Improvement of AMG Rice Dealer Workplace Safety Using Ergonomics and Six Sigma Tools

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Abstract
This study shows the streamlining of manual material handling of AMG Rice dealer workers to the task of carrying rice sacks from the delivery truck to the company's warehouse by applying the fundamentals of Manual Material Handling and Identification and Elimination of Waste (i.e., DOWNTIME, Three MU's). The researchers utilized manual material handling as the primary concept of this ergonomics paper and supported the study by applying waste elimination and risk reduction techniques while increasing worker's job satisfaction. This study also introduced Process Observation Analysis (POA) to analyze the lead time of workers when transporting the rice sacks from the truck up to the company's warehouse. The researchers used POA as the primary tool in data collection. The researchers decreased the process lead time by 45.19% by implementations of different six sigma tools and application of proper manual material handling techniques. Furthermore, the study used the NIOSH Lifting Equation for calculating the recommended weight of the rice sacks that each worker must carry. The results of the study showed beneficial effects to both the worker's safety and AMG Rice Dealer's transporting processes.

Keywords
Manual Material Handling, DOWNTIME, Process Observation Analysis, and NIOSH Lifting Equation.

1. Introduction
Rice is a vital food source in the Philippines. As a nation, Filipinos are used to having cooked rice and different viands in order to have a complete meal. In line with this, one of the most popular business ideas in the country is rice retailing.

Companies that distribute or sell rice to the public ensure that the quality of their products are of the highest level. Be it corporate-level rice distributors or family-owned businesses, the quality of food-grade products will not be achieved if not for complete participation and dedication of the entire enterprise.

The effort exerted by workers of rice dealers when discussing manual labour should not be overlooked. They have to lift multiple rice sacks from one location to another for several times a day. This action of having humans participate in the transportation of products or materials in a company is coined as Manual Material Handling (MMH).

MMH is identified as any activity concerned with having humans lift, carry, move, or restrain objects with the exclusion of any other animate entities. (Dick et. al 2016)

This technique is often utilized in many companies in the country as it minimizes overall costs. More often than not, most rice mills or rice distributors prefer the traditional way of applying MMH in transporting their products so long as the job gets done. Such thinking may lead to fostering an unsafe working environment for employees. In the rice retailing business, employees are often required to manually carry sacks of rice which on average weigh about 25 kilos.

Zurada (2012) mentioned that manual material handling is the primary source of work-related low back disorders (LBDs). It is a staple in the industrial working population in the U.S. that LBDs stem from prolonged exposure to manual material handling. MMH ranges from lifting to pushing and if it is done on a daily basis with heavy loads physical injuries will become inevitable and physical health will surely degrade. Suffering from health conditions are triggers to the decline of worker efficiency and worker motivation which is considered to be a major handicap in a company's pursuit of profitability.

Rahman et al. (2015) investigated the effects of manual material handling to aged workers and applied ergonomics to recommend techniques to make manual material handling safer for older workers.

1.1 Objectives

The study aims to inspect the task of transporting products from the delivery trucks to the company's warehouse since this process requires the most manual handling in the company's processes. The study utilizes the useful tools such as the Six Sigma Target Calculation Equation, and the NIOSH Lifting Equation in the analysis of the weight limits for safe manual handling. Additionally, the study aims to improve the process of transporting the rice sacks per work by combination of applying the NIOSH Lifting Equation and the Six Sigma Target Equation. The combination of all these tools seek to apply proper manual material handling and process lead time reduction to lower probable workplace hazards in AMG Rice Dealer.

2. Literature Review

Wiengpon (2000) wrote that the accompanying targets of the study utilized a planned trial for its completion. The correlation of the physiological reactions, as estimated during conveying exercises in various sizes of rice-packs and in various kinds of conveying errands and advancement and testing of a numerical model for the forecast of the adequate load of rice-packs conveying utilizing the basis of a person's VO2 esteem at 30%VO2max.

There are numerous constructive outcomes of weight lifting, including lifting a sack of rice. Over the long haul, weight preparation causes helpful changes in both a person's physical and emotional wellness. (Myers 2019)

Barone (2015) questioned the harmful effects of lifting weights in the long run. He mentioned that he had developed a craving to go to the exercise center several times each week to lift loads since having shown up at school.

According to Thamotharan (2021) the body distress level assisted in investigating the technique for Rapid whole-body evaluation (REBA). In this study, six male truck stacking administrators participated as subjects. They stacked paddy sacks from the truck to a stacking region manually. The assignment included dull little development while dealing with material; because of this, the heap man has confronted business-related musculoskeletal issues.

Middlesworth, M. (December 5) states the revised NIOSH Lifting Equation is a device utilized by word related wellbeing and security experts to survey the manual material taking care of dangers related with lifting and bringing down undertakings in the working environment. A lifting task is characterized as the demonstration of physically getting a handle on an article with two hands, and in an upward direction moving the item without mechanical help. The NIOSH Lifting Equation considers a few occupation task factors to decide safe lifting practices and rules.

ISHN (2017) verifies that in assembling and different enterprises where lifting is essential for the work, messes that influence the muscles and bones are a typical issue. At the National Institute for Occupational Safety and Health (NIOSH), researchers study the causes and anticipation of these common problems, including low back torment.

The accompanying suggestions depend on the Revised NIOSH condition for the plan and assessment of manual lifting tasks. The NIOSH lifting condition considers the load in addition to a few different factors in lifting errands that add to the danger of injury

Bich Huynh (2020) explains the NIOSH lifting condition instrument was created to survey and assess as far as possible two-gave lifting assignments to help managers in lessening the danger of lifting-related wounds.

This investigation expects to add to a superior comprehension of the Revised NIOSH Lifting Equation applied to handle conditions by giving a depiction of the methodology for estimating its factors. These methodologies were taken on during the assessment of a lifting/bringing down undertaking of steel sheets in a vehicle parts fabricating plant. (Okimoto, 2009)

Miller B.M (2018) states the National Institute for Occupational Safety and Health (NIOSH) requested that the RAND Corporation foster a methodology, announced here, for assessing the financial advantage of NIOSH research, utilizing three contextual investigations.

Vague low-back torment (LBP) by Arun Garg (2013) is a typical issue in workplaces. Lifting Index (LI) and Composite Lifting File were processed for each subtask. Furthermore, task that a specialist performed at gauge just as for those undertakings that changed during the subsequent period

According to Sandra Cole (2009) this contextual analysis explored the adequacy of formal guidance of the Revised NIOSH Lifting Equation for college understudies who might utilize the condition in their future work. Their victories and difficulties were inspected through a class exercise and two tests, all of which adhered to the homeroom guidance in applying the Lifting Equation.

3. Methods

The study behaved in a quantitative nature and used of various techniques from multiple schools of knowledge. However, in the achievement of the study's goals, the researchers prioritized quantitative methods for data collection and data processing while the researchers used a qualitative approach for the remainder of the paper.

The researchers adopted anthropometric techniques in manually measuring the body dimensions of the worker. A close-up observation implemented by the team in order to collect data from the workers. Different tools used in the study allowed thorough inspection of the problem.

The study utilized only a single mathematical equation known as the Six Sigma Target Calculation Equation—a technique to manually calculate for a new baseline (or target) value for an improved process.

Whereas,

Baselining (BL) – It is the +/-3 sigma level measurement to set our improvement target to attain must be at least 30% improvement.

Entitle (ENT) – It is the lowest data on the data that we gather whereas our equation is to decrease lead time therefore the ENT must be the lowest data (The lower, the better).

$$\text{Target} = \text{Baseline} - 70\% \times (\text{BL} - \text{ENT}) \quad (1)$$

The NIOSH Lifting Equation is an ergonomic tool used in determining proper metrics in lifting and lowering acts in the materials. The study utilized the equation in order to determine the recommended weight limit of the materials for each worker.

Whereas the Task variables needed to calculate the Recommended Weight Limit (RWL) itself to prove that weight is compatible for the task are:

H which is the horizontal distance between the object
V which is the vertical location of the object relative to the floor
D which is the distance the object moved vertically
A which is the asymmetry angle or twisting requirement
F which is the frequency and duration of lifting activity
C which is the coupling of the workers grip on the object
LC which is the load constant of 51 lbs.
W which is a constant given in the formula for computing recommended weight limit

And for the multiplier column:

Horizontal Multiplier (HM) –It is the given formula of 10/H. When H is less than or equal to 10 inches, the multiplier is 1.0.

Vertical Multiplier (VM) – It is the given formula of (1-(0.0075[V-30])). Through the data given by the researchers, the V is 30 inches therefore the multiplier is 1.

Distance Multiplier (DM) – It has the formula of 0.82 +(1.8/D). In this case, when D is less than or equal to 10, the multiplier is 1.00.

Asymmetry Multiplier (AM) – It has the formula of 1-(0.0032A). When A is 0, the multiplier is 1. As A is increased, the multiplier is decreased.

Frequency Multiplier (FM) –It is how frequent the activity is done. As the frequency is increased, the multiplier is decreased. When F is less than or equal to 0.2, the multiplier is 1. However, when F is greater than to 15, the multiplier is 0.00.

Coupling Multiplier (CM) – It is based on the design of the object. When an object has a good and fair design, the multiplier is 1. However, when it is poor, the multiplier is 0.90.

Table 1. Recommended Weight Limit Table

RWL	**Multiplier**
H	HM
V	VM
D	DM
A	AM
F	FM
C	CM
Weight	W

$$RWL = LC\ (51) \times HM \times VM \times DM \times AM \times FM \times CM \quad (2)$$

The remainder of the paper used other tools in various disciplines in data collection, data processing, and data interpretation.

4. Data Collection

The data collected for the study involved a thorough inspection of the workplace. The researchers took photos of the lifting technique used by the workers and the necessary demographics for various calculations.

Table 2. Data Collected from Workplace Inspection

Information	Data
Working hours per shift	8 hours
Number of shifts per day	1 per day
Available worker per shift	1-2 workers
Process Lead Time (per rice sack)	32.15 seconds
Daily production	15 to 27 sacks per shift

The information in Table 2 presented the necessary data that the researchers gathered upon manual inspection. These data informed the researchers of the different aspects of the workload through which improvement needs to be implemented on to make the work manner safer for the workers.

The primary concern that the researchers discovered is the lifting technique and the process lead time that is incurred in manual handling the materials. Prolonged exposure to improper lifting techniques and heavy loads increases the risk of workplace injuries or irreversible health hazards.

Figure 1. Photo of How the AMG Worker Lifts Rice Sacks.

Figure 1 presented the lifting technique used by one of the company's workers. This sort of lifting technique is dangerous especially when done in multiple instances in a single shift.

Table 3. Worker's Body Dimension vs. Product Weight

Measurement	Worker's Body Dimensions	Product Weight (per sack)
Weight	137 lbs	25 kilos
Height	5'6"	

Table 3 showed that the worker's physical measurements is not a concern. However, the improper lifting technique and the considerably lengthy process lead time makes the task too strenuous for the worker.

Table 4. Task Variables

RWL	**Multiplier**
H = 9 in	HM = 1.00
V = 10 in	VM = 0.85
D =15 in	DM = 0.94
A=90 degrees	AM = 0.71
F = 2	FM = 0.91
C = 2	CM = 1.00
Weight = 55 lbs	W = 51 lbs

Table 4 showed the task variables or parameters that researchers used for the calculation of the previous recommended weight limit (RWL) of the rice sack as dictated by NIOSH Lifting Equation.

Figure 2. Visual Representation for Identifying Task Variables

Table 5. Task Variables

RWL	**Multiplier**
H = 9 in	HM = 1.00
V = 30 in	VM = 1.00
D =9 in in	DM = 1.00
A=90 degrees	AM = 0.71
F = 2	FM = 0.91
C = 2	CM = 1.00
Weight = 55 lbs	W = 51 lbs

The image in Figure 2 and the data in Table 5 showed the parameters that the researchers used in order to calculate for the proposed recommended weight limit (RWL) as dictated by the NIOSH Lifting Equation.

These data collected by the researchers were analyzed and utilized in calculations in order to determine the necessary actions to make the workplace safer for the workers.

5. Results and Discussion

5.1 Numerical Results

The calculation of the new baseline using the Six Sigma Target equation showed drastic improvements for the process lead time of the manual material handling of rice sacks by the workers of AMG Rice Dealer.

Six Sigma Target Calculation:

Calculation of New Baseline for the Process Lead Time

BL - 70% (BL - ENT)
32.17 - 0.70 (32.17 – 30.22)
Target = **30.80s**

The six sigma baselining target calculation showed that the researchers were able to obtain a new target baseline for the job's process lead time. From 32.17 seconds, they are able to reduce it to 17.55 seconds through elimination of waste in the process (i.e., unnecessary actions, lengthy transportation distance).

Table 6. Comparison of Old and New Process Lead Time

Old Process Lead Time	New Process Lead Time	Percentage Difference
32.17 seconds	17.55 seconds	45.44%

The calculation of the new baseline for the job's process lead time showed a 45.44% improvement. This showed that the through optimization, the process lead time decreased from 32.17 seconds to 17.55 seconds. The researchers found out that this is a significant improvement since it can help reduce the length of time that the worker is exposed to the manual handling of the material.

Calculation of the previous Recommended Weight Limit vs. Calculation of the proposed Recommended Weight Limit

Previous Recommended Weight Limit (RWL):	Calculation of the proposed Recommended Weight Limit (RWL):
RWL = 1.00 x 0.85 x 0.94 x 0.91 x 0.71 x 1.00 x 51	RWL= 1.00 x 1.00 x 1.00 x 0.71 x 0.91 x 1.00 x 51
RWL = **26.33lbs or 12kg.**	**RWL = 33lbs or 15kg**

The calculation shows the previous Recommended Weight Limit for the sack to be lifted as the researchers identified and observed the overburden of the workers. This calculation relies heavily on the parameters provided in Table 4. Moreover, the depicted the researchers' calculation for the recommended weight limit for the sack to be lifted of AMG Rice Dealer. This calculation relies heavily on the parameters provided in Table 5. Upon analysis of the calculation results, the researchers found out that the previous parameters in recommended weight limit of lifting rice sacks can be addressed through proper material handling. From the previous RWL of 12 kilograms, the workers can still lift and carry up to 15 kilograms of weight based on the result of the proposed RWL through orientation and training of the proper lifting and carrying techniques.

5.2 Graphical Results

Figure 3. Proper Lifting Technique for a Product-Filled Sack

The researchers observed that in Figure 1 the worker lifts the rice sacks up to their head and repeats this process for an average of 21 times in a single shift. Also considering that the rice sack stays in this position for 32.17 seconds, the job can be categorized as very risky for the worker's safety and health.

In Figure 3, this proper lifting technique can be applied to the worker. Instead of lifting the rice sacks by letting 25 kilos rest on top of their heads, the safer and less risk method is to transport it by their shoulders.

Figure 4. Photo of AMG Worker Applying the Proper Lifting Technique

Upon application of the proper lifting techniques as shown in Figure 4, the worker will be able to reduce the risk to both their safety and health.

5.3 Proposed Improvements

The completion of the analysis and calculations allowed the researchers to arrive at the process of making proposals for improvements.

The researchers calculated that by removing wastes in the process, the process lead time maybe reduced significantly. An observation of the working environment led the researchers to recommend that the distance from the source (the delivery trucks) to the destination (the warehouse) be reduced as much as possible.

The recommended weight limit is a pressing issue since the company cannot simply reduce the weight of their products, the researchers recommend that the company should invest in equipment to assist in the manual material handling of the rice sacks. Since the worker's safety and health and the product size cannot be compromised, the best course of action is to invest in equipment (i.e., trolleys, racks) that will reduce the worker's exposure to the weight of each rice sack they transport.

The researchers also recommend regular training for proper manual handling of materials to the workers. Such training should be done in a regular basis be it quarterly or annually depending upon the company's budget. Implementation of proper training assists in the reduction of risks to the worker's safety and health.

Additionally, the researchers also recommend the maintenance and improvement of the optimized process over-time. The improvements predicted by the researchers through the study will be the initial results of addressing the company's issues regarding worker safety. However, in order to ensure that the worker feels the security of safety in their workplace, the optimized process should be maintained.

6. Conclusion

The researchers concluded that the study was able to successfully inspect the task of manually transporting the products from the delivery trucks to the company's warehouse. This success paved way for the researchers to analyze points of improvement in the task. The researchers concluded that the study improved the process of transporting the rice sacks through the use of the Six Sigma Target Equation and the NIOSH Lifting Equation. The combination of these tools allowed for the researchers to analyze the parts of the process where improvement will create a significant change.

Furthermore, the researchers concluded that the key contribution of this study is that it's unique combination of applying both an ergonomic tool (the NIOSH Lifting Equation) and a Six Sigma technique (the Six Sigma Target Equation) in order to improve worker's safety in the workplace by predicting an improvement in process lead time

and by implementing proper lifting techniques in order to make manual material handling in AMG Rice Dealer's transportation processes safer.

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Biography

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