Redesign of Supermarket Check-Out Counter Using Ovako Working Posture Analysis System (OWAS) and Rapid Entire Body Assessment (REBA)

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Abstract
One of the essential establishments in the commercial area is the supermarket where people can buy their necessities and wants. To provide adequate services and products, the role of Manpower and machines is vital. The development of these sources must maintain as time goes by for customer satisfaction and safety. Also, to secure the safety and health of its employee. Musculoskeletal disorder is one of the health problems face by supermarket employees such as cashiers. The researcher observed erroneous dimension and measurement of the check-out counter is the reason for this challenge. The application of the Ovako Working Posture Analysis System (OWAS) and Rapid Entire Body Assessment (REBA) used in this study to measure how does the current check-out counter affects the health of the cashiers. Thus, the research team proposes an improved check-out counter that addresses this problem. The proposed new design also aims to maintain social distancing due to the new normal. The findings of the study prove that the social distancing in the supermarket is not sustainable. Besides, the results of the Ovako Working Posture Analysis System (OWAS) and Rapid Entire Body Assessment (REBA) performed on cashiers in San Juan City depict risk in their musculoskeletal system.

Keywords
Check-Out Counter, Ovako Working Posture Analysis, Musculoskeletal Disorder, Rapid Entire Body Assessment

1. Introduction
People's necessities and wants can find in the supermarket. It allows people to shop for varieties of foods, beverages, and other household items. Also, it provides service along the lines of assisting customers, ensures safety, and for the payment process. This statement will depict the vitality of the labor in the commerce. The role of the employees is one of the keys to the success and growth of the business. The particular reason for this circumstance is they are responsible for performing necessary works within the company. The roles of cashiers in the supermarket fall on this notion. Being a cashier is a pertinent job for a supermarket since it considers as a business entity that sells human necessities and wants. They have enough acumens in terms of managing the payment systems of their customers. Without their knowledge and skills, the financial progress of the supermarket will not monitor. Hence, it is necessary to have a competent cashier. Management of this kind of business must also ensure the employee's working conditions to maintain virtuous services and performance. Related to this, several cashiers in the Philippines are standing throughout their shift (Ligaya, 2017). It can result in musculoskeletal disorders due to their working position. Unlike in other supermarket personnel, cashiers only stay at the check-out counter. It can be a reason why they experience musculoskeletal disorders. According to the Centers for Disease Control and Prevention, working with the neck in a chronic flexion position, and performing repetitive forceful tasks are some of the examples that may lead to

musculoskeletal disorders. These conditions are pertinent in the cashier's working methods. Thus, it must address this inadequate working condition to prevent MSD that may affect the cashier's performance. Besides, the risk level of their health increase nowadays because of the threat of Covid-19. It is crucial to maintain their health well amid the pandemic since their workplace is for the public where anyone can go. Thus, the virus can acquire in supermarkets. There are cases in the United States reported some of the supermarket cashiers tested positive in COVID-19 (Khazan, 2020). It will affect the performance and system of the supermarket's demand. The particular reason for this circumstance is that cashiers can spread the virus to the customers. It can result in decreasing number of shoppers because of the fast-spreading of the virus in supermarkets.

Concerns mentioned above prompt the researchers to innovate and develop the check-out counters in the supermarkets. The researchers propose a new design to address inadequate working conditions by making it anthropometric. This study will delve into the working station of the cashier for their safety to prevent musculoskeletal disorders. Also, to maintain social distancing between the customers and the cashier. And lastly, this study seeks to gain in-depth knowledge about ergonomic aspects of design.

1.1 Objectives

This study aims to accumulate more knowledge/be knowledgeable about the working conditions of the cashier in the check-out cashier area. The project objective is to propose a new check-out counter design in the supermarket and develop it to decrease the probability of musculoskeletal disorders of cashiers. Besides, the risk level of the cashiers and customers in the supermarket will increase because of the COVID-19. The proposed design develops to maintain social distancing practice. It enlightens each of them to have a more comfortable check-out counter that will benefit the cashier's service and performance. And lastly, this study will identify the significance of anthropometry in the working condition of them.

2. Literature Review

The research design utilized by the researchers are case studies and journals. The researchers applied the research design for it produces a comprehensive examination of certain aspects of the productivity in supermarkets which is relevant to the research topic about the proposed design of the check-out counter amidst of new normal. The main method used in the study in this section is an E-Library Research. With the study being quantitative, the researchers employed the use of Google Scholar as a medium for finding the required information needed for the research. The method also employs the use of articles, journals, books, electronic sources, and other studies related to the topic.

According to Maligaya VH, et.al (2017), several cashiers in the Philippines are standing throughout their shift in the check-out counter. The said employees are also subjected to repetitive tasks and having a not sufficient posture. The study investigates the working conditions of the cashier. The researcher used the Cornell University Musculoskeletal Discomfort Questionnaire (CMDQ) to determine data. They also conducted a Rapid Entire Body Assessment (BEBA) to evaluate the postures and identify the risk level of cashiers. The perceived pain and the risk level were then tested for correlation using Spearman’s Rho. The research teams conclude that there is no significant correlation in their data. However, the team gathered the proper and relevant workstation measurements to enhance the anthropometric design of the cashier. The data results showed that much can be done on their workstation to enhance man-machine interaction and to mitigate the risks of MSD.

According to Godilano EC, et.al, (2018**)**, the WMSD Risk Reduction Among Grocery Shoppers and Clerks by Redesigning Double Basket Shopping Carts study created an ergonomically designed double basket shopping cart with a purpose of reducing Work-Related Musculoskeletal Disorders (WMSD) risks to grocery shoppers and clerks. This study proved that the present design of the double basket shopping cart provides pain and discomfort to the grocery shoppers and clerks which can lead to WMSD. It also showed that incorporating ergonomic features on the proposed design of the double basket shopping cart reduce the pain and discomfort to the grocery shoppers and clerks. The study was conducted in Rey-Sal Grocery Store in Cabuyao, Laguna. Rapid Entire Body Assessment (REBA), NIOSH, Nordic Questionnaire, and surveys were used to determine the pain and discomfort that the grocery shoppers and clerks feel. Statistical Package for the Social Sciences (SPSS) was used to help in the regression analysis of the researchers. Anthropometry was used in the designing the proposed design, to develop the optimal dimensions of the double basket shopping cart for the comfort of the users. The proposed design of the double basket shopping cart effectively reduced the pain level and the discomfort of the grocery shoppers and clerks. It eliminates the need for lifting motions of the grocery shoppers due to the new design. The methods that were used were essential in reducing the risk of WMSD to grocery shoppers and clerks. Cost-benefit analysis and Failure Mode and Effect Analysis were

also executed to evaluate the proposed double basket shopping cart design financially, its reliability, durability, and performance.

According to Ayu DP, et.al (2018), the ergonomic working posture research was done to reduce Musculoskeletal Disorders in working activity at putting the wheel into the position in Perum Pengangkutan Penumpang Djakarta (PPD) by three workers to address the problem. Researchers found out that workers are working in bending and crouching in long periods of time that can cause Musculoskeletal Disorders. Due to being busy and focus on work, workers are generally paying less attention to their body posture. The Rapid Entire Body Assessment (REBA) method and Ovako Work Posture Analysis System (OWAS) method is used to analyze the body posture of the study. By interviewing the par ties concerned at the activity used as a method to gather data.

According to Almoro JJ, et. al (2018), the WMSD Risk Reduction Among Grocery Shoppers and Clerks by Redesigning Double Basket Shopping Carts study created an ergonomically designed double basket shopping cart with a purpose of reducing Work-Related Musculoskeletal Disorders (WMSD) risks to grocery shoppers and clerks. This study proved that the present design of the double basket shopping cart provides pain and discomfort to the grocery shoppers and clerks which can lead to WMSD. It also showed that incorporating ergonomic features on the proposed design of the double basket shopping cart reduce the pain and discomfort to the grocery shoppers and clerks. The study was conducted in Rey-Sal Grocery Store in Cabuyao, Laguna. Rapid Entire Body Assessment (REBA), NIOSH, Nordic Questionnaire, and surveys were used to determine the pain and discomfort that the grocery shoppers and clerks feel. Statistical Package for the Social Sciences (SPSS) was used to help in the regression analysis of the researchers. Anthropometry was used in the designing the proposed design, to develop the optimal dimensions of the double basket shopping cart for the comfort of the users. The proposed design of the double basket shopping cart effectively reduced the pain level and the discomfort of the grocery shoppers and clerks. It eliminates the need for lifting motions of the grocery shoppers due to the new design. The methods that were used were essential in reducing the risk of WMSD to grocery shoppers and clerks. Cost-benefit analysis and Failure Mode and Effect Analysis were also executed to evaluate the proposed double basket shopping cart design financially, its reliability, durability, and performance.

According to Deng M, Wu F, Luan, F (2019), human mental and emotional factors can affect performance at work. The purpose of this study was to examine the relationships of supermarket cashiers between the musculoskeletal disabilities (MSDs), psychological distress, and job mistake. In this study 443 Chinese supermarket cashiers were surveyed. Of these cashiers, 431 were collected for valid samples. The research analysed the MSDs, psychological distress, and supermarket cashier mistake at work. In this study 443 Chinese supermarket cashiers were surveyed. Of these cashiers, 431 were collected for valid samples. The study analysed the severity of MSDs, supermarket cashier psychological distress with MSDs Likert scale, and Symptom Checklist-90 (SCL-90), accordingly. The supermarket managers provided the Job Error data for each cashier. Chinese supermarket cashiers' rising working years related to increased MSDs. Important variations in MSDs and cashier job error from various supermarkets were found (various checkouts). Supermarket cashiers' physiological health and psychological distress are critical for the success of the job and require considerable attention. Effective plain-conveyor checkout counter design is helpful in reducing cashier MSDs and job errors.

3. Methods

This section presents the methods that the researchers used in this study. The approach of the study was used by the researchers is descriptive that falls to qualitative research. This section includes the method, respondents of the study, sampling techniques, instrument of the research, procedures on how to gather data, and data analysis techniques.

3.1 Method of Research Used

The research team used observation and ergonomic assessment through Ovako Working-Posture Analysis System and Rapid Entire Body Assessment hat falls to the ergonomic data of the study. In gathering other data, the researchers surveyed to fully assess the problems of customers and cashiers in the check-out counter area. Through this, it will help them to enhance the new proposed design.

3.2 Respondents of the Study

San Juan City in the Philippines is a highly urbanized city in Metro Manila. There are a lot of business establishments in this area such as malls and supermarkets. It means that the number of cashiers who use check-out counters is

numerous. Besides, San Juan City is one of the affected areas of the COVID-19 virus. According to Zamora, 2,717 confirm COVID-19 cases in San Juan City as of September 28, 2020. Since there are many malls and supermarkets in this area, the fast-spreading of the virus is possible. The reasons mentioned above help the researchers decided to choose San Juan City's population as respondents. Hence, respondents of this study were the 122, 935 population of San Juan City.

3.3 Sampling Techniques

Using the Slovin's formula, the researchers use the said tool to determine the number of the customer and cashier respondents in this study. The said 122, 935 number of people of San Juan are not all will take the survey form. The result samples to be taken are expected to answer it. Thus, the results and data from the respondents will be tabulated by the researchers. The study used 5% of a marginal error as the basis in solving Slovin's formula.

$$\mathbf{n = N/(1+ e^2)}$$

where:
n = No. of samples
N = Total no. of Population
e = Margin of Error

Therefore, the sample size of 122, 935 population of San Juan City is 383 respondents. 35% of the sample size are the cashiers and the remaining 65% are the customers.

3.4 Research Instrument

The research instrument is the application of Microsoft Word and Google Form to gather, tabulate, and encode the result data. Also, the researchers used Ovako Working-Posture Analysis System (OWAS) and Rapid Entire Body Assessment (REBA) as an ergonomic tool. It will identify the most common work postures for the back, arms, legs, and the weight of the load handled by the cashier. In order to depict the proposed design of the check-out counter, the researchers will use AutoCAD and anthropometers such as tape measure and ruler.

3.5 Data Gathering Procedure

The research team will gather data and results by surveying Google Forms. In terms of the anthropometric measurement, the researchers used the study of Lu entitled Anthropometric measurement of Filipino manufacturing workers as body measurement of the cashier. Besides, this study uses the feedbacks of the customers to develop the product. These procedures will serve as a baseline to innovate and develop the design of a check-out counter to address the said problems in this study.

4. Data Collection

This chapter presents the findings, analysis, and interpretation of data gathered whose main objective is to know the factors in creating a new design of check-out counter in supermarkets.

4.1 Selection of Dimensions

Anthropometric measurement is vital in this proposed design to identify the required or ideal measurements of it based on the result data. There are body dimensions that are essential in designing especially for the cashiers. Thus, the researchers gather the required body dimensions. As a standard for their body dimensions, this study used ISO 7250 (Basic Human Measurement for Technological Design).

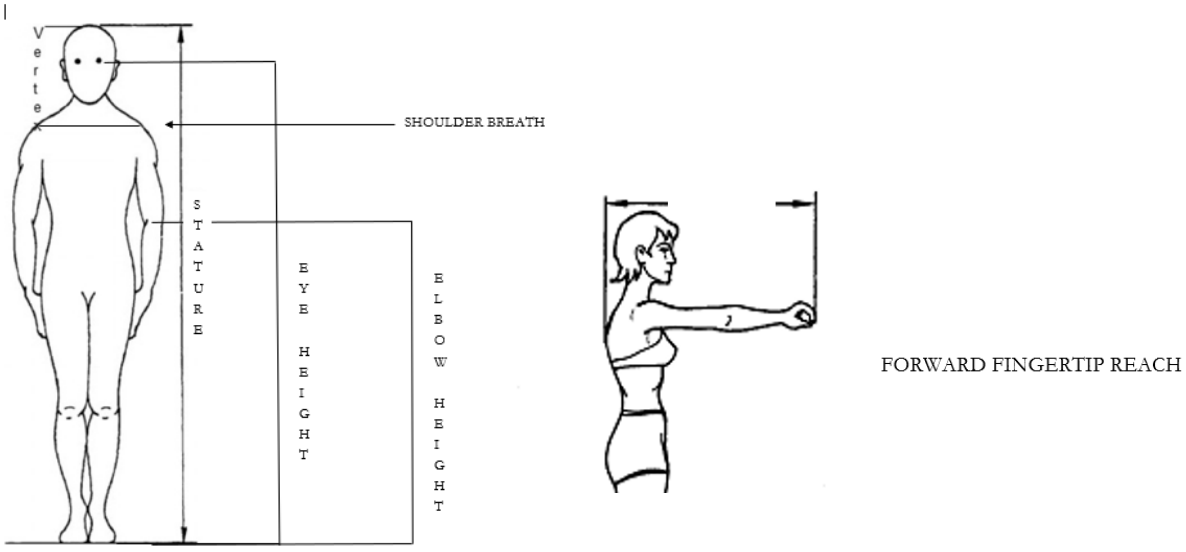

Figure 1. Anthropometric Data required for Proposed Design based on ISO 725
(Basic Human Measurement for Technological Design)

4.2 Data Analysis

The result data was gathered and analyzed with the help of Microsoft Excel 2013. Standard Deviation, 5thand 95th Percentile and Mean are the used for this analysis. All dimension is in centimeters (cm). The given data are from the results of study of Lu and it will serve as the descriptive statistics for measured anthropometric dimensions for female cashier.

Table 1. Descriptive statistics for measured anthropometric dimensions for Filipino female worker

Body Measurement	5th Percentile	95th Percentile	Mean	SD
Stature (cm)	143	165	153.92	8.28
Eye Height (cm)	134	153	143.05	6.15
Elbow Height (cm)	89	104	96.28	7.39
Forward Fingertip Reach (cm)	59	72	66.04	5.77
Shoulder Breadth (cm)	34	46	40.24	8.29

4.3 Results and Discussion

Table 1 present descriptive statistics of all the measured anthropometric measurements for female cashiers in supermarket, respectively. The proposed check-out counter design is currently being preferable due to its capability of decreasing the probability of having a musculoskeletal disorder of cashiers. Also, it will maintain social distancing that is essential amid the new normal. Table 2 shows the descriptive statistics for ergonomic design of check-out counter.

Table 2. Descriptive statistics for ergonomic design of check-out counter

Features		Anthropometric Measurement	Design Dimension	Criteria Determinant
Height	With Barrier	Standard Height of Cashier	94cm + 65cm + 35cm	Adding the standard Height of cashier plus the ideal height of barrier and Item Passageway.
	With Monitor Screen	Eye Height	134 cm	5th Percentile of female eye height. The 27cm monitor screen is included.
		Elbow Height	89 cm + 5 cm (94 cm)	5th Percentile of female plus 5cm allowance
Width	Platform	Propose Width	40 cm	-
	Workstation	Shoulder Breadth	34 cm + 26 cm (60 cm)	5th Percentile plus 26 cm allowance
	Entire check-out counter	Propose Width	175 cm	Summation of proposed width of platform, 35 cm width of cashier's passageway and workstation of cashier
Length	Workstation	Forward Fingertip	59 cm plus 1 cm (60 cm)	5th Percentile plus 1 cm allowance
	Entire check-out counter	Propose Length	185 cm	Summation of 85 cm cashier platform for tools (Monitor Screen, Keyboard, CPU, and others.), 5thpercentile of Forward Fingertip Reach of female and 40 cm width of platform.

4.4 Design of Proposed Check-Out Counter

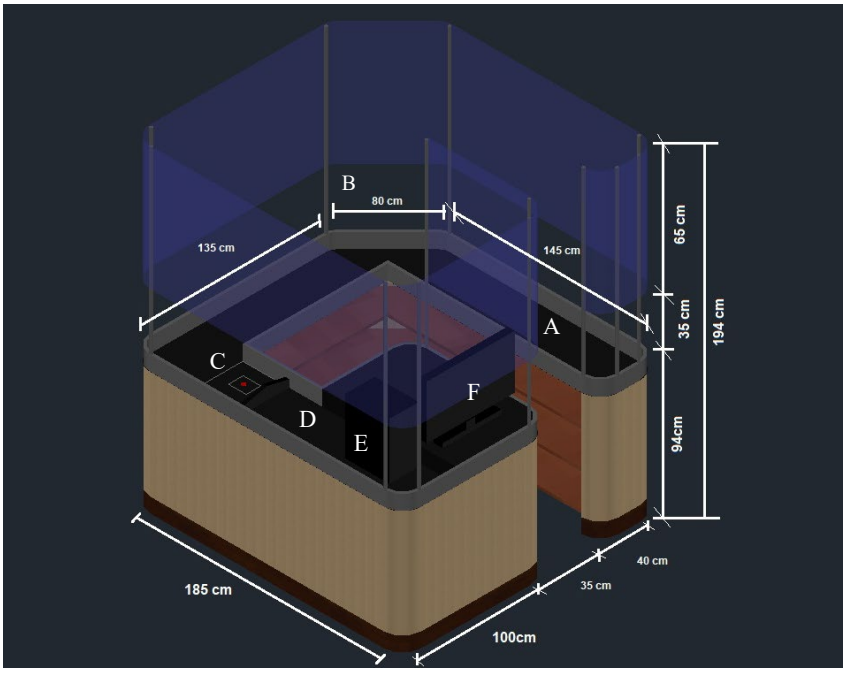

Figure 2. Isometric View of Proposed Design

LEGENDS:
A- Item Platform
B- Item Passageway
C- Barcode Scanner
D- Claiming and Payment Area
E- Computer's CPU
F- Monitor

Figure 2 illustrates the isometric model of the proposed check-out counter design. It includes some features of it including the item passageway, a barrier made by acrylic glass and item shelve. The check-out counter is made of stainless-steel type of metal. It is good to use due to its quality such as being corrosion resistance, unlike carbon steel. The edges of the check-out counter are curved to avoid sharp corners. The design has 3-layer shelves which can put some working tools and equipment needed by the cashier such as notebooks, reports, pen, calculator, etc. Also, this design can accommodate 2 or more customers which can put their items on the platform to decrease musculoskeletal disorder through handling heavy baskets. Even they can put their basket on the floor and used carts, it will cause bottlenecks. Researchers observed that carts and baskets on the floor affect the space. Therefore, the research team suggests putting their items on the platform can help the customers. And lastly, this design will maintain social distancing practice since per division has a 1-meter distance which is required nowadays. In line with this, the design has an item passageway to have social distancing between the cashier and the customer.

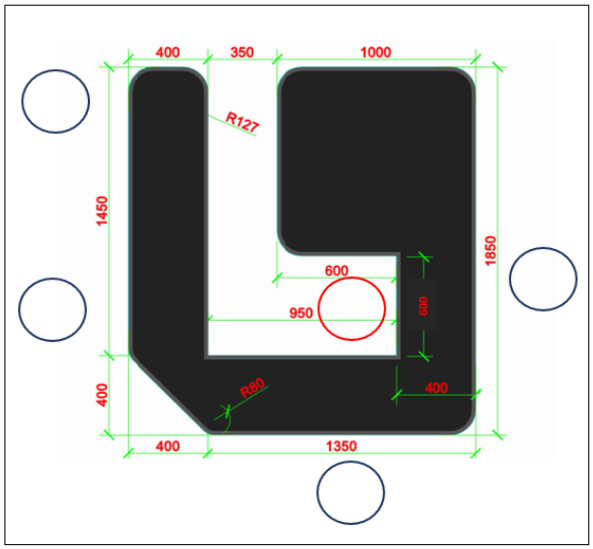

Figure 3. Plan Design

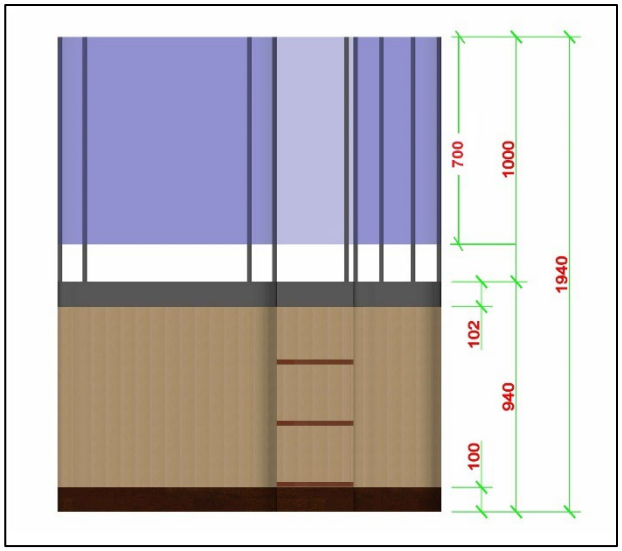

Figure 4. Front View of Proposed Design

LEGENDS:

-Cashier -Customer

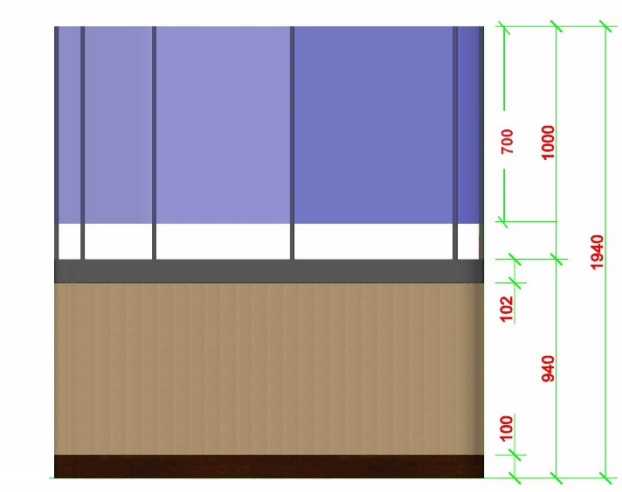

Figure 5. Left View of Proposed Design

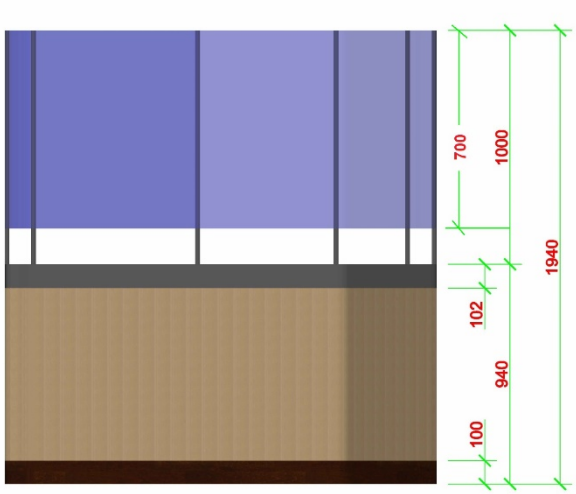

Figure 6. Right View of Proposed Design

5. Results and Discussion

This section will provide the numerical result of the study by the ergonomic tools such as Ovako Working Posture Analysis System (OWAS) and Rapid Entire Body Assessment (REBA).

5.1 Numerical Results

The numerical results of this study are presented. The researchers used the Ovako Working Posture Analysis System (OWAS) and Rapid Entire Body Assessment as a tool to identify the common work postures of a cashier that can be a factor in musculoskeletal disorders.

5.1.1 Ovako Working Posture Analysis System Result

This section will provide the comparative assessment of Ovako Working Posture Analysis System of using the current and proposed check-out counter design.

5.1.1.1 Using Current Check-Out Counter

Figure 7. Working Posture of barcoding activity of the female cashier

Table 3. Ovako Working Posture Analysis System of barcoding activity of the female cashier

	Score	Explanation
Back Posture	2	Bent
Arm	1	Both arms are below the shoulders
Legs	3	Stand resting on one straight leg
Load Force	1	Load weight is less than 10 kg

Table 3 shows the rating result of the assessment of encoding is **2131** code. Based on the OWAS Action Category, 2131 points falls to **3rd category**. It means that the posture in barcoding should have a **corrective measurement as on as possible.**

5.1.1.2 Using Proposed Check-Out Design

Table 4. Ovako Working Posture Analysis System of using proposed check-out design

	Score	Explanation
Back Posture	1	Straight
Arm	1	Both arms are below the shoulders
Legs	2	Stand resting on both legs straight
Load Force	1	Load weight is less than 10 kg

The rating result of the assessment in table 4 is **1211** code. Based on the OWAS Action Category, 1211 points falls to **1st category**. It means that the posture should have a **no action required.**

5.2.2 Rapid Entire Body Assessment Result

This section will show the comparative analysis of Rapid Entire Body Assessment of using the current and proposed check-out counter design.

5.2.2.1 Using Current Check-Out Counter

Table 5. Rapid Entire Body Assessment by using current check-out counter

	Score
Posture A	**7**
Force/Load	**0**
Neck, Trunk and Leg	**7**
Posture B	**7**

Coupling	**1**
Wrist and Arm	**8**
Table C	**9**
Activity Score	**1**
Rapid Entire Body Assessment	**10**

Score A consists of the neck, trunk, and leg analysis. This analysis got 7 points. Meanwhile, Score B consist of arm and wrist analysis got a score of 7. The result of the sum for these two scores is 9 points based on table c. The activity score is 1 point because the cashier repeated small range actions. Therefore, table 5 shows that the REBA score is 10 which means the said activity is **High Risk. Investigate and Implement Change.**

5.2.2.2 Using Proposed Check-Out Counter

Table 6. Rapid Entire Body Assessment by using proposed check-out counter

	Score
Posture A	**1**
Force/Load	**0**
Neck, Trunk and Leg	**1**
Posture B	**2**
Coupling	**0**
Wrist and Arm	**2**
Table C	**1**
Activity Score	**1**
Rapid Entire Body Assessment	**2**

Score A consists of the neck, trunk, and leg analysis. This analysis got 1 point. Meanwhile, Score B consist of arm and wrist analysis got a score of 2. The result of the sum for these two scores is 8 points based on table c. The activity score is 1 point because the cashier repeated small range actions. Therefore, the REBA score is 2 which means the said activity is **Negligible Risk.**

5.2 Graphical Results

The researcher conducted a survey with 65% of customers and 35% of cashiers in San Juan City. The respondents are composed of males and females ages 19 to 59 years old. And the researchers interviewed some of the representatives from the cashiers in supermarkets. Based on the result of the survey, 88.1%out of 100% of respondents are female. Therefore, the female is the common gender of cashiers in San Juan City. The result also depicts that most of the cashiers are ranging from the age of 31 to 40 years old. The common problems of customers show that 74.7% of them answered social distancing is not maintained while waiting in the check-out counter line, 66.3% of them also answered that they are having difficulties in carrying baskets and carts because it has heavy load amount of item. Also, 54.4% of them encounter a delay in service. 36.1% of respondent's experience bottlenecks in the area. According to one of the customers, she told the researchers that there are a lot of baskets and carton boxes around the counter which are consuming more spaces. While there are 0.8% of respondents do not have problems in the check-out counter area. The cashiers also face some problems with their workstation. The data result shows that 85.1% of cashiers said that the keyboard and bar code scanner is too low or high. Also, 81.3% of them answered that the monitor screen is not compatible with their eye level. Lastly, 76.9% of the cashier answered that their workplace is too close-fitting. In addition, 89.2% of customers and 72.4% of cashiers are not satisfied with the safety protocols in supermarkets. These problems motivate them to suggest some features in developing the check-out design. The result shows that there are 85.9% of customers answered, "Have a platform to put the items instead of carrying the basket or cart while waiting." While 83.1%of them answered, "Have concrete and a safe barrier between customer and cashier." And there is 0.4% do not have any suggested helpful features for developing the current cashier counter. 90.3% of cashiers also answered, "Widen my workstation." while 88.8% of them answered, "Have concrete and a safe barrier between customer and cashier." And there is 0.7% answered, "Use good quality of the material." The majority of cashiers and customers believe that the proposed design will help them in different aspects such as maintaining the social distancing that is essential for this period.

5.3 Proposed Improvements

Supermarket management must secure the working condition of their employees through consulting with a medical practitioner to prevent musculoskeletal disorders. In terms of the cost of the product, the researchers suggest recycling current check-out counter materials to produce it since almost all its materials are the same as the proposed design. The new check-out counter design can also use after the pandemic by removing the barrier glass. Through this, more customers can put their items on the platform. Also, Local Government Units (LGUs) should have a concrete plan and implementations in supermarkets. Supermarkets are one of the most visited places in the commercial areas. Therefore, there a chance that passing the virus nowadays will be more accessible if the social distancing is not maintained. To prevent the transmission of the virus, the management must allow a limited number of people inside the supermarket as a part of the new normal. The researchers recommend this study to future researchers as their basis and guide in developing equipment and tools that are needed to enhance due to the implementation of new normal and musculoskeletal related study.

5.4 Validation

As the results show, the Ovako Working Posture Analysis System by using the current check-out counter has a code of 2131 that falls to the 3rd category. It means that the posture in barcoding should have a corrective measurement as on as possible. However, the proposed design has a code of 1211. Based on the OWAS Action Category, 1211 points fall to1st category. It means that the posture should have no action required. On the other hand, the score of using the current check-out counter in Rapid Entire Body Assessment is 10 which means the said activity is High Risk, Investigate and Implement Change. But this score will be decreased if the proposed design will be used. The researchers found that the Rapid Entire Body Assessment score of the proposed design is 2 which means the said activity is Negligible Risk.

6. Conclusion

The ergonomic assessment tools and survey results prove that the cashier can cause musculoskeletal disorders using the check-out counter. Ovako Working Posture Analysis System results depict corrective measurement as on as possible is suggested baseline to address this working condition. Thus, researchers found that using the proposed check-out counter has no action required since it is improved and developed through changing the dimensions and adding features. Besides, the Rapid Entire Body Assessment result shows that there is a high risk. It should investigate and implement Change. Similar to the OWAS, this study uses the said result for the improvements. The proposed design will satisfy the performance of the cashiers based on the results of the ergonomic tools and surveys. Also, it will address the issue regarding the social distancing protocol because researchers believe that COVID-19 can acquire in check-out counters. Hence, it will have significant changes and improvements. The researcher concludes that the current check-out counter design must improve and innovate design that will fit in the new normal, reduce and prevent musculoskeletal disorders, and attain adequate work performance.

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Biography

Alfred Joshua S. Aquino is a 3rd-year student from the Industrial Engineering Department at Technological Institute of the Philippines-Manila. He is a current member of the Inhinyera and Junior Philippine Institute of Industrial Engineering. He finished his senior high school at Central Colleges of the Philippines with the strand of Science, Technology, Engineering, and Mathematics by 2018. Aquino has authored research entitled "Academic Performance in Calculus and Level of Proficiency in Solving Problem in Physics 1 of STEM Students in Central Colleges of the Philippines" as a partial fulfillment in the research project.

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