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Enhancing Comfort and Ergonomic Redesign of Seats for Tricycle Drivers at the Tricycle Operators and Drivers Association in Lipa City, Batangas

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Abstract

The proposed research article, Enhancing Comfort and Ergonomic Redesign of Seats on Tricycles to the Tricycle Operators and Drivers Association in Lipa City, Batangas, intends to identify and evaluate the current sitting design of tricycles to increase the level of comfort, safety and ergonomic efficiency in drivers. The drivers of the tricycles are known to undergo excessive sitting and vibrations and bad postures that cause them to be discomforted and strained. The researchers measured the existing seat design on dimensions, materials, posture assistance, and vibration absorption through surveys, interviews and ergonomic assessment tools. The results indicated that the majority of tricycle seats do not have lumbar support, cushioning and adjustability and are associated with fatigue and health hazards in drivers. On the basis of the results, the proposed ergonomically redesigned seat prototype was offered, which took into account the anthropometric data, the necessity of durability but comfort material and the enhancement of the seat contour. The redesign is expected to increase the level of comfort in the driver, the degree of physical strain, and the overall driving performance. The research paper indicates the significance of ergonomic design in facilitating occupational health and safety of local transport operators and makes a contribution to sustainable livelihoods in the Lipa City tricycle community.

Keywords
Nordic Musculoskeletal, Rapid Upper Limb Assessment, Rapid Entire Body Assessment, Driving Posture, TODA (Tricycle Operators and Drivers Associations).

1. Introduction
Tricycles have been a major component of transport in the Philippines as early as late 1950s particularly in short route transportation within urban and rural surroundings. They are still among the modes of public transport that are extensively used. Tricycles are the second in seven modes of transport with an average of 5,687 trips per day, with jeepneys being the third on the list (6,763 trips), and buses (2,352) and trains (1,485) the last ones. Although tricycles are popular and have cultural values, their passenger capacity (45 people) is usually low, and fares may be charged differently based on the location.

Though designs of tricycles have been especially aesthetic in diverse regions, ergonomics has been given minimal attention. Ergonomics is aimed to design the tools and systems in a way that they are more comfortable, safe and useful due to the matching of its characteristics to the human anatomy and physiology. Asael (2023) notes that the majority of tricycle upgrades are directed at looks and do not consider the ergonomic issues. Current research primarily focuses on how to accommodate the passengers whereas little attention has been given to the drivers as they spend most of their time operating the tricycles thus being exposed to inadequate seating design, inadequate space, and insufficient support, which cause musculoskeletal disorders (MSDs) and posture strain.

The proposed research intends to come up with an ergonomically enhanced motorized tricycle seat that is founded on the anthropometric factors of Filipino drivers, along with the road and environmental conditions of the area. It aims at designing a cost effective design that will ease the comfort of the drivers, their safety, and the general ease of use without imposing any financial strain on the operators. The research aims to minimize occupational risks to health and enhance the standards of public transport through driver-centered design. The research also contributes to the United Nations sustainable development goals, especially SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), and SDG 11 (Sustainable Cities and Communities), which improves safety and more inclusive transport of tricycle drivers in the Philippines.

1.1 Objectives

This research aims to recognize ergonomic risks, measure them with ergonomic tools, study their relationship with the driver and use what is learned to rebuild the seat according to ergonomic principles . The purpose is to reduce stress on the body, enhance user comfort and support proper posture over the long term.To examine the current seating design and driving posture of tricycle drivers in Lipa City, Batangas through:1. 1 Observation of real-time driving postures during operation and;1.2 Measure seat dimensions and spatial layout.To identify the ergonomic risk factors associated with tricycle driving postures through the application of validated ergonomic assessment tools, such as:2.1 Nordic Musculoskeletal Questionnaire 2.2 RULA to evaluate upper limb and neck postures and;2.3 REBA to assess full-body ergonomic strain.To analyze the correlation between driver characteristics and ergonomic risk:3.1 Determine the relationship of age, years of experience, and daily driving hours with ergonomic risk scores (RULA/REBA);3.2 Develop and validate a regression model to predict ergonomic risk based on these demographic factors.To design an ergonomic tricycle seat that reduces musculoskeletal strain, enhances posture, and improves comfort, focusing on: 4.1 Local anthropometry; 4.2 Materials and specifications;4.3 Cost.To assess the feasibility of implementing the redesigned ergonomic tricycle seat by:5.1 Evaluating driver acceptance and willingness to adopt the new seat design;5.2 Conducting a cost-benefit analysis considering materials, manufacturing, and long-term health benefits;To evaluate the redesigned seat's effectiveness by comparing pre- and post-intervention RULA and REBA scores.

2. Methods

2.1 Research design

The study used a mixed-method descriptive research design. This approach involves collecting and analyzing data to describe a specific phenomenon without examining cause-and-effect relationships. Its purpose is to provide an accurate and comprehensive understanding of the population or subject being studied.

2.2 Subject of the Study

The Raosoft was used to identify the respondents. Out of 146 tricycle drivers of the TODA on Barangay Inusloban, Plaridel and San Lucas of Lipa City in Batangas, 106 respondents were identified with a 95% confidence level and a 5% margin of error. The sample was simple random, which means that every individual member of the population had an equal probability of being selected to be part of the sample which reduces bias and enhances the validity of the study.

2.3Data Gathering Instrument

The researchers proposed the Tricycle Operators and Drivers Association (TODA) in Inusloban, Plaridel, and San Lucas (IPS) to ergonomic tools to the drivers to tackle driver discomfort due to poor seat design, improper seat height, reduced space, and comfort deficiency by adhering to the data instrument; Direct Observation, Measuring Tape, Interview, AnthropometricSurvey,RULA(Rapid Upper Limb Assessment),REBA(Rapid Entire Body Assessment), and User Survey.

2.4 Data Gathering Procedure

The researchers will observe tricycle drivers at Lipa City, Batangas to determine their sitting position and posture while driving. The measurement of seat dimensions and spatial layout will be made, as well as the feedback about the comfort and physical discomfort during the interview and surveys. Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) will be used to assess ergonomic risks. Statistical tools will be used to analyze the results based on the age, experience, and number of hours that the drivers drive on a daily basis. Following the results, an enhanced tricycle seat in terms of ergonomics will be developed and prototyped to test the change in posture, comfortability and the decreases in musculoskeletal strain.

2.5 Data Analysis

The following is the analyzation methods applied in interpreting and examining the data of the study.; Frequency and Weighted mean,Correlation

3. Results and Discussion

The paper provides and evaluates the gathered data through the application of qualitative and quantitative data analysis. The findings are presented based on the aims of the study and with the help of graphs, tables (Table 1- Table 10), and figures (Figure 1- Figure 6). The results are discussed in a manner that they give an insight that will form the foundation of the findings in the following chapter in terms of conclusions and recommendations.

1.To examine the current seating design and driving posture of tricycle drivers in Lipa City, Batangas through:

1.1Observation of real-time driving postures during operation and;

The result showed that the proposed tricycle seat was designed to improve drivers posture, comfort and reduce ergonomic risk.

Table. 1 Seat Dimensions

Seats	Proposed Design and Dimensions
Seat Height	21.73
Seat Width	75.61
Seat Length	35.42
Seat Backrest	9.05 to 13.77 inches

1.2 Measure seat dimensions and spatial layout

On field observations done among the tricycle drivers in Lipa City, Batangas, it was noted that the existing seat designs are not ergonomically satisfactory. The majority of drivers are bent forward with rounded shoulders and straightened arms and exert unequal pressure on the spine and change weight frequently in order to relieve pain during the long working hours.

Table 2. Physical Measurement

Tricycle Variables	**Average Measured (cm)**	**Recommendation (cm)**
Seat Width	75.61	76.70
Seat Length	35.42	36.51
Seat Height	21.73	22.84

2. To identify the ergonomic risk factors associated with tricycle driving postures through the application of validated ergonomic assessment tools

2.1 Nordic Musculoskeletal Questionnaire

The results show that when the seating conditions of the tricycle drivers from the Tricycle Operators and Drivers Association in Lipa City, Batangas were assessed using ergonomic risk tools, the outcome strongly showed that their current seats are exposing them to harmful levels of strain that can affect their health and ability to work.

Table 3. Tallied Results of Survey

Assessment Tool	Risk Level	Number of Respondents	Percentage
RULA	Medium to High Risk	70 out of 106	66.04%
REBA	High Risk	90 out of 106	84.91%
AVERAGE EXPOSURE	Significant Ergonomic High Risk		Average Percentage=75.48%

2.2 RULA to evaluate upper limb and neck postures

The results show that the Rapid Upper Limb Assessment (RULA) evaluation of the tricycle drivers' working posture produced a final score of 7, which means the present seating and control conditions are at a level that requires immediate investigation and implementation of change.

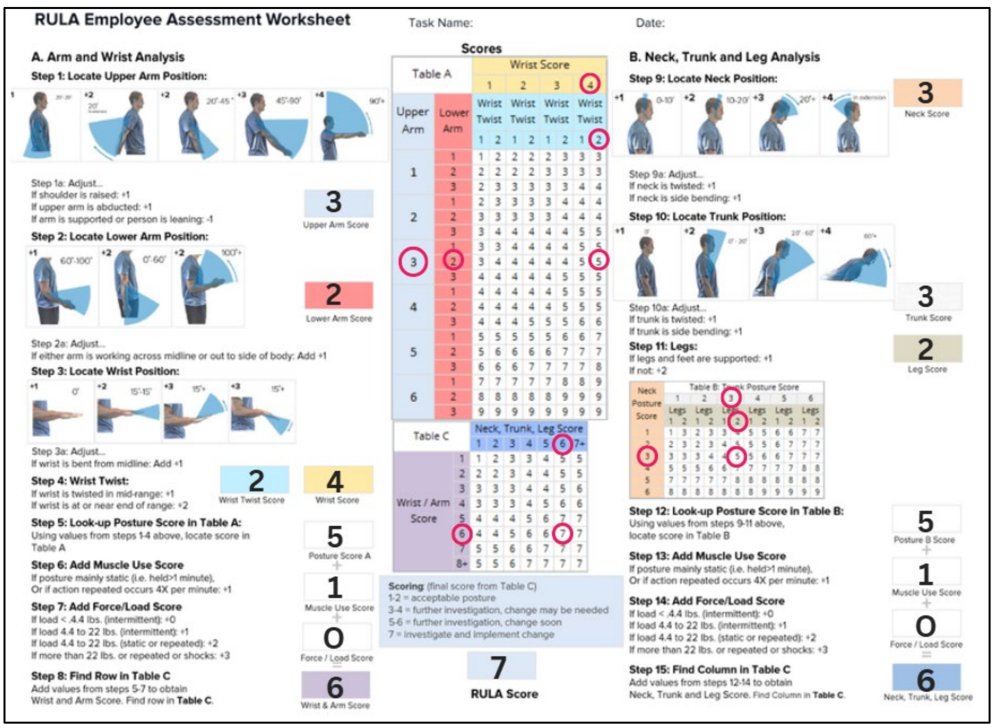

Figure 1. Rapid Upper Limb Assessment

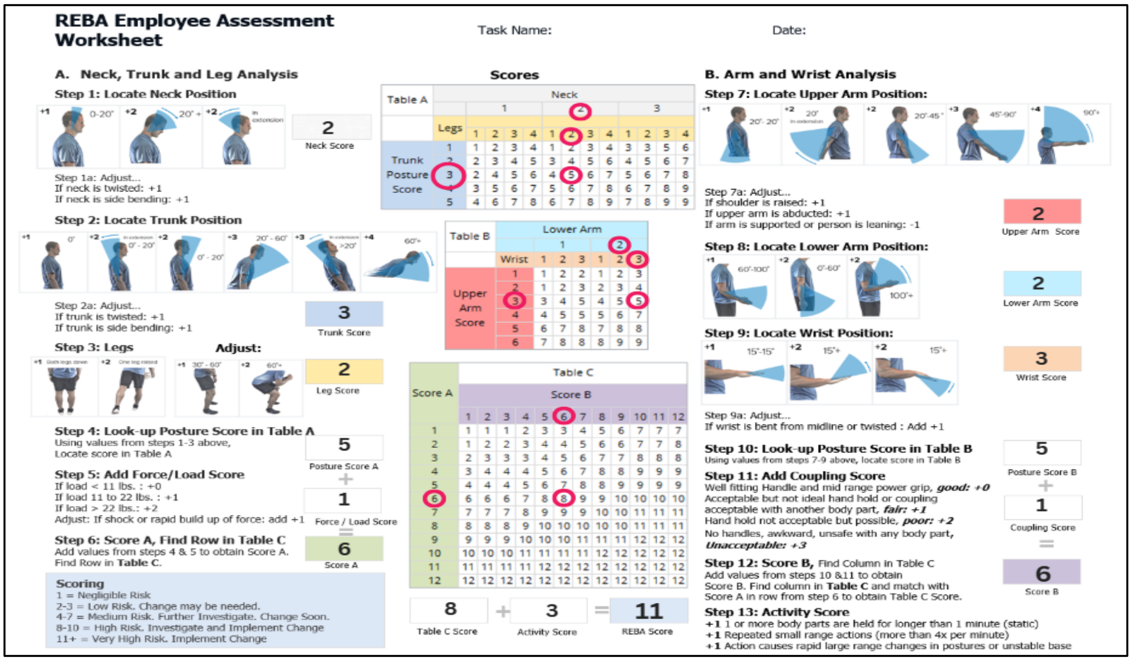

Figure 2. Rapid Entire Body Assessment

The results show that the Rapid Entire Body Assessment (REBA) conducted on the tricycle drivers' working posture yielded a total score of 11, which is classified as very high risk and requires immediate ergonomic intervention

3.To analyze the correlation between driver characteristics and ergonomic risk

3.1 Determine the relationship of age, years of experience, and daily driving hours with ergonomic risk scores (RULA/REBA)

Table 4. Hypothesis Testing

Test:	
Null Hypothesis	Ho : (no relationship)
Alternative Hypothesis	Ha : (there is a significant relationship)

The Table 4 shows the null hypothesis (Ho) states that there is no relationship between the variables being examined, meaning that any observed connection might be due to random chance. On the other hand, the alternative hypothesis (Ha) claims that a significant relationship does exist, indicating that the variables are meaningfully linked. These hypotheses lay the groundwork for the hypothesis testing process, helping to interpret the statistical results and deciding if the data offer enough proof to reject the null hypothesis in favor of the alternative.

3.2 Develop and validate a regression model to predict ergonomic risk based on these demographic factors

Regression Equation

Daily Driving Hrs			
10 or more hours	RULA	=	5.826 - 0.02562 Age - 0.04555 Years of Experience
11 or more hours	RULA	=	5.199 - 0.02562 Age - 0.04555 Years of Experience
4-6 hours	RULA	=	4.113 - 0.02562 Age - 0.04555 Years of Experience
7-9 hours	RULA	=	4.532 - 0.02562 Age - 0.04555 Years of Experience
less than 4 hours	RULA	=	4.242 - 0.02562 Age - 0.04555 Years of Experience

Figure 3. Regression Analysis

The outcomes of the RULA results indicate that the longer the working hours per day in driving and the number of working years the higher the ergonomic risk of the neck, trunk, and upper limbs. Drivers working 7-10+ hours a day would score higher in RULA as they spend many hours sitting in one posture, repeat the same steering motions, and have a poor seat design. To reduce these risks, it is possible to improve the ergonomics of the seats and promote changes in the positions or stretching.

Regression Equation

Daily Driving Hrs			
10 or more hours	REBA	=	12.474 - 0.0718 Age - 0.0067 Years of Experience
11 or more hours	REBA	=	10.15 - 0.0718 Age - 0.0067 Years of Experience
4-6 hours	REBA	=	11.70 - 0.0718 Age - 0.0067 Years of Experience
7-9 hours	REBA	=	11.11 - 0.0718 Age - 0.0067 Years of Experience
less than 4 hours	REBA	=	13.56 - 0.0718 Age - 0.0067 Years of Experience

Figure 4. Regression Equation

The outcomes of the RULA results indicate that the longer the working hours per day in driving and the number of working years the higher the ergonomic risk of the neck, trunk, and upper limbs. Drivers working 7-10+ hours a day would score higher in RULA as they spend many hours sitting in one posture, repeat the same steering motions, and have a poor seat design. To reduce these risks, it is possible to improve the ergonomics of the seats and promote changes in the positions or stretching.

4. To design an ergonomic tricycle seat that reduces musculoskeletal strain, enhances posture, and improves comfort, focusing on:

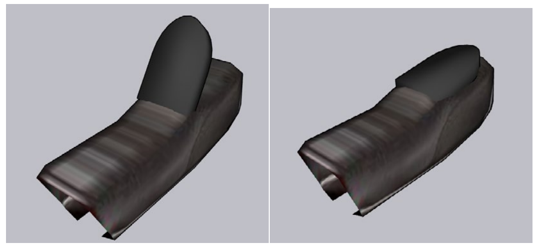

Figure 5. Ergonomic Design Seat for Tricycle Drivers

The redesigned ergonomic tricycle seat is expected to prevent musculoskeletal stress, improve the sitting posture, and overall comfort among tricycle drivers by meeting the physical requirements of extended tricycle driving.

4.1 Local Anthropometry

The results show that the local anthropometric measurements of tricycle drivers in Lipa City give a precise guide for designing an ergonomic seat that supports proper posture and comfort during long driving periods (Figure 6).

Anthropometric Measurement (cm)	Mean	5th Percentile	Median	95th Percentile	Std. Dev.
Sitting Height	81.53	69.00	78.00	88.40	3.20
Buttock to Knee Length	50.12	40.00	50.00	59.00	3.30
Buttock to Popliteal Length	42.11	32.00	42.00	50.00	3.22
Knee Height	50.24	37.60	50.00	54.00	3.19
Popliteal Height	47.11	29.86	40.25	49.00	3.25
Shoulder to Elbow Length	31.53	25.72	30.00	38.20	2.40
Elbow-Finger tip Length	42.51	30.51	41.00	45.10	2.58
Shoulder Breadth	40.33	30.74	39.40	42.35	3.88
Hip Breadth	33.87	26.50	30.00	40.20	4.30
Hand Length	19.33	14.00	17.00	19.54	1.30
Handbreadth(metacarpal)	10.08	8.00	9.00	10.40	0.75

Figure 6. Local Antropometry

4.2 Materials and Specifications

The criteria are assessed using a primary score and weighted score in parenthesis. Molded Foam ranks the highest in general (52), which means that the company has balanced performance in most aspects. This aligns with studies showing that molded polyurethane foams have a microstructure that provides excellent cushioning, vibration damping, and compressive strength, making them suitable for comfort and shock absorption applications

Table 5. Pairwise Matrix of Foam

Criterion	Comfortability	Flexibility	Shock Absorption	Thickness	Durability	Lightweight	Score
Molded Foam	3 (3.5)	3 (2.5)	2 (5.5)	2 (2.5)	3 (3.5)	3 (2.5)	52
Latex Foam	2 (3.5)	1 (2.5)	3 (5.5)	3 (2.5)	3 (3.5)	1 (2.5)	41.5
Slabstock Foam	1 (3.5)	1 (2.5)	1 (5.5)	1 (2.5)	2 (3.5)	2 (2.5)	26

Table 6. Pairwise Matrix Leather Material

Criterion	Flexibility	Moisture Resistance	Aesthetic Appeal	Score
Synthetic Leather	3 (2.5)	2 (1.5)	3 (0.5)	12
Genuine Leather	2 (2.5)	1 (1.5)	1 (0.5)	7
Polyester Fabric	3 (2.5)	2 (1.5)	1 (0.5)	11

Three alternative materials, which were Synthetic Leather, Genuine Leather, and Polyester Fabric were assessed using the pairwise matrix with regards to three factors (Flexibility, Moisture Resistance, and Aesthetic Appeal). A weight was placed on each criterion based on a pair-wise comparison with Flexibility (2.5) the most important, then Moisture Resistance (1.5), and finally Aesthetic Appeal (0.5). Concerning Flexibility, the best rating was given to Synthetic Leather (3), which implies high adaptability and comfort as compared to Genuine Leather (2) and Polyester Fabric (3). This is an indication that synthetic leather is easier to move around and has better ergonomic performance

4.3 Cost

Table presents the computed pricing details for the developed product. The total investment cost of ₱22,743,547 and annual production of 13,746 units resulted in a unit cost of ₱1,654.52. Applying a 12% VAT adds ₱198.54 per unit, while a 23.99% mark-up contributes ₱396.92 as profit. This brings the final selling price to ₱2,249.98, rounded off to ₱2,250.00. The computation ensures that the selling price covers production costs, taxes, and provides a reasonable profit margin, making the product financially viable for market distribution

Table 7. Price Study

PARAMETERS	VALUES
Investment Cost	22,743,547
Total Unit Per Year	13,746
Unit Cost	1654.52
VAT (12%)	12%
VAT	198.54
Mark-Up (25%)	23.99%
Unit Cost with Mark Up	396.92
Selling Price	2249.98
Rounded-off Selling price	2250.00

5.To assess the feasibility of implementing the redesigned ergonomic tricycle seat by

5.1. Evaluating driver acceptance and willingness to adopt the new seat design;

The Table 8 shows the ergonomic tricycle seat is a locally developed project that aims to improve comfort, correct posture, and safety among tricycle drivers in Lipa City, Batangas. It prioritizes the principles of ergonomics with anthropometric data from the local drivers of Lipa to reduce musculoskeletal strain and fatigue during long hours of driving. Based on the survey results, 95 out of 106 respondents are willing to buy the redesigned ergonomic seat.

Table 8. Survey Tallied of willingness to buy

A. Nature of the Business

Would you purchase this Ergonomic Seat?	Yes	95	85.62%
	No	16	15.09%

5.2. Conducting a cost-benefit analysis considering materials, manufacturing, and long-term health benefits

Cost-Benefit Analysis

The Cost-Benefit Analysis (CBA) evaluates the overall financial performance of ErgoTech Solutions, comparing the project's total costs with its anticipated monetary gains over a ten-year period (2026–2035). This analysis measures how efficiently the project can convert its investment into long-term financial and social benefits.

Table 9. Evaluation Metrics

Evaluation Metrics	Description
Net Present Value (NPV)	₱54,086,107.56 — A strong positive NPV, proving that total projected earnings exceed the investment cost.
Internal Rate of Return (IRR)	23.21% — Indicates excellent profitability and high efficiency in generating returns from invested funds.

Simple Payback Period	Approximately 3.49 years — Reflects a rapid recovery of the initial investment during the first operational year.
Average Net Income	₱5–₱6 million annually — Shows consistent financial performance and effective cost management.
Return on Investment (ROI)	19–21% — Confirms sustainable and favorable profit levels relative to the total capital invested.

The table shows that contains the assessment values of the financial performance of a project. It shows that the Net Present Value (NPV) is equal to 54,086,107.56, and it implies that the future earnings are higher than the cost of investment. The Internal Rate of Return (IRR) stands at 23.21 which is a good indicator of good profitability and effective utilization of funds invested. The simple payback period stands at about 3.49 years which indicates that the initial investment would be broken even within a fairly short period. It is also mentioned in the table that the total net income is approximately 5-6 million a year, which is consistent in terms of financial performance, and the Return on Investment (ROI) is 19-21 which is a positive and sustainable profit in terms of the total capital invested.

6. To evaluate the redesigned seat's effectiveness by comparing pre- and post-intervention RULA and REBA scores

Table 10. Results of RULA and REBA

Assessment Tool	Risk Level	Number Of Respondents	Percentage
RULA	Acceptable	95 out of 106	89.62264151
REBA	No. of Negligible	96 out of 106	90.56603774%
AVERAGE EXPOSURE	Significant Ergonomic Acceptable		Average Percentage=90.09%

The redesigned seat significantly improved ergonomics, according to the post-intervention assessment using RULA and REBA. Approximately 89.62% of drivers had acceptable RULA scores, and 90.57% displayed negligible risk in REBA, indicating less strain on the entire body as well as the upper body. Better posture, less musculoskeletal strain, and increased ergonomic safety and comfort were confirmed by mean RULA scores falling from 2.98 to 1.68 and REBA scores falling from 8.48 to 2.94.

4. Summary of Findings, Conclusions, and Recommendations

4.1 Summary of Findings

The seats on tricycles in Lipa City are (75.61 cm wide, 35.42 cm long, and 21.73 cm high), which don't fit the average Filipino body size. This makes it hard for them to support their thighs, legs, and lower back. many drivers lean forward, which puts stress on their spines and makes them tired. About 83.96% of drivers said they were uncomfortable, especially in their lower back, buttocks, shoulders, and legs.

RULA and REBA tests showed that most drivers had a medium to high ergonomic risk. But the new seat, which had adjustable backrest angles, lumbar support, and cushioning that absorbed vibrations, helped with posture and lowered the risk of injury.Also, 74.53% of drivers said they would be interested in buying an ergonomic seat, which costs an average of ₱2,500. The project's NPV is ₱54,086,107.56, its IRR is 23.21%, and it will pay for itself in 3.8 years. This means that it is good for both the economy and society.

4.2 Recommendation

The recommendations to enhance comfort, safety, and productivity for drivers are based on the findings and conclusions of this study.(1)For manufacturers and designers, tricycle seats must be developed using Filipino anthropometric data and quality materials for better shock absorption, cushioning, and breathability. (2)It is recommended that government agencies and transport authorities develop ergonomic design standards for tricycles and frequently conduct inspections to ensure compliance with such standards. (3)Future studies should be done in other regions for academic institutions and future researchers to establish a national anthropometric database for public transport workers. (4) the community and societal levels, support for ergonomic innovations is warranted by emphasizing the ideals of safer, healthier, and more sustainable transportation.

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