ASSESSMENT OF THE KINEMATICS OF HANDLING LOADS: BASIS FOR DESIGN AND DEVELOPMENT OF ERGONOMIC INTERVENTION

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Abstract

Kape at Kakaong Batangas is a small scale firm that caters coffee-bean roasting to the coffee farmers in Lipa City. The company still employs the conventional process especially in material handling. The process manifests the kinematics of the body while handling loads which requires lifting and carrying sacks of coffee beans while climbing the ladder to reach the huller. This process poses exposure to risk factors that could result to low-back pains which is a type of Work-related Musculoskeletal Disorder (WMSD). The purpose of this study is to design and develop an ergonomic intervention that will provide ease and efficiency to the workers particularly in the roasting section. Anthropometric measurements of 100 males were obtained which served as bases for the design of prototype. Ergonomic assessment tools were used such as NIOSH Lifting Equation, Quick Exposure Check (QEC), Manual handling Assessment Chart (MAC), Manual Task Risk Assessment (ManTRA) and Tile, individual, Load and Environment (TILE) assessment. The operations in the roasting section were assessed to ascertain the risk factors present and the level of exposure of the workers. The results of the assessments revealed that there is moderate to very high exposure to risk which is evident in manual material handling. After the assessment, necessary ergonomic intervention was formulated. A screw conveyor was designed and developed as an engineering controlthat aids to eliminate the team-lifting and manual material handling resulting to a very low risk exposure among the workers in the hulling section.

Keywords: Ergonomics, Kinematics of Handling Loads, Ergonomic Assessments, Work-related Musculoskeletal Disorders, Ergonomic Intervention

1. Introduction

Ergonomics is a scientific discipline that is focused on providing fit and suitable design of the human and work environment based on the individual's qualities and attributes. Its major objective is that man-made tools, machines, equipment, devices, and environment should enhance and upgrade, explicitly and implicitly, the welfare, safety and well-being, and performance of an individual or group of people (Kroemer, 2017). It is the rational train that involves the understanding of collaboration and harmony among people and various elements of a structure, and the calling that harness standards, hypothesis and proposition, information and tactics to configuration with certainty on the intention to heighten human prosperity, and framework execution in general (International Ergonomics Association, 2015).

The goal of ergonomics is to promote workers' safety and for workers to handle workloads with ease by developing and designing ergonomic intervention for the task. In a workstation, there are jobs that include frequent lifting and carrying tasks without help from other workers or equipment, performing only a singletask or movement for a prolonged period of time, sometimes exceeding to eight hours a dayin a much faster pace of work while lifting or carrying heavy loads. Ergonomics aims to identify workplace hazards and ergonomics risk factors which can plague the body of the workers. Throughout the day, workers are exposed to physical stress of the body, fatigue from activities requiring overexertion with forceful repetitions, awkward postures, repetitive motion and heavy lifting. Safe working environment can be achieved by applying ergonomics to the workstation which requires thorough assessment to identify human hazards and ergonomic risk factors present in the workstation.

Applying ergonomics often helps the company to a greater success and provides a safety culture in the workstation where workers can perform their duties to utmost with motivation and peace of mind that they are being taken cared for by the company. Throughout a typical workday, workers handle a variety of equipment and materials such as heavy coffee beans sacks and other lifting equipment. The bodies are exposed to ergonomic risk factors due to manual handling of materials. In performing the operations, workers exert heavy force when lifting and loading coffee beans to the machine. Using ergonomic assessment in manual material handling, and providing ergonomic intervention, thee workers can do job safely, and with ease and efficiency.

Kinematics of handling loads in the company is concerned with the manual material handling, transferring, loading and lifting of coffee beans sacks which are evident at Kape at KakaongBatangas when workers load coffee beans to the hulling machine which are identified through sets of ergonomic risk assessment focused on manual material handling. The ill-advised manual treatment of materials as often as possible will result to musculoskeletal dosrders, most regularly business related lower back wounds/torment.

Manual material handling (MMH) is the way toward moving or supporting a question by physical power. Pushing, pulling, lifting and conveying are for the most part cases of manual dealing with tasks. MMH represents a few dangers to workers. The contributing variables for these dangers fluctuate, yet incorporate the weight, size, shape and steadiness of the protest;

recurrence and separation of the move; and the body mechanics and in general well-being concerning security condition of the specialists (CCOHS, 2018). Work-related low back pain and injuries are the most generally perceived musculoskeletal disorder caused by manually handling materials. Segments that extend the threat of harm fuse the stack being excessively significant, colossal, and difficult to understand or flimsy. The task being exorbitantly strenuous includes lumbering positions or advancements, and the working environment which lacks satisfactory space is obvious at the Kape at KakaongBatangas. The existing procedure of stacking espresso beans utilizing vertical stage expects the worker to lift and carry the overwhelming 60kgs espresso beans sack while climbing the stairs to the platform.

Espresso or coffee is the second-most-exchanged product, generally devoured by industrialized countries while being created by less created countries. It has a long and overall ware chain that includes creation, trading, bringing in, broiling, dispersion and retail. After reaping, espresso is either obtained from agriculturists by agents, or specifically sent out by extensive espresso domains and ranches. The production of coffee goes through different processes such as preparing the raw goods, hulling, roasting and grinding before packaging it for delivery or retail. Intensive tasks in producing coffee exposed workers in risk factors such as repetitive motion due to high frequency of production, high forces and awkward postures.

One of the most prevalentreasons of ergonomic risk factors is manual material handling (MMH). This study aimed to analyze the existing operations in coffee hulling process, and develop ergonomic intervention related to manual material handling tasks. These tasks include loading of coffee beans to the huller were activities such as lifting, carrying, and manually loading the sacks of coffee beans to the hulling machine are done.There is a Threshold Limit Values (TLV) that plans to decrease the predominance of work-related wounds caused by introduction to manual dealing by putting limits on the heaviness of burdens to be dealt with. Edge measurements of tedious work must incorporate thought of the level of effort, and the stances required, and additionally the level of reiteration and term (Burgess-Limerick, 2003).

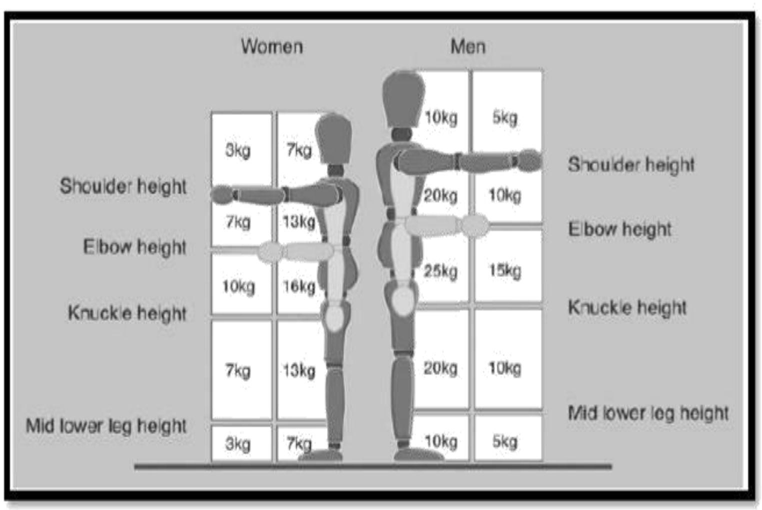


Figure 1. The Weight Guidelines

No single individual ought to be compelled to carry or lift, lower or convey stacks greater than 55 kg. This point of confinement would just apply, nonetheless, when the load matches the individual's abilities and no other hazard elements are available (eg. no bowing or turning is required to get the load; the load is smaller and simple to get a handle on; it is held near the storage compartment and not conveyed as often as possible or for long separations) (Worksafe WA, 2000).

2. Materials and Methods

The study focused on assessment of kinematics of handling loads and development and design of ergonomic intervention. To achieve the goal of the study, the researcher used descriptive and case study type of research toassess and evaluate the impact of improper or awkward working posture of the workers at Kape at KakaongBatangas which rooted from manual handling and lifting of coffee beans sacks before loading to the hulling machine. The study is suitable for elimination of ergonomic risk factors associated with manual material handling.

The descriptive research methodology is an indispensableresearch strategy that focuses on the situation, as it occurs in its momentum state. Engaging examination comprisesdiscerning proof of traits of a specific wonder in light of an observational premise, or the examination of connection between at least two marvels (Leedy and Ormrod, 2001). In this study, the researchers described the existing process in loading the sack of coffee beans to the machine at Kape at KakaongBatangas. It is analyzed that the awkward working postures should be eliminated or corrected due to intense physical effort and forceful exertions.

Case study research design is the examination of a single or multiple specific instances of something that includes the cases in the research study. It can be something relatively distinct such as an organization, a group or an individual, or something more abstract such as an event, a management decision or a change programme (Yin 2014, Gomm ,2001). In this study, the researcher identified ergonomic risk factors with the use of assessment tools to further evaluate the coffee beans hulling process. The manual material handling at Kape at KakaongBatangas poses risks to the workers such as awkward postures, forceful exertions, and repetitiveness that may affect their health and safety.

This study focused on the six (6) workers who are directly involved in the hulling process. They were the major respondents as well as the owner of the company. The researcher collected anthropometric measurements and use the design for the minimum population value because this design is an applicableapproach if a given minimum value of some design characteristics must accommodate the entire population (Niebel and Freivalds, 2014).The ergonomic analysis requires the proponent to utilize anthropometric data. The major objective of measurement and approximation of anthropometric data is to develop “machines” which matches or improves the fit with the target users. By enhancing the design, it implies that the workers comfort and convenience is upgraded, thus reducing or eliminating the strain and fatigue felt by the body while exposed in a physically challenging work environment (Hodson, 2001).

In this study, different ergonomic assessment tools were used to evaluate the material handling process in the hulling section. The following are the tools and instruments used in the conduct of the study:

2.1 Quick Exposure Checklist (QEC)

The QEC was developed to enable the ergonomist and health and safety practitioners to undertake evaluation of the workers' exposure to ergonomic hazards and risk factors (Li and Buckle, 1999). Quick Exposure Check underscores the evaluation on the level of exposure and change in exposure, thus allowing the advantages of ergonomic interventions and engineering controls to be evaluated speedily.

2.2 Manual Handling Assessment Chart (MAC)

MAC tool was developed to aid the user in identifying the level of risks in manual handling tasks which can be utilized to evaluate the hazards accompanied by manual lifting, carrying and team manual handling activities. It is designed for a better comprehension, interpretation, and categorization of the level of risks of the different risk factors involved in manual handling activities. Thisintegrates a numerical and a color-coding scoring method to emphasize the high-risk manual handling activities.

2.3 NIOSH Lifting Equation

The NIOSH Lifting Equation is an instrument used to evaluate the risks related in manual material handling which includes lifting and lowering tasks within a workstation. The mainoutput of the NIOSH lifting equation is Recommended Weight Limit (RWL) which connotes the maximum allowable weight (load) that almost all healthy workers or operators could lift over the course of an 8-hour shift without increasing the risk of musculoskeletal disorders (MSD) to the lower back. Furthermore, NIOSH also calculates a Lifting Index (LI) to establish a comparativeassessment of the intensity of physical stress and WMSD hazardconnected with the manual lifting work activities evaluated.

2.4 Manual Task Risk Assessment Tool (ManTRA)

A Manual Tasks Risk Assessment Tool (ManTRA) is a tool that is intended for use by overseers amid working environment reviews to give an appraisal of the level of danger of damage related with particular work environment undertakings. The instrument was created as a major aspect of an examination joint effort between Curtin University of Technology, the University of Queensland, and the Division of Workplace Health and Safety.

3. Results and Discussions

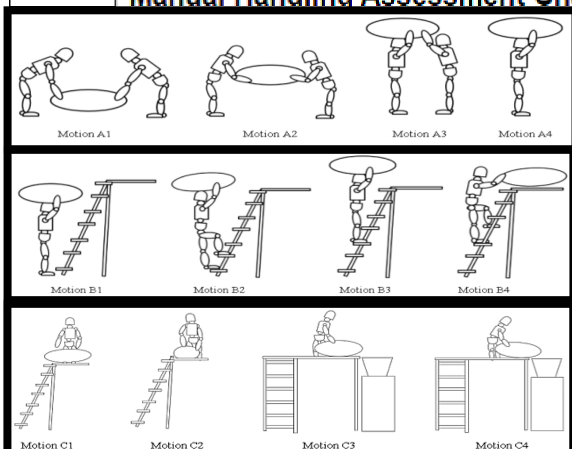
3.1 Status of current operations in terms of ergonomic safety

The succeeding Table 1 shows the MAC score sheet with four color bands G, A, R and P. G is green (low level of risk), A is amber (medium level of risk), R is red (high level of risk) and P is purple (very high level of risk). Lifting operations' total score is 23; carrying operations total score is 24; while team handling's total score is 21. In the manual handling assessment checklist result, carrying has the highest total score with 24 where ergonomic risk is evident and intense. The researcher observed that the workers may suffer from numbness, and back pain due to team lifting or handling, and manual carrying of load onto the head or shoulders. Therefore, the workers' exposure to ergonomic risk and hazards need to be eliminated or reduced to avoid work-related low back pain and other possible work-related musculoskeletal disorders.

Table 1. MAC Score Sheet for Manual Material Handling

HSE Health & Safety Executive

Manual Handling Assessment Charts (MAC) - Score Sheet



Insert the colour band for each of the risk factors in the boxes below, referring to your assessment using the tool.

Risk Factors	Colour Band (G, A, R, or P)			Numerical Score		
	Lift	Carry	Team	Lift	Carry	Team
Load weight and lift/carry frequency	Purple	Purple	Red	10	10	6
Hand distance from the lower back	Red	Red	Red	6	6	6
Vertical lift region	Red		Red	3		3
Trunk twisting/sideways bending Asymmetrical trunk/load *(carrying)*	Green	Green	Green	0	0	0
Postural constraints	Green	Green	Green	0	0	0
Grip on the load	Red	Red	Red	2	2	3
Floor surface	Green	Green	Green	0	0	0
Other environmental factors	Red	Red	Red	2	2	2
Carry distance *(carrying only)*		Amber			1	
Obstacles en route *(carrying only)*		Red			3	
Communication and co-ordination *(team handling only)*			Amber			1
Total Score				23	24	21

Other risk factors, eg individual factors, psychosocial factors etc
For information on reducing the risks of individual or psychosocial factors Click here

Are there indications that the task is high risk? (please tick appropriate boxes)

- [ ] Task has a history of manual handling incidents *(eg company accident book, RIDDOR reports)*
- [x] Task is known to be hard work or high risk
- [x] Employees doing the work show signs that they are finding it hard work *(eg breathing heavily, red-faced, sweating)*
- [ ] Other indications, if so what?

Signature ______ Date 04/07/2018

The TILE assessment shown in the following Table 2 reflects the risk factors that are evident in the team-lifting. The work load is heavy and strenuous since the workers need to carry an average of 60 kg sack of coffee beans to be transferred to the platform where the huller is located. The task requires physical effort with excessive lifting that could result to low back pain. Further, the tasks demand to be repeated several times since 60-70 sacks of coffee beans need to be hulled per day. This poses ergonomic hazards to the workers since the job is done manually. Work practice control is important to provide harmless & effective procedures for successfully attaining the work activities can decrease WMSD risk. Further, it is necessary that workers be guided on the correct work practices and inspirethem to accept their responsibilities for WMSD elimination or prevention (Middlesworth, 2010).

Table 2 TILE Assessment for Team Lift

	DESCRIPTION	REMARKS
TASK	"Motion A" shows the initial team lift which is done every 10-15 minutes for 8 hours work shift Motion A1 - stooping, reaching downward, bent back, facing forward, static position, reaching away from the body Motion A2 – bent back, supporting load with arm and shoulder, reaching away from the body, static position Motion A3 – straight back, overhead lifting, reaching upwards, grasping unstable load, balancing load Motion A4 – single-carrying of coffee beans sack, straight back, hand and arms overhead and away from the body, straight body maintaining balance ready for carrying	Motion A has high risk exposure level due to the identified risk factors such as awkward postures, forceful and sustained exertions, repetitive motion, the load is (heavy, unwieldy, has to be held at a distance from the trunk), strenuous, physical effort made with body in and unstable, over frequent, insufficient recovery period, excessive lifting and carrying (HSE, 1992). Low back is prone to ergonomic risk and other parts of the body. The workers repeat motion every time they need to queue coffee beans sacks on top of the platform that need to be hulled. Motions took short time but required high frequency which is taxing to the bodies of the worker that can result to job-related low back pain/injuries. Other parts of the body are exposed to ergonomic risk factors. The workers repeat motion every time they need to queue sack of coffee beans on top of the platform that need to be hulled. Motions took short time but required high frequency which is taxing to the bodies of the worker that can result to work-related low back pain/injuries.
INDIVIDUAL	Workers on coffee beans hulling process are not physically fit for the tasks as the one carrying the load has 5'1" height which is short and not well-built to support the kind of tasks. Extra effort and energy are needed by the workers just to execute the required motions for the tasks	Workers that should be assigned need to be physically fit and should know the proper procedure when lifting heavy loads. Workers need to do the tasks continuously to meet the quota for the day which is 60 to 70 coffee beans sacks that need to be hulled.

LOAD	The sack contains coffee beans (raw materials) weighing maximum of 60kgs, heavy to be lifted by one person, bulky, difficult to grasp due to irregular shape and unstable overhead lift due to unequal weight distribution. There are 60-70 coffee beans sacks that need to be hulled in a day.	No single individual ought to be allowed to lift or carry, lower or convey stacks greater than 55 kg. This point of confinement would just apply, nonetheless, when the load is inside the individual's abilities and no other hazard factors are available (Worksafe WA. 2000)
ENVIRONMENT	Workstation has minimal space constraints, dry flooring which is suitable, even floor, low lighting, extreme hot temperature and low visibility due to smoke produced by coffee bean roasting process.	Space constraints can cause accidents and extra motions when doing the tasks. Low visibility and extreme hot temperatures can affect the safety and health of the workers as they need to climb the platform which is risky. The task is repeated many times since operators work for 8 hours a day.

Similarly, ergonomic hazards were presented in the TILE assessment in carrying the loadshown in the succeeding Table 3. The task demand physical effort as the worker climb up the stairs to reach the platform while carrying the sack of coffee beans. The task will have to be repeated many times since 60-70 sacks of coffee beans need to be hulled per day. The worker has to queue the sacks in the platform for hulling. This means that the worker is repetitively performing strenuous activity that poses ergonomic risks.

Table 3 TILE Assessment in Carrying the Load

	DESCRIPTION	REMARKS
TASK	"Motion B" shows the single carrying of coffee beans sack which is done every 10-15 minutes for 8 hour-work shift Motion B1 – hands away from the body while supporting the load, straight back, neck and head to balance the load while carrying the sack Motion B2 – climbing up the ladder's step while carrying the load Motion B3 – carrying the load near the top of the platform and preparing to toss the sack Motion B4 – reaching forward and hands away from the torso while tossing the sacks on top of the platform which needs arm and shoulder strength	Motion B has high risk exposure level due to the identified risk factors, the load is (heavy, unwieldy, has to be held at a distance from the trunk), strenuous, physical effort made with body in and unstable, over frequent, insufficient recovery period, excessive lifting and carrying (HSE, 1992). Low back and other body segments are prone to ergonomic risk. The employees repeat the motion every time they need to queue coffee beans sacks on top of the platform in preparation for the hulling process. Motions take short time but demands high frequency which is taxing to the body that can result to work-related low back pain/injuries.

INDIVIDUAL	Workers on coffee beans hulling process are not physically fit for the tasks as the one carrying the load has 5'1" height which is short and not well-built body for this kind of tasks. Extra effort and energy are needed by the workers just to execute the required motions for the tasks.	Workers that should be assigned need to be physically fit and know proper procedure when lifting heavy loads. Workers need to do the tasks continuously to meet the quota for the day which is 60 to 70 coffee beans sacks that need to be hulled.
LOAD	The sack contains coffee beans (raw materials) weighing maximum of 60kgs, heavy to be lifted by one person, bulky, difficult to grasp due to irregular shape and unstable overhead lift due to unequal weight distributed. There are 60-70 coffee beans sacks that need to be hulled in a day.	No single individual ought to be compelled to carry or lift, lower or convey stacks greater than 55 kg. This point of confinement would just apply, nonetheless, when the load is inside the individual's abilities and no other hazard factors are available (Worksafe WA. 2000)
ENVIRONMENT	Workstation has minimal space constraints, dry flooring which is suitable, even floor, low lighting, extreme hot temperature and low visibility due to smoke produced by coffee bean roasting process. Further, a narrow and steep ladder is used by the workers to reach the huller platform while the sack of coffee bean is carried on the head or shoulders.	Space constraints can cause accidents and extra motions when doing the tasks. Low visibility and extreme hot temperatures can affect the safety and health of the workers as they need to climb platform which is risky and work for 8 hours a day.

Workers' strain and fatigue can be reduced by eliminating the excessive force and awkward posture requirements and permit highly repetitive activities to be done without substantial intensification in WMSD risk for most workers (Middlesworth, 2010). Many work activities demand huge force loads on the human body. Muscle exertion escalates in reaction to high force demands, intensifying the accompanying strain or fatigue which can lead to WMSD.

The following Table 4 shows detailed risk assessment for the hulling process. The task also required lifting and pulling the load to the huller. Risk factors were identified such as high task repetition, high force and awkward posture. The task demands high physical and strenuous effort that is not healthy for the worker since it may develop to low-back pain and other work-related musculoskeletal disorders. Middlesworth (2010) explains that many work activities and cycles are strenuous and repetitive in nature, and are often regulated by daily or hourly production goal and work processes. High task repetition, coupled with other risks factors such high force and/or awkward postures, can cause to the development of WMSD. If the cycle time of work activity is 30 seconds or lower, the task is deemed highly repetitive.

Table 4 TILE Assessment in Hulling

	DESCRIPTION	REMARKS
TASK	"Motion C" shows the loading of coffee beans on the coffee beans huller which is done every 7 minutes Motion C1 –neutral position, static position Motion C2 – awkward posture due to aligning of heavy coffee beans sack, stooping, reaching load away from the body, working on space with constraint and elevated footing Motion C3 – preparing to unload the coffee beans content on the coffee beans huller. Motion C4– reaching forward and hands away from the torso while unloading the sack's content on the coffee beans huller.	Motion C has high risk exposure level due to the identified risk factors.The load is strenuous, physical effort made with body in unstable, over frequent, insufficient recovery period, excessive lifting and carrying (HSE, 1992). The low back and other parts of the body are prone to ergonomic risk. The operators show repeated motion every time they need to queue coffee beans sacks on top of the platform in preparation for the hulling process. Motions took short time but required high frequency which is taxing to the body of the workers that can result to work-related low back pain/injuries.
INDIVIDUAL	Workers on coffee beans hulling process are not physically fit for the tasks as the one carrying the load has 5'1" height which is short and not well-built for this kind of tasks. Extra effort and energy are needed by the workers just to execute the required motions for the tasks.	There is a mismatch on the task and the worker. Workers that should be assigned need to be physically fit and know proper procedure when lifting heavy loads. Workers need to do the tasks continuously to meet the quota for the day which is 60 to 70 coffee beans sacks that need to be hulled.
LOAD	The sack contains coffee beans (raw materials) weighing an average of 60kgs, heavy to be lifted by one person, bulky, difficult to grasp due to irregular shape and unstable overhead lift due to unequal weight distribution. There are 60-70 coffee beans sacks that need to be hulled in a day.	No single individual ought to be compelled to carry or lift, lower or convey stacks greater than 55 kg. This point of confinement would just apply, nonetheless, when the load is inside the individual's abilities and no other hazard factors are available (Worksafe WA. 2000)
ENVIRONMENT	Workstation has minimal space constraints, narrow platform where the sacks are pushed and pulled, low lighting, hot temperature and low visibility due to smoke produced by coffee bean roasting process.	Space constraints can cause accidents and extra motions when doing the tasks. Low visibility and extreme hot temperatures can affect the safety and health of the workers. It is also risky for the workers because they need to climb the ladderto reach the platform.

Table 5 Lifting Analysis Worksheets

LIFTING ANALYSIS WORKSHEET

DEPARTMENT	DEHULLING	JOB DESCRIPTION	COFFEE BEANS DEHULLING
JOB TITLE			
ANALYST'S NAME	IAN KIRBY		
DATE	MAY 28, 2018		

STEP 1. Measure and record task variables

Object Weight (lbs)		Hand Location				Vertical Distance	Asymmetric Angle (deg.)		Frequency Rate	Duration	Object Coupling
		Origin		Dest			Origin	Destination	lifts/min	Hrs	
L(AVG)	L(MAX)	H	V	H	V	D	A	A	F		C
50	60	17	16	26	175	159	0	0	≤ 6	≤ 8	POOR

STEP 2. Determine the multipliers and compute the RWLs

	RWL =	LC	x	HM	x	VM	x	DM	x	AM	x	FM	x	CM	=	
ORIGIN	RWL =	23	x	1	x	.82	x	.85	x	1	x	.27	x	0.90	=	3.90
DEST.	RWL =	23	x	.96	x	.70	x	.85	x	1	x	.27	x	0.90	=	3.19

STEP 3. Compute the LIFTING INDEX

ORIGIN	LIFT INDEX	$\frac{(\frac{1}{2})\,Object\ weight}{(0.90)RWL}$	=	$\frac{(1/2)\ (60kg)}{(0.90)\ (3.90)}$	=	8.55
DESTINATION	LIFT INDEX	$\frac{(\frac{1}{2})\,Object\ weigh}{(0.90)RWL}$	=	$\frac{(1/2)\ (60kg)}{(0.90)\ (3.19)}$	=	10.45

LIFTING ANALYSIS WORKSHEET

DEPARTMENT	DEHULLING	JOB DESCRIPTION	COFFEE BEANS DEHULLING
JOB TITLE			
ANALYST'S NAME	IAN KIRBY		
DATE	MAY 28, 2018		

STEP 1. Measure and record task variables

Object Weight (lbs)		Hand Location				Vertical Distance	Asymmetric Angle (deg.)		Frequency Rate	Duration	Object Coupling
		Origin		Dest			Origin	Destination	lifts/min	Hrs	
L(AVG)	L(MAX)	H	V	H	V	D	A	A	F		C
50	60	32	20	45	175	157	0	0	≤ 6	≤ 8	POOR

STEP 2. Determine the multipliers and compute the RWLs

	RWL =	LC	x	HM	x	VM	x	DM	x	AM	x	FM	x	CM	=	
ORIGIN	RWL =	23	x	.78	x	.84	x	.85	x	1	x	.27	x	0.90	=	3.08
DEST.	RWL =	23	x	.56	x	.70	x	.85	x	1	x	.27	x	0.90	=	1.86

STEP 3. Compute the LIFTING INDEX

ORIGIN	LIFT INDEX	$\frac{(\frac{1}{2})\,Object\ weight}{(0.90)RWL}$	=	$\frac{(1/2)\ (60kg)}{(0.90)\ (3.08)}$	=	10.82
DESTINATION	LIFT INDEX	$\frac{(\frac{1}{2})\,Object\ weight}{(0.90)RWL}$	=	$\frac{(1/2)\ (60kg)}{(0.90)\ (1.86)}$	=	17.92

The Lifting Analysis Worksheets depict the measurements required to evaluate the Manual Material Handling using NIOSH Lifting Equation for Worker 1 and Worker 2. The necessary measurements for the evaluation are horizontal distance of the hands from vertebral junction which is equal to 17 cm (origin) and 26 cm (destination) for worker 1 who will carry the load on top of his head while 32cm (origin) and 45cm (destination) for worker 2 who will assist the lifting. The vertical distance of the hands from the floor is equal to 26 cm (origin) and 175 cm (destination) for worker 1, while 20cm (origin) and 175cm (destination) is for worker 2. The angle of asymmetry is zero degree on both origin and destination. The Frequency Multiplier is equal to 0.27 based on the Frequency Multiplier Table because the worker lifts an average of 6 times every minute and has a duration of 8 working hours a day with small break and lunch break. While the coupling multiplier result is 0.90 because the worker has poor coupling label based on the coupling multiplier table. The actual weight of the coffee beans sack is 60kgs.

It is depicted in Table 5 that Worker 1 has a lifting index of 8.55 on the origin and 11.26 on the destination which are significantly greater than 3.0. This result is interpreted as a Bad lifting index which also means that work design is not safe. Further, the table shows that Worker 2 has a lifting index of 10.82 on the origin and 17.92 on the destination. These are considered as bad lifting indices since they are greater than the acceptable index which is equal to 3.0. This means that the work design is not safe.

Table 6 Quick Exposure Checklist Results

WORKER		SCORE	EXPOSURE LEVEL	REMARKS
Worker 1	Back	46	High	It has a high exposure level because the worker lifts and carries 60kgs of sacks which passed the threshold limit when lifting/carrying heavy objects.
Worker 2		46	High	
Worker 1	Shoulder/arm	46	High	Shoulder/arm has high exposure level because coffee beans sacks were lifted from the ground by using force of the body specifically shoulder/arm at the initial lifting.
Worker 2		46	High	
Worker 1	Wrist hand	36	High	Wrist hand is used when holding the bulky and heavy coffee beans sacks with awkward position. Used to support when lifting/carrying.
Worker 2		36	High	
Worker 1	Neck	10	Moderate	Neck is slightly bent downward when lifting the sacks from the ground and it is usually in static posture when the load is carried to the platform.
Worker 2		10	Moderate	
Worker 1	Work pace	4	Moderate	The workers do their job at a pace where there is allotted break before starting motion.
Worker 2		4	Moderate	
Worker 1	Stress	16	Very High	The exposure is very high because the work requires lifting and carrying heavy loads which is taxing to the bodies of the worker and considering also the environment where they work which is too hot.
Worker 2		16	Very High	

QEC wascreated to evaluate the changes in exposure to risk factors of some segments of the body including the back, shoulders and arms, hands and wrists, and neck before and after an ergonomic intervention. This measurement and evaluation involves the researcher or a practitioner who performs the assessment, and the employee or operator who has direct experience of the work activities. When workers are performing the tasks, the back supports the body when lifting and carrying the 60kgs coffee beans sack which will result to low back pain when tasks is done for a long period of time. Shoulder, arm, wrist and hand are used frequently when doing the manual material handling of loads as it requires the whole body to execute the motions needed in performing the tasks.

When performing the task, the workers occasionally bent their neck when performing the team lift. The minimum weight of the load (sack of coffee beans) is 55 kg and the maximum load is 60 kg. Difficulty in keeping up this kind of tasks is evident because manual material handling of 60 kg is not advisable especially if the task requires high repetition (Worksafe WA, 2000).

Table 7 Manual Task Risk Assessment (ManTRA)

			Task Codes							Cumulative Risk
Body Region	Total time	Duration	Cycle time	Repetition Risk	Force	Speed	Exertion Risk	Awkwardness	Vibration	
Lower Limbs	4	5	3	4	5	2	4	5	1	18
Back	4	5	3	4	5	2	4	5	1	18
Neck	4	5	3	4	5	3	5	5	1	19
Shoulder/ Arm	4	5	3	4	5	5	5	5	1	19
Wrist /	4	5	3	4	3	2	3	3	1	15
Hand	4	5	3	4	3	2	3	3	1	15

Table 7displays the different body segments that are affected or exposed to ergonomic risk factors or hazards as a result of repetitive lifting of loads in the hulling section. Work Health and Safety Regulations 2011 (WHS Regulations) defines a risky manual work activity as a task requiring a person tolift, lower, push, pull, carry or otherwise move, hold or restrain any person with repetitive or sustained force.These activities are evident in the manual material handling within the hulling section of the company where 60 to 70 sacks of coffee beans with 60 kilos per sack are carried and moved daily within the workstation.

It is apparent that work activities in the hulling section demands intense physical effort with high force loads on different parts of the workers' body. The muscle effort escalates retorting to great physical effort demandedby the work activity. This increases the associated fatigue which can further lead to some work-related musculoskeletal disorders.

3.2 Ergonomic Interventions

After conducting several ergonomic assessments on the activities performed in the hulling section, the researcher provided ergonomic intervention as an engineering control that will help address the issues on the exposure to ergonomic hazards or risk factors.

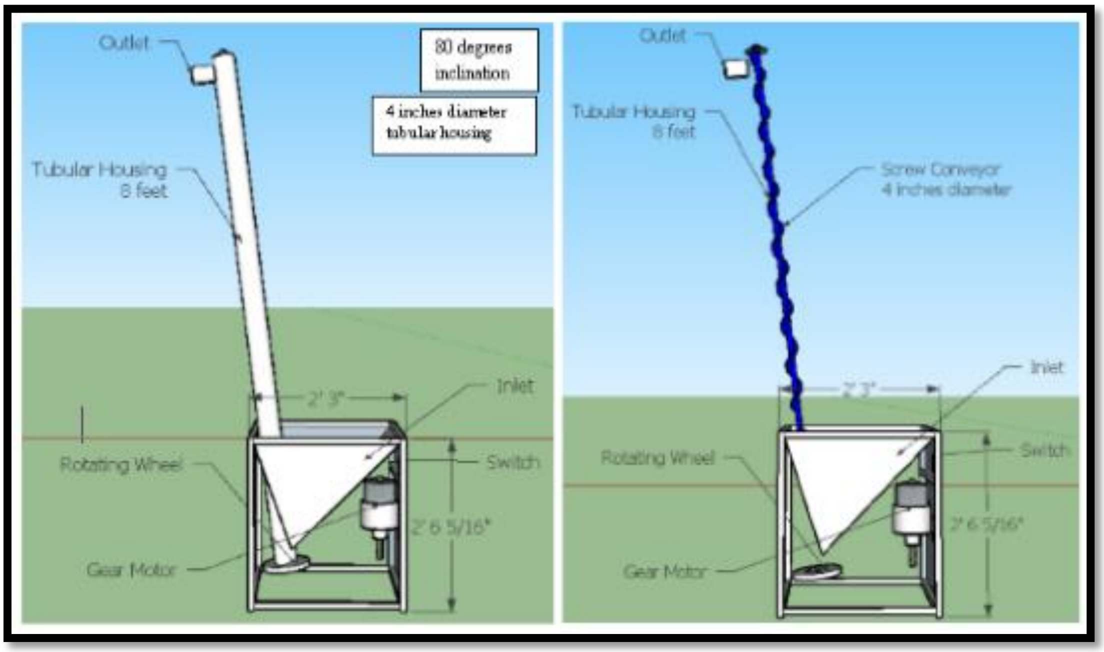


Figure 2.1.Schematic Design of Screw Conveyor as
Ergonomic Intervention for Material Handling

Figure 2.1 displays the schematic design of the screw conveyor as an ergonomic intervention for material handling. The data points or anthropometric measurements obtained from the sample population were used to identify the most suitable height of the screw conveyor's inlet that fit the operators of the equipment. The researcher used the design for the minimum population because it is believed to be asuitableapproach if a given minimum value of certain design quality must accommodate a much larger or the entire population (Niebel and Freivalds, 2014).

Figure 2.2.Actual Design of Screw Conveyor as Ergonomic Intervention for Material Handling

Figure 2.2 exhibits the actual design of the screw conveyor as ergonomic intervention to improve the processes in the hulling section. Integrating the design in the process will eliminate the team-lifting, single lifting, single carrying, climbing the ladder while carrying heavy load, and repetitive strenuous motions. The researcher chose to mechanize the manual material handling operations because it is believed to be the best solution to eliminate or reduce ergonomic risks in the workstation. Such initiative also promotes safety culture in the workplace thereby providing ease and efficiency to the workers.With the improvement in the design, it implies that the workers comfort and convenience is upgraded, thus reducing or eliminating the strain and fatigue felt by the body while exposed in a physically challenging work environment (Hodson, 2001).

This ergonomic intervention is an example of engineering control which aids to eliminate intense force requirements thus reducing or eliminating the risk of WMSD formation among the workers. Mechanical assists, powered equipment, or ergonomic tools can greatly reduce the workers' physical work effort and muscle exertions (Middlesworth, 2010). The material handling equipment as ergonomic intervention provided by the researcher eliminated the team lift in the hulling section. The material handling becomes much easier and efficient with the use of the screw conveyor in moving the coffee beans. Further, some ergonomic risk factors were eliminated such as pushing and pulling, repetitive motions, heavy force and awkward postures, and forceful exertion which are evident in team-lifting, carrying, and climbing the ladder to the huller platform, and pushing the sack to transfer the coffee beans to the huller.

Table 8 TILE Assessment for the Improved Hulling Operations

Categories	Improved	Remarks
Task	Task requires the use of screw conveyor as mechanical assist to transport the coffee beans to the huller. Improved process only requires minimal effort and does not need forceful exertions. Motions only require small movement and there is no need for prolonged physical effort as the prototype will be used to convey the bulk materials.	Awkward postures and forceful exertions are mostly eliminated due to mechanize process of material handling. The safety and health of workers when working is considered.
Individual	Workers can work with comfort and ease. Low physical capabilities workers can also do the job easily as the inlet and switches are designed using anthropometric measurement and does not requires forceful exertions such as lifting and carrying load.	Risks of injuries are minimal. Proper knowledge and training requires when using the screw conveyor. Inlet and switches are within reach so that anyone can use the prototype. Emergency circuit breaker is also included for the safety of workers. Operation manual and maintenance guide isalso given.
Load	After the improvement load will be transported using lift cart or standard hand-trolley then place the load on the conveyor. There is no need to carry the heavy 60kgs sacks repeatedlybased on the improved process.	The use of lift cart for transportation or mechanical assist and ergonomic tool will prevent carrying the heavy loads before unloading the sacks to the conveyor.
Environment	Space constraints are kept to minimal. Variations in level of floor or work surfaces are eliminated. The ladder and the platform were removed providing additional space in the workstation.	The platform is not necessary on the improved process with the use of the screw conveyor. The process only requires unloading the coffee beans to the conveyor and the beans will be transferred to the huller.

The use of platform which serves as a footing when queuing and loading the coffee beans to the huller was eliminated. The developed screw conveyor is placed and can be operated on the ground level without the need to climb up the ladder while carrying the heavy sacks of coffee beans. The improve process can convey the coffee beans to the huller using the screw conveyor as mechanical assist. This eliminated most of the risks factors associated with the existing process such as carrying the 60 kilogram-load and awkward postures when lifting, carrying, andpulling the loadto transfer the coffee beans to the huller.With this kind of improvement, the risk factors were significantly reduced if not totally eliminated which provides a more conducive working environment to the workers.

Table 9 Summary of Ergonomic Assessments for the Improved Hulling Operations

Ergonomic Assessment Tools	Improved	Interpretation	Remarks
MAC	3 for Lift 3 for Carry 0 for Team Lift	Highest score requires attention first. Most effective improvements will bring about highest reduction in score.	Lift, Carry and Team Lift scores drop considerably as there is no need for manual material handling of loads.
NIOSH	No result for "Improved" because Team Lift is eliminated	If the Lifting Index (LI) is >1.0 the work design is high risk and if the LI <1.0 the work design has nominal risk	Lifting index of both workers is >1.0 which pose high risks. Results of RWL and LI for both workers are excluded since the improvements made by the proponents totally remove the team lift of the coffee beans sacks for the hulling operation.
QEC	The exposure level becomes Low since physical and strenuous effort was eliminated in the material handling.	Significant improvement was evident in the work pace, and work stress from High to Low exposure.	The manual material handling was eliminated which also alleviate the exposure of workers to risk factors such as pushing and pulling, repetitive motions, heavy force and awkward postures, and forceful exertion which are evident in team-lifting, carrying, and climbing the ladder to the huller platform

The integration of ergonomic tool allows the workers to maintain optimal joint positions. The ergonomic intervention reduce if not totally eliminate the awkward postures. This helps to maintain joint range of motion among the workers to help them accomplish the work tasks with the mid-range of motion positions for vulnerable joints. The excessive force and excessive motions were eliminated with the integration of the screw conveyor as mechanical assist in handling and transferring materials. The demand for intense physical effort in carrying the loads was significantly reduced making the job safer, easier, and more efficient to the workers. Ergonomic design and intervention promotes productivity improvement by allowing fewer motions, less exertion, and more efficient workplace. Furthermore, providing safe working environment improves the quality and the engagement of employees. (Bautista,2013).

4. Conclusion

Ergonomic hazards or risk factors were evident in the workplace particularly in the hulling section. Some of the most visible risk factors are the high task repetition, forceful exertion, and repetitive/sustained awkward posture. The ergonomic hazards were manifested in the manual material handling where sacks of coffee beans are manually lifted, carried, lowered, pushed and pulled by the workers in preparation for the hulling operations. Such tasks require high force loads on different parts of the body where the muscle effort tend to escalate retorting to high force demand of the task which heightens the workers exposure to associated fatigue leading to possible formation of WMSD such as low-back pain, muscle-tendon strain, and tension-neck syndrome among others.

Necessary ergonomic assessments can be performed using different assessment tools and instruments to review and evaluate the workers job and their potential exposure to ergonomic risk factors and hazards. Ergonomic intervention or engineering controls are effective strategies and actions to reduce if not totally eliminate the risk factors present in the workplace. Mechanical assists, powered machine or equipment, and other ergonomic tools can be used to avoid excessive manual material handling, thus reducing work effort and muscle exertions. Work practice controls can also be employed by training the workers and improving the proper work techniques for a much safer execution of the work tasks and activities. Further, preparing and keeping safe and efficient operating procedures for fulfilling work activities can lessen the risk of WMSD. If manual material handling cannot be totally eliminated, the proper body mechanics can be exercised for appropriate lifting and work techniques to diminish the force requirements. The initiative to systematically diagnose and control the associated ergonomic hazards or risk factors is a vital function of every business organization's commitment to keeping and providing a safe and conducive workplace for all the workers.

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