the endurance time effects during MMH at 2.2 m work handling heights superseded the work demand for the load mass MMH at 1.2 m handling height. The outcome of this result implies that higher height affects the work outcome variable.

Descriptive statistics					T-test result		
Load mass (kg)	Variable	Handling heights (m)	Mean ± SD	SEM	T	Df	*p*-value
10	Productivity	1.2	93.28 ± 29.14	29.14			0.00
		2.2	87.49 ± 28.25	28.25	-3.62	623	
	Work rate	1.2	2.63 ± 2.55	2.55			0.00
		2.2	2.12 ± 0.61	0.61	-4.61	623	
	Endurance time	1.2	3009.79 ± 935.22	935.22			0.00
		2.2	2683.48 ± 1082.4	1082.4	5.56	623	
20	Productivity	1.2	41.91 ± 22.2	22.2			
		2.2	36.53 ± 11.25	11.25	3.58	389	0.00
	Work rate	1.2	0.94 ± 0.69	0.69			
		2.2	0.64 ± 0.31	0.31	8.02	389	0.00
	Endurance time	1.2	3633.62 ± 1165.52	1165.52			
		2.2	3891.67 ± 1300.65	1300.65	-5.51	389	0.00

TABLE VI
INDEPENDENT SAMPLE T-TEST FOR 1.2 M AND 2.2 M HANDLING HEIGHT VARIABLES

VII. Independent Sample T-test Analysis between Loading and Offloading Load Lifts Handling on Work Outcome

The load lifting capability in various work environments involves lifting, carrying, and lowering. In some cases, it involves moving with the load over a distance. This is found in the loading and offloading handling processes. The independent-sample t-test for the effect of lifting capacity on loading and offloading handling showed that loading that involved bend and lifts carry and move. The drop had statistically significant higher mean values for the productivity (n), work rate (load handled per min) and endurance time (s) compared to offloading, which involved lifting, carry and move, bend and drop. The groups' means are different but not significant as the *p*-value is greater than 0.05 (Table VII). This could be attributed to the fact that offloading job operations in MMH that involves handling load at heights in the direction of gravity need much guidance of the workers with less strength to overcome the weight of the load mass. The significance obtained in the analysis carried out in this study showed that the strength involved in the LML handling operations affected the work outcome. This result then implies that the participants' effectiveness through productivity, the work rate of handling the load and work rate was higher when handling loads in offloading operations than the loading operation.

Descriptive statistics					T-test result		
Load mass (kg)	Variable	MMH	Mean ± SD	SEM	T	Df	*p*-value
10	Productivity	LMOL	124.76 ± 24.09	1.22	94.23	389	0.00
		LML	111.06 ± 21.48	1.09			
	Work rate	LMOL	2.48 ± 0.53	0.03	85.85	389	0.00
		LML	1.73 ± 0.36	0.02			
	Endurance time	LMOL	7546.13 ± 2316.00	26.57	50.24	389	0.00
		LML	4017.63 ± 1141.11	44.79			
20	Productivity	LMOL	47.43 ± 7.06	0.36	118.79	389	0.00
		LML	42.21 ± 6.30	0.32			
	Work rate	LMOL	1.04 ± 0.28	0.01	13.18	389	0.00
		LML	0.91 ± 0.21	0.01			
	Endurance time	LMOL	8705.08 ± 2402.98	121.68	61.52	389	0.00
		LML	2904.00 ± 724.26	36.67			

TABLE VII
INDEPENDENT SAMPLE T-TEST FOR LOADING AND OFFLOADING

VIII. Independent Sample T-test Analysis between Standing and Bending Work Posture on Work Outcome

Posture is one of the physical factors in the working conditions variables significant in achieving the organizational objective in any working environment as it influences muscular endurance. Any working posture assumed during physical work activity depends on its sustenance over a while without frequent breaks for recovery. Transfer of load mass over a relatively short distance, mostly in stacking or arrangement of materials at the same level, may not demand much walk movement. The lifting and transfer capacity comparison test predicated on the posture, which was analyzed using the three work outcome variables: productivity, work rate and endurance time between standing and bending postures using an independent t-test showed that the three work outcome variables, productivity, work rate and endurance time in standing posture have a higher mean. All the results obtained were significantly different at $p < 0.05$ (Table VIII). The effect of posture on MMH showed that standing posture offers better work outcomes than bending posture. It then implies that in handling load, the posture should be considered as it affects the productivity, the work rate, and the maximum length of time during which an individual was capable of lifting a given load at a given work rate continuously.

TABLE VIII
INDEPENDENT SAMPLE T-TEST FOR WORK POSTURE IN LIFTING CAPACITY

Descriptive statistics					T-test result		
Load mass (kg)	Variable	Lift height	Mean ± SD	SEM	T	Df	*p*-value
10	Productivity	Standing	47.43 ± 7.06	0.36			
		Bending	42.21 ± 6.3	0.32	118.79	389	0
	Work rate	Standing	1.69 ± 1.01	0.05			
		Bending	1.30 ± 0.19	0.01	7.96	389	0
	Endurance time	Standing	2135.57 ± 962.82	48.75			
		Bending	2046.11 ± 610.35	30.91	2.15	389	0.03
20	Productivity	Standing	41.22 ± 5.27	0.21			
		Bending	36.69 ± 4.69	0.19	157.98	623	0
	Work rate	Standing	1.14 ± 0.89	0.06			
		Bending	1.46 ± 1.13	0.07	-3.64	258	0
	Endurance time	Standing	2586.08 ± 1046.8	41.91			
		Bending	2084.75 ± 935.93	37.47	9.08	623	0

CONCLUSION

The fundamental work-related health challenges like musculoskeletal disorders in heavy material handling tasks and repetitive activities proliferate are longstanding and widespread among blue-collar workers. Proper job evaluation and specifications of the work condition variables for identifying work-related risk factors, implementation, and adherence of the safe work processes in the work environment accounts for a safe work environment. The effects of working condition variables on the work outcome variables of the MMH in a blue-collar job considered for a work environment where works training is ineffective and the work station cannot be redesigned assessed an objective research approach, revealed that in situations where a high work rate is needed, there is a need to reduce the load mass. The increased endurance time to which the participants handled the work gave the participant relief and enhanced the effectiveness and productivity. However, the endurance time varies inversely with the work rate in load handling but positively correlated with productivity. This study, therefore, recommends standing work posture for load mass transfer and load split into lesser load mass for work processes that involve handling height, loading and offloading, and lifting and lowering operations.

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