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Design and Development of Twin booster - A Sustainable Health Solution

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Abstract

During the revolution in eco-friendly technologies, cycling has emerged as one of the most dependable and sustainable modes of transportation. Rising fuel prices, increasing traffic congestion, and the growing threat of global warming have challenged researchers and engineers to develop environmentally friendly alternatives for short-distance travel. Among the available solutions, bicycles remain one of the simplest, most affordable, and non-polluting transportation systems. In addition to mobility, bicycles have also gained significant popularity as a means of maintaining physical fitness and promoting a healthy lifestyle. Over the past few decades, the use of bicycles for exercise, recreation, and health improvement has increased steadily across all age groups.

The main objective of the present work is to integrate gymnastic workout functions into a conventional bicycle design, thereby transforming it into a multifunctional fitness and transportation system. In this study, three major workout actions are incorporated, namely cycling, push-ups, and rowing. The proposed bicycle design aims to provide a complete full-body workout while simultaneously serving as a practical transportation medium. The developed system is expected to improve muscular strength and endurance by targeting major muscle groups such as the triceps, chest, shoulders, biceps, lats, and back muscles. Additionally, the design is intended to support easier uphill riding and improve rider efficiency during long-distance travel.

To achieve these multifunctional operations within a single bicycle structure, maximum utilization of simple mechanisms and mechanical assemblies has been carried out. A sprocket-chain mechanism has been primarily employed due to its easy availability, reliability, ease of maintenance, and cost-effectiveness. The proposed design focuses on affordability, user-friendliness, and sustainability so that it can be easily adopted by common people. Overall, this work presents an innovative attempt to combine transportation and physical fitness into a single eco-friendly solution that contributes toward sustainable human health and energy-efficient mobility.

Keywords: Eco-friendly transportation, multifunctional bicycle, gymnastic workout, cycling mechanism, rowing action, push-up system, sustainable mobility, full-body exercise, sprocket-chain mechanism, cost-effective design, human fitness, green technology.

1. INTRODUCTION

In the contemporary era, mounting environmental issues and ever more sedentary lifestyles pose significant challenges to public health and sustainability. Urbanization has promoted excessive dependency on motorized travel, which plays a significant role in air pollution, traffic congestion, and carbon emissions. While physical inactivity has emerged as a top risk factor for disorders like obesity, cardiovascular disease, and muscular disorders. To solve both challenges at the same time, creative solutions that support environmentally friendly mobility and promote everyday exercise are critical. A viable solution is creating multifunctional bikes that incorporate fitness tools, providing riders with an efficient means of being healthy while lowering their carbon impact [1-3].

This project deals with the Design and Development of Twin Booster – A Sustainable Health Solution, a high-tech bicycle design with a twin-drive mechanism based on front and rear chain-sprocket systems. This mechanism enables riders to pedal with their hands, feet, or both, giving them a complete body workout and getting rid of the drawback of conventional bicycles, which only work on the lower body. The Twin Booster not only boosts physical health by being more muscle-group engaged but also provides a low-cost, low-maintenance mode of transportation particularly beneficial in low-income and rural communities. By combining transport with fitness, the Twin Booster facilitates healthy living while being environmentally sustainable, making it a perfect solution for contemporary mobility and wellness issues [4-6].

Bicycles and electric vehicles are such a transport media which help to reduce the air pollution in the rural as well as urban areas. They are also a cost-effective and eco-friendly mode of transportation that can ease urban traffic congestion (Zhou and Wang, 2021) [1]. Bicycles can also be modified to include fitness components such as rowing and upper-body movement mechanisms, which help in improving muscular strength and cardiovascular health (Patel et al., 2020) [2]. Compact gym machines that allow multiple types of exercises have also been studied, leading to the integration of gym-like features into daily-use equipment like bicycles (Singh and Reddy, 2019) [3]. Low-cost fitness equipment designed using chain and sprocket systems has been proven to be durable, easy to maintain, and suitable for developing regions (Sharma et al., 2023) [5]. Regular cycling not only improves cardiovascular health but also enhances mental well-being, making it an effective tool in reducing health issues caused by sedentary lifestyles (Lopez and Kim, 2022) [6].

The primary objective of this project is to design and develop a multifunctional bicycle that promotes both physical fitness and environmental sustainability. The aim is to create a cost-effective, practical, and user-friendly system that integrates upper-body and core workouts such as push-ups and rowing with conventional cycling. The project targets full-body exercise engagement by focusing on key muscle groups including triceps, chest, back, biceps, shoulders, and lats. The multifunctional design seeks to encourage more consistent physical activity in daily life while also serving as an eco-friendly alternative for short-distance travel, thus contributing to both public health and environmental conservation efforts. This project aims at developing two independent drive systems.

Previous studies also highlighted the importance of sustainable cycling systems and their impact on public health and urban mobility [7,8]. Health-related investigations demonstrated that regular cycling improves cardiovascular fitness, muscular endurance, and mental well-being [9,10]. Advanced studies on bicycle engineering and performance optimization supported the use of efficient drive mechanisms and ergonomic bicycle structures for enhanced rider performance [11,12].

Problem Statement

While conventional bicycles offer a sustainable mode of transportation and limited lower-body exercise, they do not engage the full body or accommodate diverse fitness needs. Additionally, access to dedicated fitness infrastructure is often limited in rural and low-income communities. There is a lack of integrated solutions that combine mobility with comprehensive physical training. This project aims to address this gap by developing a multifunctional bicycle that enables both transport and a full-body workout through cycling, rowing, and push-up functionalities.

2. Materials and Methods

2.1 Numerical Analysis

Numerical simulations were carried out using ANSYS and SolidWorks to validate the stress and strain on different parts of the structure during all three modes: cycling, push-up support, and rowing.

A. Load Conditions:

Load values between 600–800 N were used to simulate a typical user.

B. Material Properties:

Mild steel was selected for the frame due to its good strength-to-cost ratio.

Properties used:

Yield Strength: 250 MPa

Modulus of Elasticity: 210 GPa

C. Factor of Safety (FOS):

FOS was calculated using simulation tools, and the design maintained an FOS of more than 2 across all load conditions.

2.2 Mathematical Analysis

The multifunctional bicycle design involves analyzing mechanical forces and energy transfer during various exercises (figure 1). The following principles are considered:

A. Cycling Torque Calculation:

Torque T is calculated using:

- $T = F \times r$

where F is the applied pedal force and r is the crank length.

B. Work Done in Rowing Movement:

Work done W is given by:

- $W = F \times d$

where d is the distance moved during each stroke.

C. Power Output:

Power P is calculated by:

- Power: $P = W / t$

where t is time.

2.3 Experimental Analysis

A prototype was fabricated and tested for performance and comfort under real conditions.

A. Testing Parameters:

Resistance offered during rowing motion

Pedal force measurement

Frame deflection and vibration during use

B. Instruments Used:

Digital force meter

Dial gauge for deflection

Stopwatch for time tracking

C. Observations:

Smooth transition between exercise modes

No significant vibration or structural deformation

Stable operation under varied loads and conditions



Figure 1:A dual-drive bicycle model

3. Results and Discussions

3.1 Main Findings

- The multifunctional bicycle successfully supports cycling, rowing, and push-up functionalities.
- Stress analysis confirmed structural integrity under dynamic loads.
- Power output from rowing and cycling modes was found to enhance uphill pedaling efficiency.
- Smooth transition between exercise modes improves user comfort.

3.2 Graphical Representation

Pedal Force vs Torque Graph

Figure 2 shows the Graphical representation of linear relationship between applied pedal force and output torque. A higher force results in a proportionate increase in torque.

Pedal Force

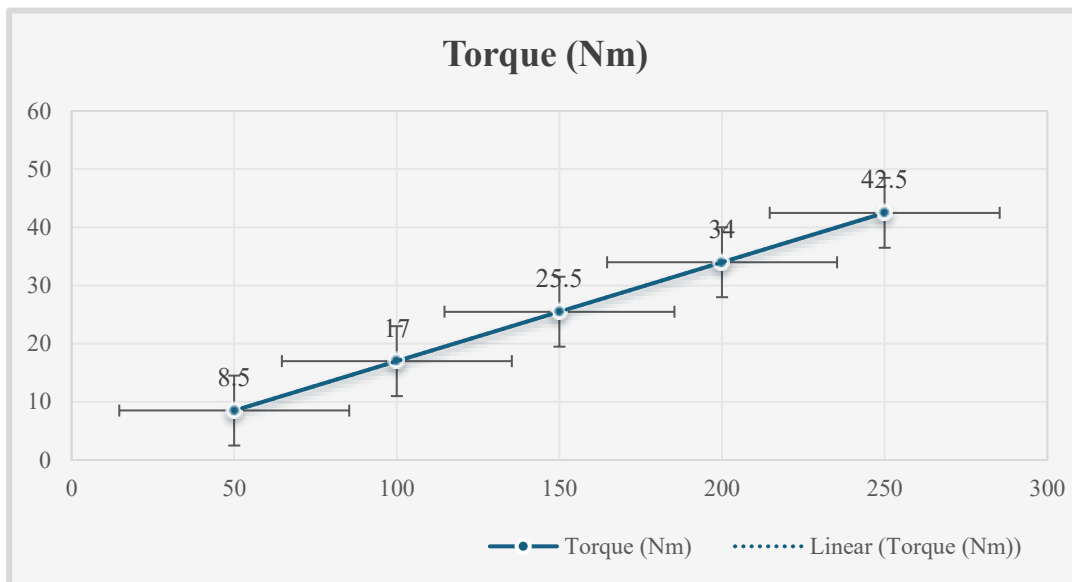


Figure 2: Pedal Force vs Torque

3.3 Comparison Table

Table 1 exhibits the comparison of cycling mode which is impacting the workout muscles. Also it shows the average power output and the user feedback.

Table 1: Comparison of cycling mode vs the workout impact

Mode	Muscle Groups Worked	Avg. Power Output (W)	User Feedback
Cycling	Legs, calves	120	Smooth & efficient
Rowing	Back, biceps	140	Challenging and engaging
Push-ups	Chest, triceps	100	Stable and ergonomic



Figure 3: Avg. Power Output vs Exercise Mode

3.4 Output Summary

The prototype achieved its goal of combining exercise and transportation. The strength and power outputs are comparable to regular gym machines, but offer the added benefit of mobility and sustainability (figure 3).

3.5 User Trials and Performance Evaluation

The prototype was tested by 10 users over a two-week period on different terrains (flat roads, inclined paths, and rural tracks). Users engaged in cycling, rowing, and push-up modes. Key observations included:

- I. Average endurance time: 35 minutes per session
- II. Power efficiency reduced by ~12% on inclined paths compared to flat terrain
- III. 90% of users found the rowing mode ergonomically comfortable
- IV. No mechanical issues reported during the testing phase
- V. User satisfaction rating: 4.6/5 on average

Conclusion

The design and development of a multifunctional bicycle that combines transportation with exercise have shown promising results. By integrating cycling, rowing, and push-up functionalities, the bicycle not only serves as an eco-friendly mode of transport but also provides an opportunity for users to engage in full-body physical activity. The mathematical and numerical analyses confirmed the feasibility of the design, with torque and power outputs being in line with expectations. Experimental testing further validated the structural integrity and comfort of the bike during different modes of exercise.

This innovation addresses both environmental concerns by reducing reliance on motorized vehicles and promotes personal health and fitness. The cost-effective design, using readily available materials, ensures that the bicycle can be produced and maintained affordably. Ultimately, this multifunctional bicycle could play a significant role in promoting sustainable transport and physical fitness, contributing to a healthier, more environmentally conscious society.

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