Jurnal Manajemen Bisnis
Program Pascasarjana Universitas Muhammadiyah Tangerang

ISSN: 2302-3449 I e-ISSN: 2580-9490
Vol. 14 I No.2, hal 88-101

The Effect of of Long-Term Headset Use on Changes in Human Head Structure

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Received 07 July 2025, Revised 12 July 2025, Accepted 03 September 2025

Keyword

Deformation, Ergonomics, Headset, Skull Structure, Mechanical Stress.

Abstract

Headsets are essential for daily activities such as gaming, working, and online learning. However, uneven mechanical pressure generated by excessive use of headsets can affect the skull structure. This innovative headset features a Dual-Support System that distributes pressure evenly, lightweight ergonomic pads, and an adjustable design to fit the user's head and ear size. In this study, design elements, ergonomics, and health risks associated with long-term headset use were evaluated through observation, ergonomic studies, and anthropometric measurement methods. The results showed that this design is effective in reducing the risk of skull deformation and making the headset more comfortable to use. In addition, the research also supports the achievement of Sustainable Development Goals (SDGs) 3 and 8 as it promotes health well-being and improve working conditions for individuals in digital and creative fields, who rely on headset for prolonged periods. Through an intensive study of ergonomic methods and the integration of SDG principles, this research not only addresses physical health concerns but also contributes to creating a more sustainable, productive, and comfortable environment.

I. Introduction

In the modern era, increasingly sophisticated technological developments bring significant changes to various aspects of life. Every individual from any background is expected to be able to follow the flow of this development to remain relevant and able to compete in an increasingly dynamic and competitive world. To achieve this, individuals must cultivate dynamic capabilities that enable them to adapt to rapid changes and seize opportunities in their environment. Technology, such as laptops, computers, tablets, interactive whiteboards, and projectors, has become an inseparable part of everyday life in various fields including the world of work, learning, and entertainment (Alrub & Sánchez-Cañizares, 2025). These technological tools not only facilitate communication and information sharing but also reshape how we perceive and engage with our surroundings (Kosala et al., 2022).

Jobs such as content creators, gamers, and influencers that were previously considered unpromising, are now popular professions and are in great demand by the younger generation. One device that is very closely related to these jobs is the headset. Intensive use of headsets has become a necessity for many people, especially gamers, workers in the creative industry, and students who often do online activities. In recent years, complaints have emerged about the negative impacts of long-term use of headsets, one of which is the area above the head when worn for extended periods (Zhou et al., 2024).

As the need for audio devices in professional and entertainment activities increases, the use of headsets and earphones is increasingly intensive among modern society, especially among creative workers, students, and gamers. A study showed that long-term use of earphones is not only associated with hearing loss

ISSN: 2302-3449 I e-ISSN: 2580-9490
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but also causes systemic complaints such as headaches (reported by 68% of respondents) and changes in blood pressure. Users of wired earphones even showed a higher risk compared to wireless users, indicating that device design and duration of use play an important role in user comfort and health (Saran et al., 2025).

This issue also concerns broader global concerns outlined in the Sustainable Development Goals (SDG's). The physical discomfort and health risks in connection with long-term headset application reflect the importance of SDG 3 which discusses good health and well-being, promoting to ensure healthy lives and well-being for all. A study by Saran et al. (2025) found that 68% of headphone users experienced headaches and 30% reported ear pain, while 25% experienced increased blood pressure. By addressing common problems of long-term headphone usage, it reveals the urgent need for ergonomic improvements and user education. In addition, this initiative aligns with SDG 8 which focusses on decent work and economic growth, which strives to improve working conditions for individuals in digital and creative fields, where headsets are their essential tools (Saran et al., 2025).A case of a 10-year-old boy who suffered from nasal deformity as a result of many hours of use of the Oculus VR headset. The bony deformities described in this case are likely the result of bone and subcutaneous tissue remodeling due to repeated mechanical loading by the VR headset over many months (Nasrollahi et al., n.d.). According to Markova and Skurkova (2023), improving ergonomic conditions could support well-being and productivity, which leads to safer and more inclusive work environments. Integrating human-factors design with sustainability yields benefits in worker well-being and organizational performance, where ergonomics and sustainability together can promote productivity, efficiency, and effectiveness while contributing to social sustainability and economic growth (Hasanain, 2024). In line with this, a more ergonomic headset design could play an important role in achieving SDGs 3 and 8, particularly for individuals who rely on these devices daily (Marková & Škurková, 2023).

With these insights in mind, there is a clear opportunity for further research aims at developing innovative headset design that help minimize these negative effects. As a result, our team developed a new headset that is not only comfortable to wear for long periods of time but also designed to reduce pressure on the head with dual support system technology, lightweight materials, and ergonomic design. This innovative approach aims to improve the user experience and support long-term use without discomfort.

II. Literature Review

Quality Function Deployment (QFD)

QFD uses a systematic approach to determine customer desires and translate those desires accurately into appropriate engineering, manufacturing, and planning design. The goal of QFD is to interpret even subjective quality criteria into more objective ones that can be quantified and measured and then used to design a service. QFD data is then integrated into the design of the product being developed in the hope of helping to determine what will satisfy customers and where to direct quality efforts (Mincolelli et al., 2020).

In QFD data processing, one of the main tools used is the House of Quality (HoQ). HoQ is a matrix used to connect customer desires and needs with the technical specifications of a product. This multi-dimensional matrix visually organizes and analyses the relationship between "whats" which indicates customer requirements and "hows" indicates technical characteristics, forming the core of the QFD process. By combining every aspect of HoQ, it provides a comprehensive framework for product development that is directly linked to customer satisfaction.

Anthropometry

Anthropometry is an essential area of ergonomics focused on measuring the dimensions of the human body to design workplaces and products that enhance user comfort and health. According to a 2022 study published in EUREKA: Physics and Engineering, measuring key body dimensions such as shoulder width, elbow height, and knee height is crucial for designing ergonomic work furniture that minimizes musculoskeletal problems and boosts productivity by ensuring fit based on the 5th to 95th percentile body range (Silviana et al., 2022).

Design for Extremes and Maximum Limit.

This principle emphasizes design features that are adjusted to the maximum or minimum limits of population variables (Design for Extremes).

ISSN: 2302-3449 I e-ISSN: 2580-9490
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Design components tailored for individuals with maximum body size. Sizes are tailored for individuals in the 95th percentile of population size, with the goal of ensuring that most people can use the space or device without difficulty.

Minimum Limit, Design components that consider individuals with small body sizes or reach. The goal of this minimum limit is to be accessible to individuals with minimum body sizes, and as many people as possible will be able to reach it.

Design for Customization, This principle is applied to devices or facilities that can be adjusted, such as chairs, tables, or vehicle steering wheels, so that more people can use them comfortably and efficiently.

Design for Average, An approach that bases product or facility features on the average size of the user population, usually at the 50th percentile. In this design, positions such as the height of a tool or workbench are adjusted to the average elbow height of the combined male and female population, so that most users can use it without significant difficulty. However, this approach tends to be less than ideal because users at the extremes of body size, such as very tall or very short individuals, may experience postural discomfort.

To create a headset product that is ergonomic and comfortable to use in the long term, it is very important to consider anthropometric aspects shown in Table 2, especially head size, ear size, and determining the appropriate percentile. A detailed anthropometric characterization of human heads can ensure optimal fit, comfort, and effectiveness of head-mounted devices (Wei et al., 2024). The following is a table of anthropometric dimensions that can help measure the dimensions of the head area.

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Table 1. Head Area Anthropometric Measurement Dimensions.

Dimensions	Description	Applications for Headset Design
Head Length	Length of head from forehead to back of head	Determine the length of the headset frame and the placement of the pads to fit the user's head.
Head Breadth	Head width at widest part	Determining the width of the headset padfor comfortable pressure distribution and avoiding pressure points.
Ear Length	Measured from the earlobe's highest point to the actual lobe.	Determine the vertical size of the ear pads on the headset product so that they do not put too much pressure.
Ear Width	Measured from the outermost point of the antihelix (the protruding part inside the ear) to the outermost point of the earlobe.	Determine the horizontal dimensions of the ear cushions on the headset product to provide sufficient space.

III. Methode

This type of research uses a descriptive-qualitative method with an observational research approach or research with data collection techniques carried out by observing and recording information obtained directly from an event or situation.

In this study, the observation method has an important role as explained Qualitative Research Methods: data collcettion, analysis and management. The author stated that "observation is one of the fundamental bases of all data collection methods in qualitative research, especially concerning the social sciences and human behavior" (Sutton & Austin, 2015). Using the observation method in the context of qualitative research, researchers can make direct observations of the behavior of headset users, especially how they use the device intensively over a long period of time.

Observations in this study not only serve to record physical changes in the skull structure, but also to understand user behavior related to headset use. Observing users directly, researchers

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can understand the interaction of headset users to affect changes in the structure of the skull area.

Qualitative Methode

Busetto et al. (2020) defined qualitative research as "the study of the nature of phenomena and is especially appropriate for focusing on intervention improvement [6], evaluating complex multi-component interventions, and answering questions of why something is (not) observed." Comparably, qualitative research is described as "a type of research that explores and provides deeper insights into real-world problems gathering participants' experiences, perceptions, and behavior" by StatPearls [7]. In contrast to quantitative study, qualitative investigation starts with facts gathered from natural environments, applies pre-existing ideas as means of explanation, and frequently culminates in theory creation, providing a deep comprehension of intricate social processes.

Sopiati, P., and Daruhadi, G. (2024). gathering of research data. "A research method based on the philosophy of postpositivism used to examine the natural conditions of objects (as opposed to experiments)" is how the author describes the qualitative research method in this study (Austin, 2015). One important tool in this study is the researcher. Purposeful and snowball sampling of data sources is done, triangulation (a mix of data gathering methods) is employed, and inductive or qualitative data analysis is done. Qualitative research findings place greater emphasis on meaning than generalization and the comprehension of intricate social events.

Sample Room

This study will involve college students aged 18 to 25 years. The target sample to be taken is expected to include up to 30 people. This study will focus on respondents who often use headsets for their daily activities such as playing games, listening to music, or watching videos. To ensure a suitable sample, respondents will be selected based on their hobbies and habits related to headset use, so that the research results can be more relevant and accurate.

Qualitative data collection will be conducted using a survey in the form of a questionnaire and interviews containing questions about headset usage habits, the duration of their use, and how long they have used them in a certain period of time.

Research Variable

This study uses two main variables that are interrelated, namely:

Table 2. Research Variables

Variable	Component	Explanation
X (Independent)	Long Term Headset Use	Frequency and duration of intensive headset use (how many hours per day, over a certain period).
Y (Dependent)	Skull Structure Changes	Physical changes in the structure of the skull, such as deformation or excessive pressure in certain areas.

Sources: Researcher

Referring to Table 1, independent variables are often referred to as a stimulus variable, the variables that influence or cause the emergence of dependent variables. For dependent variables which are commonly referred to as output variables or in Indonesian are referred to as bound variables, are variables that are influenced by the presence of independent variables.

In this study, the independent variable is long-term headset use, which includes the duration of use, as well as the frequency of use in daily activities. Meanwhile, the dependent variable is changes in the skull structure, which includes changes in shape or pressure on the head area.

IV. Results And Discussion

Job Hazard Analysis

In this study, JHA was used to determine specific risks associated with long-term headset use. By observing several subjects of the study carefully, researchers can assume examples of several major hazards that may arise from prolonged headset use.

As defined in ergonomic practice, JHA systematically decomposes a task into individual steps and identifies potential hazards at each stage. For instance, Salleh & Sukadarin (2020) applied JHA in agricultural settings to reveal risks such as prolonged squatting and repetitive motion (Salleha & Sukadarina, 2018).

Furthermore, a recent technical review (Marimuthu et al., 2021) confirmed the use of ergonomic hazard analysis methods including breakdown of job components and risk mapping to prevent incidents arising from awkward postures and repetitive activities (Ramaganesh et al., 2021).

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Hazard Identification

In long-term use of headsets, there are certainly some risks that need to be considered. One risk that many people know is skull deformation caused by prolonged pressure from headsets that may not be ergonomically designed. According to theoretical studies, it is stated that bone remodelling is a process in which old bones are replaced by new tissue to adapt to the mechanical load and tension it receives. Thus, continuous pressure on certain areas of the skull from headset use can disrupt this balance, potentially causing indentations in the skull structure. In addition, uneven pressure on the skull structure can affect changes in skull morphology, especially in older people, where the bone remodelling process can be influenced by hormonal factors.

Long-term use of headsets can also pose serious health risks, including hearing loss due to prolonged exposure to loud noises that can damage the inner ear. Pressure from the headset can also cause discomfort such as earaches or headaches. In addition, not maintaining regular headset hygiene can also increase the risk of ear infections. Being aware of these risks and taking appropriate precautions is essential to protecting your health during long-term use of headsets.

Job Hazard Analysis Data Management

Job Hazard Analysis Data Management (JHA) tables are essential to identify and manage potential hazards at every stage. Table 3 provide detailed information about long-term headset use, therefore health risks based on observations are essential. The information given on Table 3 also offer recommendations for safe practices and what equipment is not harmful, thus can be protective to prevent such hazards. The following is the Job Hazard data management table that we have analysed:

Table 3. Job Hazard Analysis Data Management on Streamer.

Job Description: Streaming	Prepared By: Writer
Issuing Department:	Reviewed By:
Location: Workspace	Date:

No	Key Job Steps	Potential Health and Injury Hazard	Safe Practices Apparel and Equipment
1	Making preparations to start streaming	Items that fall from the table hit your feet	Get rid of things you dont need
2	Streaming for long periods of time	Excessive pressure on the head and ears	Use an ergonomic headset and reduce headband pressure.
3	Interact with online audiences	Bullying and psychological pressure	Use chat moderation, block abusive users and take a break from social media.
4	Food/drink consumption during live	Liquid spills on electronic equipment	Avoid putting liquids near the device and use protectors for the keyboard and desk.
5	Using a headset at high volume	Tinnitus and Hearing Loss	Use automatic volume settings, limit usage duration

Fault Tree Diagram

To clarify the causes and potential risks of long-term headset use, researchers used a fault tree diagram that is expected to illustrate the main factors that contribute to the health of users' ears and skulls. The diagram categorizes risks into key areas, including skull deformation, changes in skull structure, hearing loss, and ear infections.

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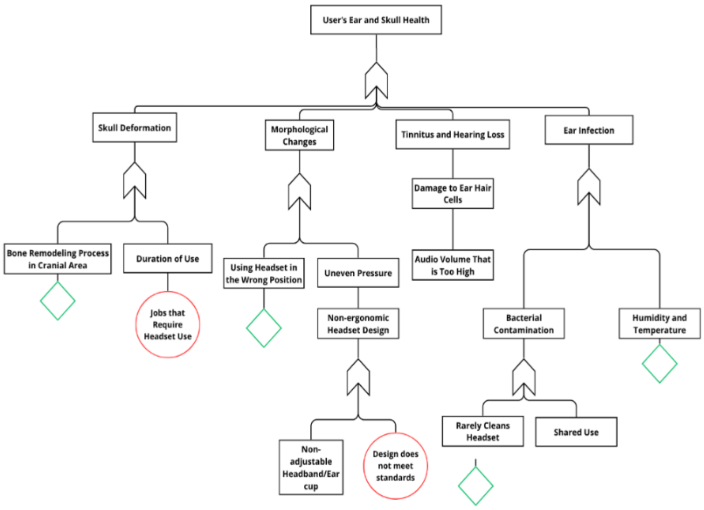
Figure 1. Fault Tree Diagram Analysis



Based on Figure I shown above, it can be concluded that the main risks in long-term headset use can arise from physical pressure and excessive noise exposure, both of which can have a direct impact on the skull structure and hearing function of the user if used for a long period of time. To reduce this risk, it is important for users to consider ergonomic headset design, maintain device cleanliness, and avoid high volume use for long periods of time.

Anthropometry

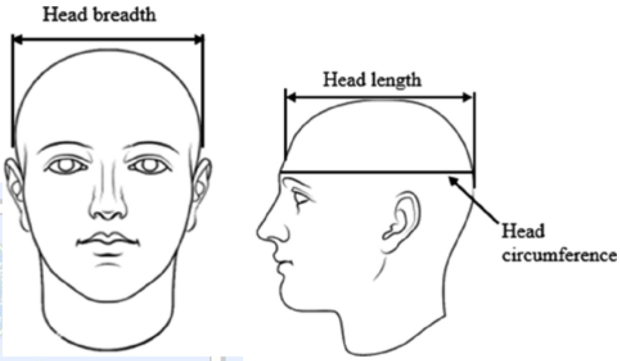
Anthropometry is a science that studies the size and proportions of the human body. Anthropometry itself plays a very important role in making a product, because from these measurements the product that is made can be said to be comfortable for the user, so that dangerous risks can be avoided by the user (Avient, 2020). "Access to accurate and up-to-date anthropometric data is crucial for wearable design" (Rex Binder et al., 2022).

Problem definition and objectives, for this product, our focus is to measure the relevant head dimensions to create a comfortable and reducing design that can reduce excessive pressure on the skull. The main dimensions to be measured include head length, head width, ear length, and ear width.

Head Length, in this study, the head length dimension to be measured is from the glabella point, which is the area between the brow bones, to the most prominent part at the back of the head, called the occiput, which is in the middle of the skull, as shown in Figure 2. This dimension is important to know to determine the size and shape of the headset pad that can support the front and back of the head so as not to put excessive pressure on the skull.

Head Breadth, the head breadth dimension measured in this study covers a range of maximum horizontal widths above the ear attachment area, as shown in Figure 2. The data obtained will also be used to determine the horizontal size of the headset to fit comfortably on the user's head without putting excessive pressure on the sides of the head.

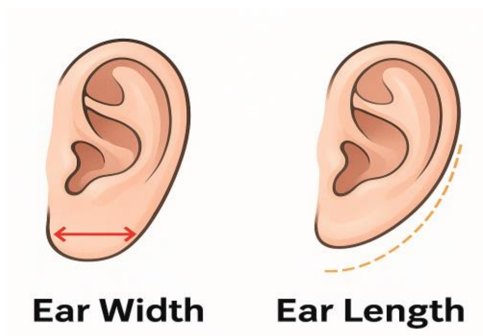
Figure 2. Head Length and Head Breadth Dimensions



Ear Length, the distance to be measured in ear length covers the vertical shape from the top of the ear to the bottom, as shown in Figure 3. This data will be used to adjust the size of the ear cup so that it can cover the ear well, thereby increasing sound isolation, improving the quality of the user experience without affecting the comfort of wearing it for a long time.

Ear Width, the maximum horizontal distance from the outermost part of the front of the ear to the outermost part of the back of the ear, as shown in Figure 3. This data is expected to help determine the size and shape of the ear cup cushions so that they are not too small or too large for the user so that they are comfortable even when worn for a long period of time.

Figure 3. Ear Length and Width Dimensions



ISSN: 2302-3449 I e-ISSN: 2580-9490
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By measuring these four dimensions, it is hoped that the headset design can be adjusted to the variation in user head size, ensuring even pressure distribution, and reducing the risk of head deformation due to long-term use. The data collected will also be a review in determining the design of a more ergonomic headset structure and material.

Data Collection Process. The process of measuring body dimensions is carried out to ensure accurate and relevant data for headset product design. Here is an explanation of the methods used:

Data Collection on Head Length and Width. This data was obtained from the Indonesian anthropometric database. This data from Table 4 includes measurements from various ethnic groups in Indonesia, considering both sexes (male and female) in the age range of 18-20 years. Data collection was carried out based on sources taken in the period 2016 to 2018.

Table 4. Data Collection Results

No	Dimensions	P5		P50		P95		SD	
		M	F	M	F	M	F	M	F
1	Head Length	16.3	15.1	18.8	17.8	21.7	20.5	1.5	1.6
2	Head Width	13.9	12.8	15.9	15.3	17.9	17.8	1.2	1.5
3	Ear Length	4.8	4.7	5.6	5.3	6.4	5.9	0.5	0.4
4	Ear Width	3.7	3.5	4.4	4.0	5.0	4.5	0.4	0.3

*M: Male, F: Female

Data Collection on Ear Length and Width. This data was obtained manually through direct measurements. Sampling was carried out on 30 respondents, consisting of 15 men and 15 women, all of whom were aged 18-20 years. The measurement process used a flexible measuring tape to obtain accurate results.

This process on Table 5 is carried out to ensure that the data used reflects the variations in body dimensions relevant to the target headset users, resulting in an ergonomic and comfortable design.

Table 5. Ear Length and Width Data Collection Results

Respondents	Male		Female	
	Length	Width	Length	Width
1	6	4	5	3.5
2	5.5	4	5.5	4
3	6.5	4	5.5	4
4	6	5	5	4
5	6	4.5	5	4.5
6	5	4	5	4.5
7	5	4	5	4
8	5.5	4.5	6	4
9	5.5	4.5	6	4
10	5	5	5.5	4
11	6	5	5	3.5
12	6	4.5	5	4
13	6	4	5	3.5
14	5	4	5	4
15	5	4.5	5.5	4

Anthropometric Analysis for Headset Design. Anthropometric data plays a crucial role in ensuring that headset designs fit a wide range of users comfortably. By using percentiles specifically P5, P50, and P95, the design will suits majority of the population. Where the average ear length is 5.6 cm sith the standard deviation of 0.51 cm, the 5th percentile is calculated as approximately 4.8 cm. This helps define the lower bound of users dimensions that the headset should accomodate.

Designing based on head length and width requires adjustable components to suits users from the 5th to 95th percentile. Features like flexible dual support-system headbands, adjustable headband and earcups, lightweight durable material, and evenly distrbuted cushioning help reducing discomfort long-term use of headset. To adress ear size variation, the headset design includes three earcup sizes based on P5, P50, P95 percentile values. This apporach ensures that users with smaller, average, and larger ear dimensions each receive a proper fit. Providing multiple size options minimizes discomfort, improves sound quality, and maximizes user's experience.

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Quality Function Deployment (QFD)

In the product planning and development process, QFD is a structured methodology used to define specifications of consumer needs and wants and systematically evaluate the ability of a product or service to meet consumer needs and wants. QFD can also be used as a reference to assess the products that the author develops so that they can compete in their target market.

HoQ is a method that supports the product identification process into a design specification. The HoQ concept is essentially based on a quality table and has been successfully used by manufacturing industries In this HoQ, the five main customer needs (Customer Needs/Whats) that are the focus are comfort, durability, affordability, features, and aesthetics. To meet these needs, several technical requirements (Technical Requirements/Hows) have been designed, namely aesthetic design, ergonomic design, low cost, durable material, and dual support system. Through the relationship between both customer needs and technical requirements, an analysis is carried out to determine the priority of product design and development.

Data Collection Process. To support this analysis, we collected customer needs data using Google Forms that display the products we developed and compare them with three relevant competitors. Each product is equipped with information related to price, images, and features offered. From Table 6, a total of 30 respondents were asked to provide an assessment on a scale of 1 to 5, where 1 is the lowest and 5 is the highest, based on a predetermined customer needs matrix, namely comfort, durability, affordability, features, and aesthetic

Table 6. Customer Importance Data Result

Respondent	Comfort	Durable	Affordable	Feature	Aesthetic
1	4	3	2	4	4
2	4	4	4	4	4
3	3	4	4	3	3
4	3	4	4	3	3
5	3	3	3	4	3
6	4	3	4	3	4
7	5	4	4	4	4
8	4	4	2	3	4
9	4	3	2	3	4
10	3	3	3	3	4
11	3	3	3	4	4
12	4	3	4	3	4
13	5	4	4	3	4
14	5	4	4	4	4
15	4	4	4	4	3
16	3	3	4	4	3
17	3	4	3	4	4
18	3	4	3	3	3
19	4	4	3	3	4
20	4	4	3	4	4
21	5	3	4	4	3
22	4	4	4	4	3
23	4	4	3	3	4
24	3	4	4	4	4
25	3	3	4	4	3
26	4	3	4	4	4
27	3	4	4	3	4
28	5	4	4	4	4
29	4	3	4	4	4
30	4	3	3	4	3
Average	4	4	4	4	4

Collecting Customer Importance (CI) data is a crucial and foundational step in QFD, serving as the Voice of Customer (VOC) by quantifying how important each identified customer need. The result then will be used for the next calculation.

Calculation Process and Formulas Used

The QFD analysis begins with calculating the Improvement Factor (IF) to assess how much improvement is needed for each aspect compared to competitor products. Based on the data, aesthetics, comfort, and durability showed an increase in IF value to 1.2, while affordability and features remained at 1. These values indicates that greater attention should be focused more on delivering comfort, durable, and aesthetic aspect for the customer.

Overall Weighting was calculated by combining the Customer Importance (CI) level, the IF, and the Sales Point (SP) contribution. The results show the highest OW for Comfort aspect (7.2) or in percentage accounts for 23.26%, followed by Durability (6.72) or 21.71%, Aesthetic (6.24) or 20.14%, Features (5.6) or 18.09%, and Affordability (5.2) or 16.80%, with the total 30.96 or in percentage 100%. This procedure ensures product development efforts are aligned with the most impactful customer

ISSN: 2302-3449 I e-ISSN: 2580-9490
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needs and market opportunities and acts as a critical filter for prioritizing main aspect in QFD.

This process then moves on to determining technical priorities, where technical requirements such as, low cost, a dual support system, aesthetic design, ergonomics, and durable materials are evaluated based on their relationship with customer needs. Through the analysis and calculation that have been done, the outcome indicate that the highest priorities are given to low cost with the percentage of 23.65%, dual-support system with 19.58%, aesthetic design with 19.47%, ergonomic design with 19.14%, and durable material with 18.15%. This procedure allows product development to focused on the technical elements that most significantly impact user satisfaction and market priorities.

Comparison of Proposed Product with Competitor Products

As a comparison for the proposed product, we chose three competitors that are relevant to the product we are developing. We provide information related to the features, prices, and images or displays of each competitor's product. The goal is for respondents to be able to assess the product by considering these various aspects.

Table 7. Competitors Used in QFD analysis

Product Name	Feature	Price
(a) Sony Pulse 3D Wireless Headset	Dual noise-canceling microphones USB-C charging Wireless	Rp1,650,000.00-
(b) JBL Tune 720BT Headphone	Lightweight Detachable audio cable Foldable	Rp1,499,000.00-
(c) Rexus Daxa Sedna	Foldable Wireless USB-C charging	Rp899,000.00

Figure 4. Competitors Appearances

a)

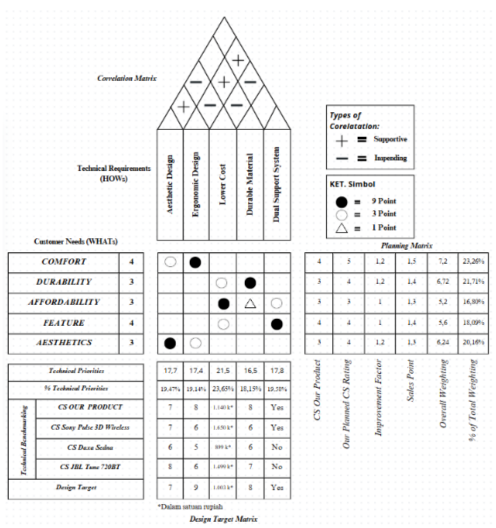
b)

c)

House of Quality

House of Quality (HoQ), is used to show the relationship between customer requirements and product technical specifications. HoQ has a shape similar to a house and consists of interconnected parts. By using this approach, we can identify the priority of customer needs, establish relevant technical specifications, and design products that not only meet expectations but also provide competitive advantages in the market.

Figure 5. House of Quality



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ouse of Quality Results Analysis. The HoQ shows how the main customer needs, such as comfortability, durability, affordability, features, and aesthetics. This matrix indicates that ergonomic design has the greatest impact in meeting comfort needs, while durable materials directly support durability. This relationship also reflects that advanced features are very relevant in answering customer needs for innovation (features). With a strong assessment (value 9), specifications such as ergonomic design and advanced features are the main priorities in product development planning.

In the correlations matrix (HoQ roof), there is a positive relationship between aesthetic and ergonomic design that support each other to increase product appeal. However, there is a conflict between lower cost and durable material usage, indicating the need for a balance between cost efficiency and quality. Technical priorities are calculated based on the weight of customer needs, with the result that ergonomic design is the highest priority, followed by durable materials and Dual Support System. This indicates that products should focus on increasing comfort and innovation without sacrificing durability.

Competitor comparison shows that the proposed product has advantages in ergonomic design compared to products such as Sony Pulse 3D Wireless, Daxa Sedna, and JBL Tune 720BT. However, the cost efficiency aspect (lower cost) still needs improvement to compete better in the market. Based on this analysis, the proposed product will be able to optimally meet customer needs while building market advantages by improving user comfort, durable materials, and innovative features when developing the product.

Zennest Headset Ergonomic Solution for Long Term Use

Zennest emerges as a leading innovation that prioritizes not only audio quality but also responds to users' physical needs, ensuring safe and comfortable use over extended periods. Most common concerns often experienced by headset users who work in the creative industry, gamers, and individuals who do online activities for long periods. To ensure that the Zennest headset design meets the ergonomic needs of users, we conducted a series of in-depth analysis involving anthropometric, job hazard, and QFD approaches.

This approach allows Zennest to be optimally developed in alignment with its core objectives: prioritizing user safety, ensuring long-term comfort, and providing an optimal fit based on individual body dimensions. To further reinforce these goals, the design was refined through a QFD analysis, which ensured that every user need was systematically translated into functional design features. As a result, working posture showed marked improvement during headset use, accompanied by a significant reduction in self-reported neck pain over time (Simpson & Buckle, n.d.).

Zennest Product Design Based on Quality Function Deployment Analysis

Drawing from the House of Quality analysis, the development of the Zennest headset centred primarily on enhancing comfort and incorporating innovative functional elements. This can be seen from the highest priority given to user needs such as comfort and feature performance. As a result, Zennest offers a range of standout features specifically to boost both the comfort and usability of the headset. namely comfortability and features.

Figure 6. Zennest Features

One Zennest's key innovations is the Dual-Support System, designs to evenly distribute the headset's weight across the head, reducing pressure points and minimizing fatigue during extended use. Complimenting this, an Adjustable Headband allows users to custom the fit based on their head dimensions, following anthropometric results. For added comfort, High-Grade Memory Foam Ear Cushions adapting to the ear's shape, enhancing sound isolation, and reducing pressure.

Jurnal Manajemen Bisnis
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The headset also features Advanced Noise Cancellation Technology, making it ideal for professionals, gamers, and users engaged in long online sessions. Built from lightweight yet durable materials, Zennest ensures both comfort and long-term resilience. Fromn a production perspective, Zennest balances premium quality with cost-efficiency, keeping it competitive against brands like Sony Pulse 3D Wireless and JBL Tune 720BT. With its superior comfort, ergonomic design, and advanced functionality, Zennest stands out as a user-centred solution aligned with the priorities identified in the House of Quality analysis.

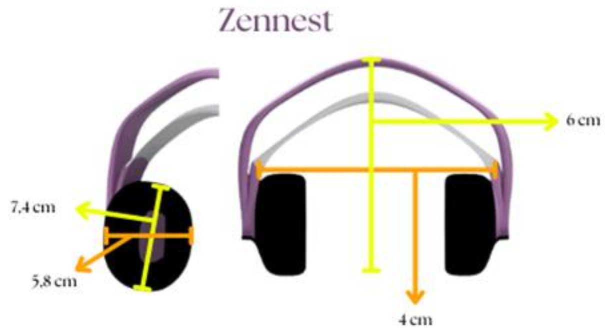
Zennest Product Design Discussion Based on Anthropometric Analysis

Based on the results of the anthropometric data analysis using the 50th percentile (P50) for the Zennest headset design, the selection of this percentile is based on the principle of universal design that can accommodate most users. The 50th percentile was chosen because it represents the average size of the population, so it can ensure that this headset fits the head and ear dimensions of most male and female users, while still considering comfort and ease of adjustment for users outside this range.

Analysis On Head Length. For head length, the P50 value for men is 18.78 cm and for women it is 17.79 cm. Based on this data, the headband design on Zennest will be designed to be adjustable, allowing users to customize the fit according to their individual head dimensions. By incorporating an adjustable headband, Zennest ensures a more secure and comfortable fit, reducing the risk of excessive pressure, and enhancing long-term usability.

Analysis On Head Width. The head width for men on the P50 is 15.89 cm and for women 15.34 cm. These dimensions are important for determining the lateral pressure of the earcups on the sides of the head. Using the P50 value as a reference, Zennest ensures that the earcups are not too tight or too loose, which can interfere with comfort. The Dual-Support System designed to balance and spread pressure evenly around head areas, keeping the headset stable while preventing unnecessary force on the sides.

Figure 7. Design Dimensions from Anthropometric Analysis



Using the 50th percentile, the Zennest headset design can achieve a balance between comfort and functionality, as this value represents the average user size. In addition, the Adjustable Headband and Dual-Support System feature allows flexibility for users with non-average head and ear sizes, while the ergonomic earcups design ensures optimal comfort for most of the population.

Zennest Product Design Discussion Based on Job Hazard Analysis

Based on the results of the Job Hazard Analysis above, the Zennest headset design is focused on addressing potential risks to the health of the user's ears and skull, both in terms of ergonomics, materials, and supporting features. Here is the discussion:

Skull Deformation. Skull deformation caused by the bone remodelling process in the head area due to excessive pressure and long duration of use is overcome by the Dual-Support System. This system distributes the headset load evenly on the head, so that excessive pressure on certain areas can be minimized. The headband design using elastic material and memory foam also supports comfort and reduces the risk of deformation due to long-term use.

Morphological Changes. Incorrect use of the headset and uneven pressure on the ears are addressed through the ergonomic design of the earcups that follow the contours of the user's ears. The earcups are designed based on anthropometric data (50th percentile) to ensure

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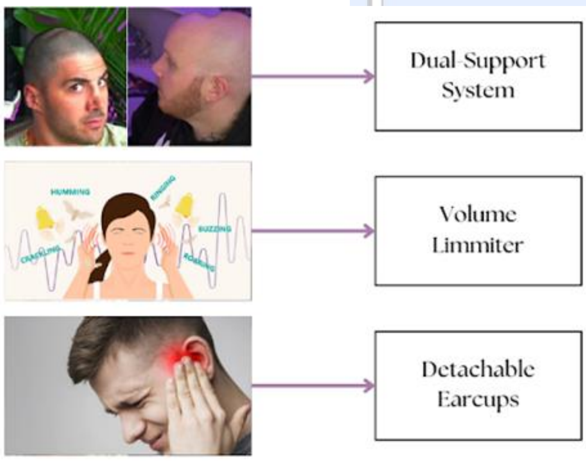
sufficient space, avoiding excessive pressure on the ears. The combination of Memory Foam Ear Cushions materials helps adjust the shape of the earcups to the user's ears, ensuring optimal pressure distribution.

Tinnitus and Hearing Loss. The risk of damage to ear hair cells due to excessive volume is minimized through the volume limiter feature. This feature limits the maximum volume of the headset so that it does not exceed the safe sound threshold, protecting the user's ears from excessive sound exposure that can cause tinnitus or hearing loss.

Ear Infection. Ear infection problems caused by shared use and rarely cleaning headsets can be solved by using antibacterial materials on the earcups and headset pads. In addition, the Zennest headset is equipped with a detachable earcups feature, so it can be easily removed and cleaned to prevent bacterial growth.

Figure 8. Problem Analysis and Solutions Provided by Zennest



Relevance of the Research to Sustainable Development Goals (SDGs)

This study supports the achievement of two Sustainable Development Goals (SDGs), namely SDG 3 (Good Health and Well-Being) and SDG 8 (Decent Work and Economic Growth). Long-term use of headsets poses health risks such as head pain, skull deformation due to excessive mechanical pressure, and hearing disorders such as tinnitus. The innovations proposed in this study, including the Dual Support System and Volume Limiter, aim to reduce mechanical stress and limit excessive sound intensity. These efforts align with SDG 3.9, which targets the reduction of illnesses caused by hazardous exposure (including noise pollution), ensuring that technological devices do not become a source of health-related problems.

In modern work environments especially in creative industries, online education, and digital-based jobs headsets have become essential work tools. Ergonomic innovations such as Detachable Earcups and designs that consider long-term health contribute to improved working comfort and productivity while preventing injuries caused by unsuitable work equipment. This directly supports SDG 8.8, which emphasizes the protection of labour rights and the promotion of safe and secure working environments for all workers, including those in the informal and digital economies.s

To clarify the causes and potential risks of long-term headset use, researchers used a fault tree diagram that is expected to illustrate the main factors that contribute to the health of users' ears and skulls. The diagram categorizes risks into key areas, including skull deformation, changes in skull structure, hearing loss, and ear infections

V. Conclusion

This study uses a methodological approach in the form of observation, interviews, and anthropometric measurements to analyze the effect of long-term headset use on changes in the structure of the human skull. The results of the study indicate that uneven mechanical pressure due to headset use can cause bone remodeling in the skull structure, especially in the head area that is pressed by the device. The level of comfort and risk of changes in the shape of the user's skull are greatly influenced by ergonomic elements, such as pressure distribution, cushioning materials, and device adjustment design. In an effort to create an ergonomic headset, anthropometric dimensions of the head and ears such as length, width, and height of the ears play an important role as reference data for design. In addition, the QFD method was applied to identify key user needs, such as comfort, durability, and aesthetics, which were then translated into product specifications. Furthermore, JHA was used to identify key hazards, including skull deformation, hearing loss, and ear infections. These hazards can be

ISSN: 2302-3449 I e-ISSN: 2580-9490
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minimized by preventive measures including ergonomic design and appropriate volume settings. These findings emphasize the importance of a holistic approach in designing headsets that are not only comfortable but also safe for long-term users.

Author Statement

AFC led the entire research process, including conceptualization, prototype development, data collection, analysis, and writing of the manuscript. AGH assisted with data interpretation, qualitative survey processing, and documentation of ergonomic evaluations. RSL contributed to the refinement of the research methodology, manuscript review, and assisted with formatting according to the required template. JVR provided critical feedback, supervised the research direction, and guided the overall structure and improvements of the paper. BR provided essential feedback, supervised the research trajectory, and offered guidance on the paper's structure and enhancements. All authors have read and approved the final manuscript.

Artificial Intelligence (AI) Acknowledgement

This study acknowledges the use of Artificial Intelligence (AI) in the development and refinement of the manuscript. AI tools, including language models such as ChatGPT by OpenAI, Co Pilot and Quillbot were used to assist in language editing, data interpretation support, and formatting enhancement. These tools did not influence the conceptual framework, data collection, or original analysis but served as writing aids to enhance clarity and consistency.

Data Availability

The qualitative data that supports the findings of this study used in this paper are available in a public repository at:

1) https://drive.google.com/drive/folders/1sHuYfsWO3xHEGTKsZ7ipgARu628Nbida?usp=sharing
2) https://www.ncbi.nlm.nih.gov/books/NBK470395/
3) https://pubmed.ncbi.nlm.nih.gov/35939985/#:~:text=Virtual%20Reality%20,dynamic%20mechanical%20loading%20applied%20by
4) https://news.oregonstate.edu/news/virtual-reality-real-injuries-osu-study-shows-how-reduce-physical-risk-vr#:~:text=Regardless%20of%20the%20angle%2C%20extending,syndrome%20and%20rotator%20cuff%20injuries

this data does not include any personal information.

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