INTERNATIONAL JOURNAL OF ADVANCED INNOVATIVE TECHNOLOGY IN ENGINEERING

Published by Global Advanced Research Publication House Journal

Home page: www.ijaite.co.in

A Review - Design and Fabrication of All Terrain Wheelchair (ATWC)

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Article History

Received on: 25 April 2023

Revised on: 15 May 2023

Accepted on: 30 May 2023

Keywords: Lever, wheelchair, drive train, variable speed, developing countries, all terrain.

e-ISSN: 2455-6491

DOI:

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ABSTRACT

The all-terrain lever-powered wheelchair (ATWC) is an assistive device designed to enhance the mobility of individuals with limited mobility. Its primary purpose is to allow users to navigate rugged and uneven terrains with ease. This paper presents the design and fabrication process of an ATWC specifically developed to improve the mobility of disabled individuals. The ATWC incorporates a unique system of two hand levers for propulsion, turning, and braking. These hand levers employ different hand grasp and gross movement patterns compared to conventional wheelchairs. This design feature enhances the wheelchair's efficiency and makes it suitable for various functional mobility applications. The ATWC is built upon the fundamental design elements of an existing model developed for third-world countries. By leveraging these design elements, the wheelchair benefits from proven concepts and techniques. Additionally, the plan is to manufacture the ATWC in India, where the availability of higher-performance materials and bicycle parts opens up a wider range of design possibilities. Utilizing these resources will significantly enhance the overall performance of the wheelchair. By improving mobility independence and enabling individuals to adventure into all-terrain environments, the ATWC has the potential to positively impact the lives of disabled individuals not only in India but also in other developing countries. It offers an opportunity for individuals to overcome mobility limitations and experience greater freedom and independence in their daily lives.

1. INTRODUCTION

The All-Terrain Wheelchair (ATWC) is an affordable, all-terrain wheelchair designed for use in developing countries. It incorporates a unique lever propulsion system that offers various benefits in terms of user ergonomics and versatility. Instead of the conventional push rims on the drive wheels, the ATWC utilizes a lever system mounted on the armrests of the wheelchair. These levers, operated by the user's arms, provide control over the wheelchair's direction and speed. The lever system allows the user to change gears by shifting their hands along the levers. Grasping near the ends of the levers increases the torque delivered to the drive train, while grasping near the pivots enables a larger angular displacement with each stroke, resulting in higher angular velocity and increased speed. One of the significant advantages of the ATWC is its

ability to navigate diverse terrains such as steep hills, sandy roads, and muddy paths. By using readily available bicycle parts, these wheelchairs can be constructed locally in any part of the world. They are designed to handle rocky surfaces, uneven ground, and even steep inclines, enabling users to enjoy outdoor activities and explore the outdoors. This enhanced mobility opens up opportunities for individuals with disabilities to engage in physical activities and experience the freedom of outdoor exploration.

Additionally, the lever-powered propulsion system offers a full-body workout for users, contributing to their physical health and well-being. When needed for indoor use, the levers can be removed, allowing the ATWC to function as a regular push rim wheelchair.

The primary motivation behind the development of the ATWC is to provide individuals with disabilities in developing countries with access to mobility, regardless of their location, travel requirements, or local environment. The use of off-the-shelf bicycle parts makes it feasible to manufacture these wheelchairs anywhere, promoting accessibility and independence for people with disabilities in resource-constrained areas.

A. Problem Statement

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Figure 1: Rough terrain in rural areas

2. RELATED WORK

According to the Census of India 2011, there were approximately 26.8 million people with disabilities in India, accounting for about 2.21% of the country's population. The census data indicated that there were 14.9 million men with disabilities and 11.9 million women with disabilities. The report also highlighted that the number of disabled individuals in rural areas was over 18.0 million, while in urban areas, it was 8.1 million. The percentage of men with disabilities was reported to be 2.41% compared to 2.01% for women. The analysis based on social groups showed that 2.45% of the disabled population belonged to the Scheduled Castes (SC), 2.05% to the Scheduled Tribes (ST), and 2.18% to other categories. Based on the mentioned information, it can be inferred that approximately 3.6 million individuals with movement disabilities reside in rural parts of India. On the other hand, the National Sample Survey Office (NSSO) conducted a survey in 2018, which estimated that there were about 21 million people with disabilities in India, representing approximately 2.2% of the population. Among them, approximately 17.9% had locomotor disabilities, which include mobility impairments. Furthermore, a study published in The Lancet Global Health in 2018 provided a broader definition of disability, encompassing both moderate and severe disabilities. This study estimated that there were around 56 million

people with disabilities in India, accounting for about 4.2% of the population. According to this study, approximately 35.4% of people with disabilities in India had mobility impairments.
It is important to note that there are discrepancies between various sources and reports regarding the number of people with disabilities in India. It is possible that the actual number is higher than the officially reported figures. Moreover, disability prevalence is likely to vary across different regions and socio-economic groups in India.

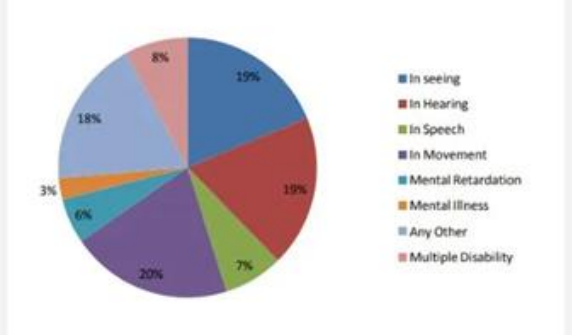

Figure 2: Disabled Population by Type of Disability in India

1. Numerical study of Manual wheelchair propulsion: highlight on the lever system by N. Skendraoui, F. Bogard, S. Murer, F. Beaumont, R. Taïar and G. Polidori. (Computer methods in biomechanics and biomedical engineering)
The authors of the paper presented a procedure for developing an upper limb kinematic model that assesses the involvement of major muscle groups in wheelchair propulsion using a lever system. The study demonstrated that the lever propulsion system is less traumatic for users compared to the hand-rim system. The ultimate goal of this research is to design a new type of manual wheelchair that incorporates an improved propulsion system based on levers, as well as ergonomic enhancements. One notable feature is an integrated seat system that enables the user to transition from a seated position to a standing position.

2.A wheelchair with lever propulsion control for climbing up and down stairs by Kai Sasaki, Yosuke Eguchi, Kenji Suzuki. (Annual International Conference of the IEEE Engineering in Medicine and Biology Society)

The authors of the paper introduce a novel concept of a stair-climbing wheelchair that utilizes lever propulsion control based on the movements of the user's upper body. Their research focuses on studying the wheelchair's performance during both ascending and descending staircases using the lever propulsion control method. To facilitate the wheelchair's descent on stairs, the authors incorporate one-way clutches into the rotary-leg mechanism, allowing the user to engage in lever operation. Additionally, the wheelchair is equipped with torque dampers to enhance stability. Safety measures are implemented by fixing the front wheels while descending stairs. Experimental tests are conducted to evaluate the wheelchair's performance and validate the effectiveness of the proposed lever propulsion mechanism for wheelchair users.

3. Wheelchair Design and Its Influence on Physical Activity and Quality of Life Among Disabled Individuals by Ali Ebrahimi, Alireza Kazemi, Azin Ebrahimi. (Iranian Rehabilitation Journal)

This review article primarily examines important biomechanical aspects related to wheeled mobility devices. The topics covered include various propulsion methods, overuse injuries associated with wheelchair use, assistive technologies, prevention of pressure ulcers, and considerations regarding tire and frame design. The article also provides a brief overview of how design modifications can contribute to increased physical activity levels and improved quality of life for adults who rely on wheelchairs.

4. Design History and Advantages of a New Lever-Propelled Wheelchair Prototype by Ahmad Rifai Sarraj and Raphael Massarelli. (International Journal of Advanced Robotic Systems (IJARS))
The objective of this study was to introduce a novel wheelchair propulsion technique utilizing a lever system. The research involved investigating various aspects, including the development of an interface prototype for users, evaluating wheelchair skills, and measuring oxygen uptake and cardiac frequency through objective and subjective studies. The prototype was specifically designed to cater to disabled athletes, providing them with certain advantages over conventional manual wheelchair propulsion techniques. By adopting this non-conventional approach, potential complications associated with traditional methods can be avoided. The study aims to explore the feasibility and benefits of this alternative wheelchair propulsion technique, particularly in the context of disabled athletes.

5. Biomechanics of wheelchair propulsion as a function of seat position and user-to-chair interface by Christopher J. Hughes, Wendi H. Weimar, Pradip N. Sheth, Clifford E. Brubaker. (Archives of Physical Medicine and Rehabilitation)
This study aimed to investigate the biomechanics of lever propulsion and hand-rim propulsion, as well as the impact of seat position on propulsion mechanics. The study involved the participation of nine able-bodied individuals and six individuals

with paraplegic spinal cord injuries. The subjects performed both hand-rim and lever propulsion using a wheelchair test simulator. Three-dimensional motion measurements were taken for the trunk, shoulder, elbow, and wrist during four-second sample periods for each seat position. Hub torque and stroke arc measurements were also recorded. The results indicated that hand-rim propulsion required less elbow motion, greater shoulder extension, reduced shoulder rotation, and less arm abduction compared to lever propulsion. However, both methods of propulsion necessitated a significant amount of internal rotation at the shoulder. Seat position modifications had a more pronounced impact on joint motion ranges when performing hand-rim propulsion. No significant differences were observed in trunk motion across the different treatments. These findings contribute valuable information for the development of a model that aims to optimize wheelchair propulsion. By understanding the biomechanical differences between lever and hand-rim propulsion, as well as the influence of seat position, researchers and designers can work towards improving wheelchair propulsion techniques and enhancing user experience.

6. Stakeholder-Driven Design Evolution of the Leveraged Freedom Chair Developing World Wheelchair by Amos G. Winter, V Mario, A. Bollini, Benjamin M. Judge, Natasha K. Scolnik, Harrison F. O'Hanley, Daniel S. Dorsch, Sudipto Mukherjee, Daniel D. Frey. (ASME 2012 International Mechanical Engineering Congress and Exposition)
This paper documents the progressive development of the LFC (Leveraged Freedom Chair) through three user trials conducted in East Africa, Guatemala, and India. The feedback obtained from the participants in these trials played a crucial role in refining the design of the chair. Additionally, survey data was collected to support the observed performance improvements seen in successive iterations of the LFC. Moreover, quantitative biomechanical performance data was measured during the trials conducted in Guatemala and India. The results revealed that the LFC outperformed conventional push rim-propelled wheelchairs in terms of speed, efficiency during daily commuting, and the ability to generate higher peak propulsion force. The findings underscore the significance of the design enhancements implemented in the LFC, as validated by user feedback, survey data, and quantitative biomechanical measurements. These results highlight the superior performance of the LFC compared to traditional push rim-propelled wheelchairs, indicating its potential to significantly enhance mobility and propulsion capabilities for wheelchair users.

CONCLUSION

The traditional wheelchairs have inherent limitations when it comes to off-road use. However, the all-terrain lever propulsion wheelchair addresses these limitations through its lever propulsion system. Comparatively, the ATWC requires less effort from users to drive the wheelchair in comparison to conventional push-rim type wheelchairs.

Although lever propulsion systems can be more complex and require additional maintenance compared to manual wheelchairs, their benefits for off-road use outweigh these drawbacks. This makes the all-terrain lever propulsion wheelchair a worthwhile investment for individuals seeking to maintain their independence and mobility.

In summary, the all-terrain lever propulsion wheelchair represents a significant advancement in wheelchair technology, holding great potential to enhance the lives of people with physical disabilities. By providing greater mobility and independence, this device enables users to participate in activities they may have otherwise been unable to enjoy. Consequently, it is a valuable addition to the field of assistive technology and should be subject to ongoing development and improvement in the future.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FUNDING SUPPORT

The author declares that they have no funding support for this study.

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