

Versatile Upper Limb Exoskeleton For Enhancing Human Locomotion And Rehabilitation

¹Dr.Jayasheela.M, ²Praveen Babu.M.S, ³Narmadha devi.S, ⁴Shaju.A, ⁵Sudeda.S, ⁶Dharunkanth.K

¹Professor and Head, ²Student, ³Student, ⁴Student, ⁵Student, ⁶Student

Biomedical Engineering,

KIT - Kalaignar Karunanidhi Institute of Technology, Coimbatore, Tamilnadu, India

1jayasheelabme@gmail.com, 2kit.25.21bbm302@gmail.com, 3kit.25.21bbm031@gmail.com
4kit.25.21bbm049@gmail.com, 5kit.25.21bbm053@gmail.com, 6kit.25.21bbm301@gmail.com

Abstract — Exoskeletons are wearable mechanical structure that enhances or augments the physical abilities of the user. Upper limb exoskeletons have emerged as a revolutionary technology offering diverse applications, from rehabilitation to augmenting human strength and performance. In the realm of weight lifting, these devices promise substantial benefits including injury prevention, performance enhancement, and rehabilitation support for individuals recovering from upper limb injuries. This research focuses on the design, development, and evaluation of an upper body exoskeleton designed for heavy-duty applications. Design and develop a multifunctional upper extremity exoskeleton to increase the user's strength and endurance in weight lifting. The exoskeleton is adjustable to accommodate different user needs and arm sizes, and be constructed from lightweight, durable materials for long-term use. This Upper Limb Exoskeleton integrates a one-touch length adjustable mechanism into an upper limb exoskeleton, enhancing user comfort and adaptability. The upper limb exoskeleton showed promising results in enhancing weight lifting capacity. The exoskeleton's comfort, usability, and perceived effectiveness in enhancing their lifting capabilities. These findings highlight the potential of exoskeleton technology to improve strength and reduce fatigue during weight lifting activities.

Index Terms — (Upper limb Exoskeletons, supportive structures, locomotion, neurological injuries, rehabilitation, active components, control systems, mobility, stability, quality of life, advanced materials, carbon fibre, polyurethane, aluminium, strength-to-weight ratio, cushioning properties, durability, comfort, upper limb exoskeleton, ergonomic assistance, accident injuries, patients, cost, light weight, functional outcomes)

I. INTRODUCTION

In industries and tasks that involve heavy lifting, workers are often exposed to significant physical strain, which can lead to fatigue, injuries, and long-term musculoskeletal disorders. To address these challenges, exoskeletons have been developed as wearable devices that augment human capabilities, enhancing strength and reducing the physical burden of lifting tasks. In Existing exoskeletons often rely on complex systems of sensors and actuators to provide active assistance, requiring power sources and sophisticated control systems. However, such designs can be costly, bulky, and may require regular maintenance, making them less practical for widespread use in various environments. This project aims to develop a passive upper limb exoskeleton that enhances the user's ability to lift heavy weights without the need for sensors or actuators. By utilizing purely mechanical components, such as sponges, aluminium and structural supports, the exoskeleton will provide natural, intuitive assistance to the user. The design is focus on optimizing load distribution, reducing muscle fatigue, and minimizing the risk of injury, all while maintaining a lightweight, comfortable, and durable structure. This approach seeks to deliver an affordable and reliable solution for workers in industries where heavy lifting is a regular requirement, promoting safer and more efficient manual labor practices.

II. OBJECTIVES

To design and develop a versatile upper limb exoskeleton that enhances the user's strength and endurance for heavy weight lifting. This device aims to allow users to perform a range of daily activities with reduced effort and fatigue, while providing a natural range of motion without restricting or hindering movement. The exoskeleton is adjustable to accommodate different user needs and arm sizes, and be constructed from lightweight, durable materials for long-term use.

III. METHODOLOGY

A. One Touch Length Adjustable Mechanism

This Upper Limb Exoskeleton integrates a one-touch length adjustable mechanism into an upper limb exoskeleton, enhancing user comfort and adaptability. This mechanism allows users to quickly adjust the exoskeleton's length to match their arm dimensions, ensuring a personalized fit. The exoskeleton's design emphasizes ease of use, ergonomic support, and improved mobility, making it suitable for rehabilitation, assistive technology, or industrial applications where precision and user adaptability are crucial.

B. Calculation Of Pressure value by applying load

Pascal :

Pascal (Pa) is the SI (International System of Units) unit of pressure. It is defined as one newton per square meter. Lifting any weight by wearing an exoskeleton (Figure 3), the pressure is calculated by Pascal. The pascal value is calculated by Force and Area. The contact area (A) is 0.03m².

Bone Mineral Density(BMD) value & Pascal Value of Upper Limb :

BONE	BMD (Bone Mineral Density) (Normal Value)	PASCAL Value (without exoskeleton)	Pa value (With Exoskeleton)
Humerus	0.8 – 1.2 g/cm ²	4905Pa	2000 – 3500Pa
Radius	0.6 – 0.9 g/cm ²	4905Pa	2000 – 3500Pa
Ulna	0.6 – 0.9 g/cm ²	4905Pa	2000 – 3500Pa
Carpals	0.4 – 0.7 g/cm ²	4905Pa	2000 – 3500Pa



Figure 3 : Wearing exoskeleton Model

$$F = \text{mass} * \text{acceleration of the gravity} \quad \text{----- (1)}$$

$$Pa = \text{Force(F)/Area(A)} \quad \text{----- (2)}$$

C. PROBLEM STATEMENT

In many industrial and manual work environments, workers are often required to perform heavy and other physically demanding tasks that put stress on their bodies. These environments, such as construction sites, warehouses, and manufacturing facilities, require heavy, repetitive physical work, leading to high rates of musculoskeletal injuries and chronic fatigue. Despite advances in ergonomics and lifting aids, traditional solutions often fail to provide the comprehensive support needed to reduce physical stress and improve patient performance. The main problem with current solutions is that they are not flexible.

D. PROPOSED SYSTEM



Fig 4 : Solid Work Design of (Bach Support)



Fig 5 : Solid Work Design (Hand)

The Proposed system process begins with identifying the specific needs of the target users, which include industrial workers who require support for lifting and carrying heavy loads activities. The versatile upper limb exoskeleton is designed to support both bulk and medium weight individuals, ensuring versatility and broad applicability. To accommodate various body sizes, the exoskeleton features an adjustable mechanism that allows for a universal fit. This ensures that the device can be used by a wide range of individuals without compromising on comfort or functionality.

Evaluate And Testing

The evaluation and testing phase involves subjecting the exoskeleton to load testing to ensure that it can support the specified weight range. This involves testing the exoskeleton under various weight conditions to ensure it meets the design specifications. Trials are conducted with industrial workers to gather feedback on comfort, usability, and performance. This feedback is used to make iterative improvements to the design. Based on the feedback and testing results, iterative improvements are made to the design. This involves refining the fit, adjusting the support mechanisms, and enhancing user comfort.

Cost Estimation

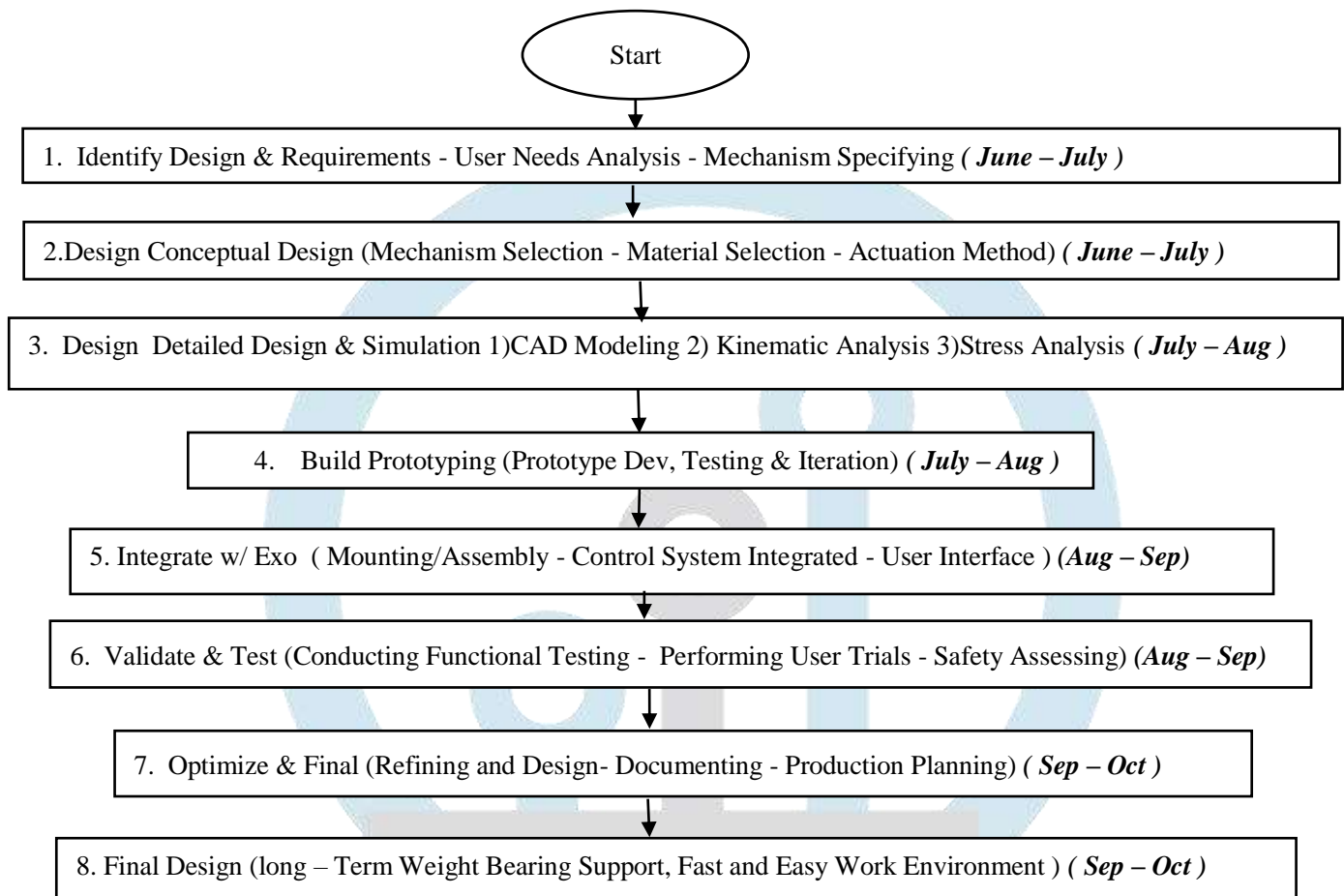
S.No	Materials	Quantity	Price
1	Gas Spring	4	4800
2	Spring	6	3750
3	Stapes	Required	2800
4	Aluminium	6kg	4600
5	Stainless Steel	Required	950
6	Wrist Band	4	2400
7	Sponge	Required	600
8	Hand Support	4	2800
9	Back Push	2	2500
		Total	25,200

E. APPLICATION

1. Health care
2. Rehabilitation
3. Assistive Device
4. Industrial
5. Military Application



Figure 6 : Proposed Model Image

F. WORKPLAN**G. REFERENCE**

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