MARI

MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

Vol. 7 No. 2 (2026) 144-152
https://publisher.uthm.edu.my/periodicals/index.php/mari

Foldable Tennis Ball Picker

Muhammad Adam Haris Mohd Fadhil[1], Rasyidi Badrun[1], Muhammad Izzad Asyraf Jamaludin[1], Mohd Najib Janon[1,2]*, Hafsa Mohammad Noor[1,2], Tuan Mohd Hafeez Tuan Ibrahim[1,2]

[1] *Department of Mechanical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, Pagoh, 84600, MALAYSIA*
[2] *Sustainable Product Development (S-Proud), Department of Mechanical Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Pagoh, Johor, MALAYSIA*

*Corresponding Author: mohdnajib@uthm.edu.my
DOI: https://doi.org/10.30880/mari. 2026.07.02.019

Article Info

Received: 1 March 2026
Accepted: 1 May 2026
Available online: 30 June 2026

Keywords

Tennis Sport, Tennis Ball,

Foldable Tennis Ball Picker

Abstract

During tennis training sessions, large numbers of balls are dispersed and must be retrieved quickly to maximize practice efficiency; however, existing retrieval tools are often either manually operated and physically demanding or mechanically powered, bulky, and non-portable. To address these challenges, a Foldable Tennis Ball Picker was designed and developed for individual players and training facilities using a systematic product design process that translated user needs into product specifications and screened alternative designs via a weighted rating method. Performance testing revealed that the prototype consistently outperformed manual collection, achieving an average retrieval time of 7.58 seconds and providing an average time saving of 2.26 seconds per test. The device features a ball storage compartment with a 70-ball capacity and an integrated folding mechanism that reduces storage volume by more than 50%. Structural durability was confirmed by rolling the picker over court surfaces more than 500 times, during which the aluminum frame and joints remained secure and perfectly aligned. Collectively, these results demonstrate that the foldable ball picker successfully supports efficient retrieval, minimizes physical strain, and offers a compact, cost-effective solution suitable for various tennis training contexts.

1. Introduction

During tennis practice, balls are inevitably scattered across the court, creating a highly repetitive, physically demanding retrieval process. Players are often forced to constantly bend and squat to pick up the balls, which studies show leads to significant physical fatigue and ergonomic strain over time [1]. While several collection tools have been introduced to ease this process, each comes with notable operational limitations. Manual methods are simply exhausting [2], mechanical rollers struggle with uneven surfaces [3], and automated robots are costly and rely heavily on battery power [4], [5]. Because these current solutions either fail to prevent strain or are impractical for everyday users, there is a clear demand for a more reliable mechanical aid.

Beyond physical strain, the structural design of most commercially available tennis ball pickers presents a major storage issue. Current manufactured pickers and trolleys typically feature rigid, one-piece frames that are non-foldable and consume excessive storage space [6]. For individual users or smaller training facilities,

Multidisciplinary Applied Research and Innovation Vol. 7 No. 2 (2026) p. 144-152

dedicating large areas to store bulky equipment is highly inefficient. A mechanical design incorporating a collapsible mechanism would overcome this spatial limitation without sacrificing functionality. Therefore, this project aims to design and develop a lightweight, Foldable Tennis Ball Picker that integrates ergonomic retrieval and compact storage to provide a highly portable, cost-effective solution.

1.1 Literature Review

Understanding the evolution of tennis ball retrieval is crucial for identifying current design gaps, with existing methods generally falling into three main categories: manual picking, mechanical rollers, and automated systems [4]. Manual collection remains the most widely used baseline technique worldwide due to its simplicity and zero equipment cost. However, as shown in Fig. 1(a), the continuous bending and reaching required to gather scattered balls place a severe musculoskeletal burden on players over time, making it an unsustainable long-term practice [1], [2]. This inherent physical toll has driven the need to develop intermediate tools designed specifically to mitigate human fatigue.

Mechanical wire-cage rollers were introduced to improve manual collection and operational workflow. The image illustrated by Fig. 1(b) demonstrates that these designs allow users to collect balls by simply pushing a rolling mechanism, eliminating the need to bend down [7]. While this is a massive ergonomic improvement, these rollers have significant design constraints. Their mechanism often jams or fails on uneven court surfaces [3], and the rigid cage has a fixed, limited volume that requires frequent manual emptying [7]. Consequently, while mechanical rollers are a step in the right direction, their structural rigidity and operational limits restrict their overall effectiveness.

On the other hand, automated systems attempt to remove human intervention from the collection process entirely. Modern robotic collectors, such as the Tennibot shown in Fig. 1(c) below, utilize advanced sensor-based controls, AI vision, and motorized drivetrains to locate and retrieve balls autonomously [5]. This high-tech approach maximizes training efficiency by allowing players to focus entirely on their game rather than on clean-up. However, integrating complex electronics and precision motors significantly increases manufacturing and retail costs while also creating a strong dependence on electrical power and battery life. As a result, fully automated machines remain inaccessible to most average players or to underfunded facilities due to their high cost and maintenance requirements.

A critical review of these existing technologies reveals a distinct gap in the current market for tennis ball collectors. Available solutions either require excessive physical exertion, feature bulky, non-foldable designs, or rely on expensive, energy-intensive electronics. There is a clear lack of an intermediate mechanical device that effectively combines affordability, ergonomic safety, and spatial efficiency. A purely mechanical system without complex electronics, enhanced with a collapsible structural frame, would perfectly balance these factors. Hence, justifies the need to develop a foldable, manual-assist tennis ball picker for everyday portability and convenience.

(a) (b) (c)

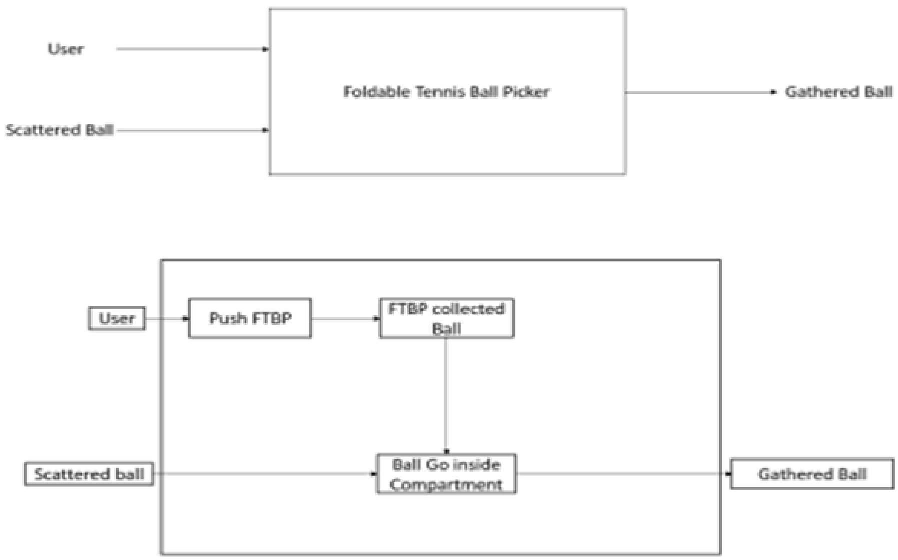
Fig. 1 *Tennis ball collection methods (a) Manual picking; (b) Mechanical wire-cage; (c) Automated System*

2. Methodology

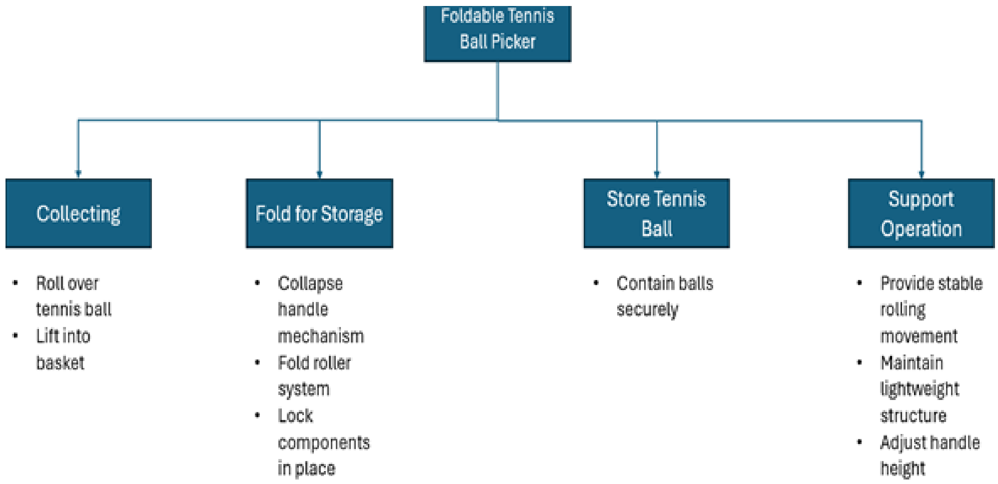
2.1 Project Methodology

The project starts with a comprehensive problem identification phase to ensure the proposed solution is both valid and strategically aligned with user requirements. This foundation directly leads to the development of the Product Design Specification (PDS), which establishes the core requirements for subsequent design stages. During the conceptual design phase, the functional requirements of the tennis ball picker are explored through the implementation of a Black-Box Model and a Product Function Decomposition. As shown in Fig. 2(a), the

Black Box Model defines the overall system inputs and outputs, while the Product Function Decomposition in Fig. 2(b) breaks down these requirements into specific sub-functions. This systematic breakdown enables the identification of alternative components for the folding mechanism and other critical subassemblies [8], [9], [10].



(a)



(b)

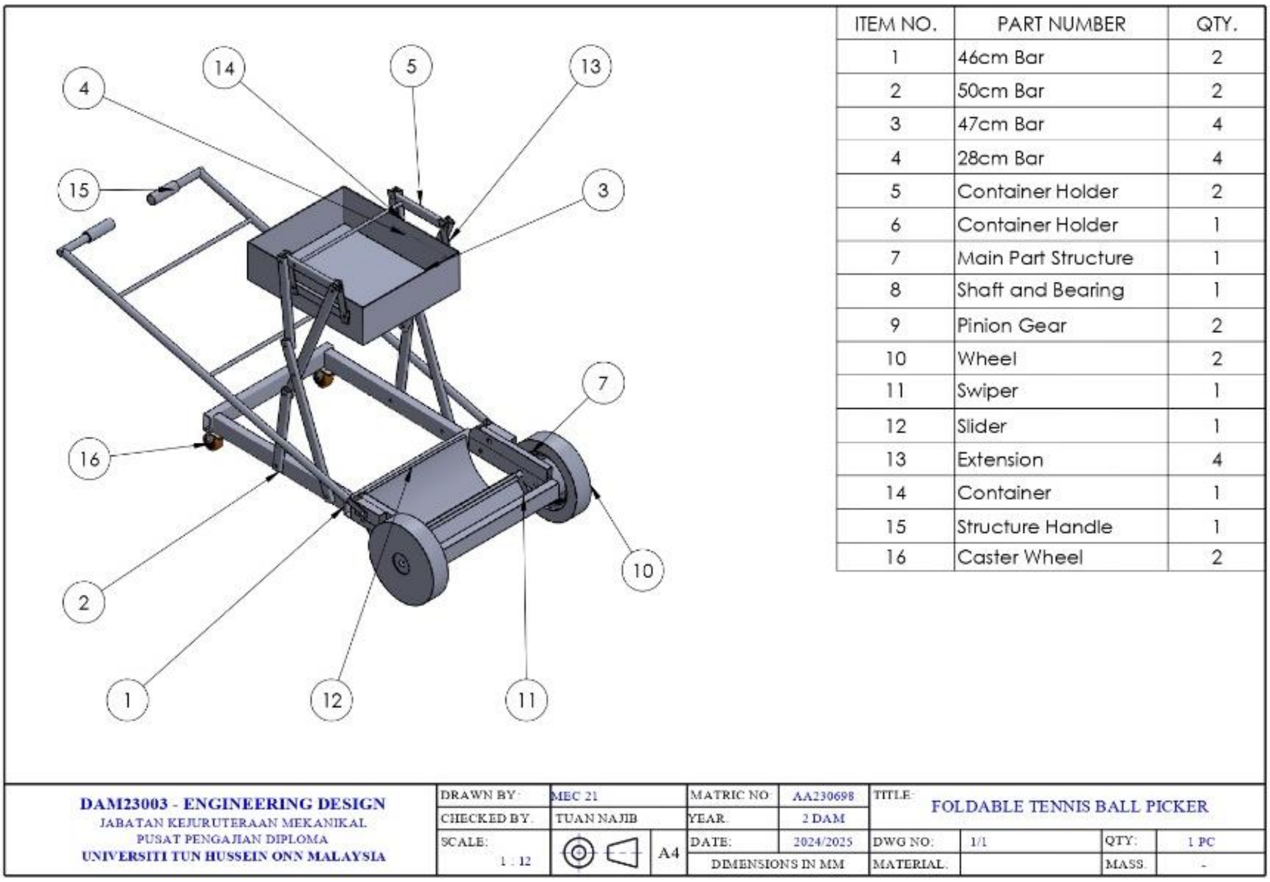
Fig. 2 *(a) Black Box Model and function structure; (b) Product function decomposition*

To determine the optimal combination of these design alternatives, the Weighted Rating Method is employed. This method involves assigning specific weight percentages to key evaluation criteria, such as cost (C), durability (D), ease of manufacture (EM), and functionality (F), based on their relative importance to the overall design goals. Each valid alternative is rated against these criteria, and the individual scores are calculated by multiplying each rating by its respective weight. The alternative achieving the highest aggregate score, derived from the sum of all weighted ratings, is selected as the superior integration option for the final design.

Upon finalizing the concept selection, the project transitions into the design configuration stage. In this phase, the product architecture is defined, establishing the spatial arrangement and interfaces between the various system components. A detailed 3D Computer-Aided Design (CAD) model is developed using SolidWorks to facilitate precise visualization, dimensional verification, and the early detection of potential design interferences or structural weaknesses. In the final stage, a functional prototype is fabricated using the specified materials and manufacturing processes. This prototype undergoes a series of rigorous performance and safety evaluations to ensure full compliance with the initial design specifications and ergonomic standards. The successful testing phase validates the product's functionality, stability, and ease of use, marking a successful transition from a conceptual framework to a viable, real-world mechanical solution.

2.2 Material Selection

The materials used in the Foldable Tennis Ball Picker were selected based on the specific roles and requirements of each component, as depicted by SolidWorks 3D-Modelling and Bill of Materials in Fig. 3 below. The structural components, such as the 46cm Bar (Item 1), 50cm Bar (Item 2), 47cm Bar (Item 3), 28cm Bar (Item 4), and Container Holder (Item 5 & 6), use Aluminium Alloy for its excellent strength-to-weight ratio as well as corrosion resistance and durability. The same material was used for the Main Part Structure (Item 7), Swiper (Item 11), and Slider (Item 12), as they needed to be rigid yet lightweight for ease of transport and use.



ITEM NO.	PART NUMBER	QTY.
1	46cm Bar	2
2	50cm Bar	2
3	47cm Bar	4
4	28cm Bar	4
5	Container Holder	2
6	Container Holder	1
7	Main Part Structure	1
8	Shaft and Bearing	1
9	Pinion Gear	2
10	Wheel	2
11	Swiper	1
12	Slider	1
13	Extension	4
14	Container	1
15	Structure Handle	1
16	Caster Wheel	2

Fig. 3 *SolidWorks 3D-Modelling and bill of materials of portable tennis ball picker*

The Shaft and Bearing (Item 8) and Extension (Item 13) are made from stainless steel, as these parts move frequently and experience mechanical stress. Stainless steel allows for a well-manageable mechanical strength, fatigue resistance, and rust resistance, making it the perfect material for these load-bearing and joint parts. The Pinion Gear (Item 9) and Wheel (Item 10) are made of nylon as this is a very suitable material for an item that experiences low friction, wear resistance, and repeated impact as it picks up tennis balls.

The Structure Handle (Item 15) is constructed from aluminium alloy for the frame and thermoplastic rubber (TPR) for the grip area. Since TPR is slip-resistant and very comfortable, it is easy to grip and well-suited to user ergonomics. Finally, Caster Wheels (Item 16) are generally constructed with a nylon or hard plastic body and stainless-steel hardware for superior movement across the court surface while providing durability. The selected materials ensure structural integrity and user comfort while prioritizing sustainability. Aluminium and stainless steel are both recyclable and offer longevity, reducing the environmental impact of the product, as compared to non-recyclable alternatives.

2.3 Engineering Analysis

Engineering analysis employs mathematical, scientific, and computational models to evaluate the performance and behavioral characteristics of engineering components. By deconstructing complex systems into manageable parts, this analytical approach enables systematic prediction of how components interact under specific operational conditions.

In this project, several fundamental mathematical equations are utilized to investigate and validate the following criteria:

i. Force, F

The force required to move or lift the tennis balls is calculated using Newton's Second Law.

$$F = ma \tag{1}$$

where:

F = Force (N)
m = Mass (kg)
a = Accelaration (m/s²)

2. Torque, τ

The torque needed for rotational components like wheels or rollers is determined by:

$$\tau = r \times F \tag{2}$$

where:

τ *= Torque (Nm)*
r = Radius (m)
F = Force (N)

3. Results and Discussion

3.1 Product Specification

The Foldable Tennis Ball Picker is a lightweight, ergonomic tool developed to optimize ball retrieval through a formal manufacturing approach. It specifically targets the physical strain and operational complexity coaches and players face during intensive training. By providing a practical solution to minimize musculoskeletal fatigue, the design allows users to focus on maintaining peak on-court performance. Consequently, this targeted development ensures the tool is a functional and vital asset for any modern sports facility.

The device's core functionality relies on an innovative roller mechanism and a collapsible frame designed for maximum spatial efficiency. This system enables rapid ball collection into an integrated compartment while reducing the storage volume by more than 50%. Such a significant reduction is essential for users with limited space, as it simplifies transport without compromising structural integrity. Ultimately, this folding capability successfully links high-capacity storage with superior portability, making it ideal for space-conscious environments.

Table 1 *Foldable tennis ball picker specification*

No.	Details	Specification
1	Maximum Ball Capacity	Up to 70 balls
2	Total Weight	Less than 8 kg
3	Operation Mechanism	Manual rolling collection
4	Movement Mechanism	Push and roll with ergonomic handle
5	Foldability	Yes – folds to less than 50% of full size for the store
6	Durability	Tested more than 500 cycles
7	Cost	Below RM300
8	Surface Compatibility	Suitable for tennis courts
9	Ease of use	A compartment can stand

The technical performance of the Foldable Tennis Ball Picker is defined by its high operational capacity and lightweight design, as summarized in Table 1. With a maximum capacity of 70 balls and a total weight below 8 kg, the device offers a balance between high-volume retrieval and ease of handling for the user. This performance is achieved through a manual rolling and push mechanism, paired with an ergonomic handle to ensure smooth movement across tennis court surfaces. Consequently, these specifications validate the product's ability to handle high-intensity training sessions while remaining light enough for effortless operation by a single individual.

Beyond its functional capacity, the design emphasizes long-term durability and spatial efficiency to meet the demands of a professional sports environment. As detailed in Table 1, the picker features a robust structure capable of exceeding 500 collection cycles while maintaining a foldable configuration that reduces its storage footprint by more than 50%. This durability is complemented by a cost-effective manufacturing target of below RM300, making it an accessible solution for both organizations and individual players. Finally, the integration of a stable standing compartment and superior surface compatibility ensures that the final product is a reliable, space-saving, and cost-effective tool for modern tennis court maintenance. When it comes to sustainability, the use of recyclable materials like aluminum means it has a smaller environmental footprint, and the overall design is built for long-term use with minimal upkeep. The compact design of the foldable picker allows it to be stored or transported safely.

3.2 Operating Procedure

The operational procedure for the Foldable Tennis Ball Picker is summarized in the following steps:

1. Unfolding and Stability: Begin by unfolding the device from its compact suitcase-like form and securing all locking hinges or folding mechanisms to ensure structural stability.
2. Ergonomic Adjustment: Adjust the extension handle to a suitable height to ensure user comfort and maintain proper posture during operation.
3. Pre-Operational Inspection: Inspect the rollers, storage compartment, and joints for any obstructions to confirm the system is in proper working order.
4. Setup for Training: Place the device on a flat court surface and set the compartment upright to serve as a stationary ball stand for active training.
5. Collection Process: Once the balls are scattered, lower the compartment and push the device forward to allow the roller mechanism to guide the balls into the integrated storage automatically.
6. Capacity Monitoring: Monitor the basket during operation and cease rolling once it reaches its maximum capacity of 70 balls to prevent mechanical jamming.
7. Storage Transition: Close the storage compartment and collapse the handle to return the device to its compact form for easy transport and space-efficient storage.

3.3 Prototype Testing and Result Analysis

Prototype testing was conducted after the prototype was fabricated. The testing phase was divided into four critical evaluations: performance test, structural test, stability test, and component functionality test. A product performance test is conducted to evaluate the time efficiency of this Portable Tennis Ball Picker compared with manual retrieval, as shown in Fig. 4. In this test, three tennis balls will be collected and placed 1 meter apart. To keep the result consistent, the same person conducted the test at a steady walking speed.

Fig. 4 *Prototype performance test for foldable tennis ball picker*

The graph in Fig. 5 illustrates the result of the performance test between these two methods. Test 1 took 10.63 seconds to gather the balls manually, whereas the tennis ball picker completed the task in just 7.54

seconds. In Test 2, the picker's performance was even more efficient, clocking in at 6.89 seconds compared to the 9.67 seconds required for manual collection. Although the difference was slightly smaller in Test 3, the picker still came out on top with a time of 8.3 seconds versus 9.2 seconds for manual retrieval. Overall, these findings highlight the tennis ball picker's superior efficiency, with an average retrieval time of 7.58 seconds, resulting in an average saving of 2.26 seconds per test. This clearly demonstrates that using the tennis ball picker not only reduces physical effort but also significantly accelerates retrieval, particularly during repetitive or high-volume tasks.

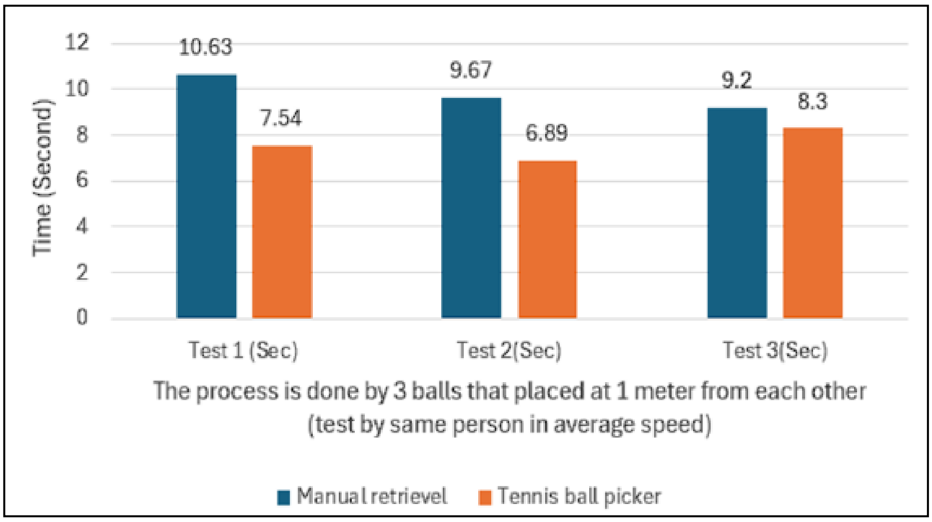


Fig. 5 *Comparison graph between manual method vs. portable tennis ball picker*

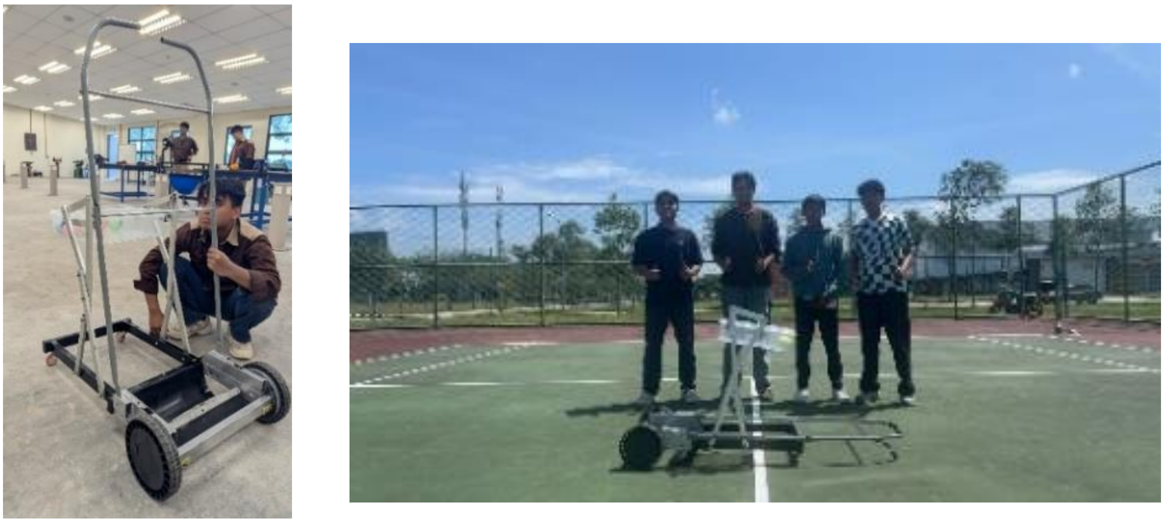
The structural test, as depicted in Fig. 6(a), evaluated the picker's durability by rolling it over a flat surface more than 500 times. Throughout the process, the aluminum frame maintained its integrity, while the rolling mechanism remained perfectly aligned and continued to rotate smoothly. These results demonstrate that the structure is highly capable of withstanding repeated use in real-world conditions. In addition, the prototype stability is tested across various smooth and uneven surfaces, as shown in Fig. 6(b). The findings indicated that the rectangular frame provided sufficient stability to prevent tipping, and the tires remained firmly attached during movement, ensuring consistently safe operation.

Functionality tests were conducted independently for each subsystem. The folding mechanism shown in Fig. 6(c) performed exceptionally well, reducing the unit's size by over 50% and providing more than 50% more storage space. Additionally, the roller system consistently retrieved balls without jamming, while the frame joints remained stable even after multiple folding cycles, as depicted by Fig. 6(d). The ball storage compartment, which holds up to 70 balls, was easy to empty and remained stable. Lastly, based on feedback from tennis club players, Mr. Muhammad Izzalif confirmed that the product is portable, user-friendly, and ergonomically designed, making it well-suited for regular on-court use as shown in Fig. 6(e).

(a)

(b)

(c)



(d) **(e)**

Fig. 6 *Prototype Testing (a) Structure Test; (b) Stability Test; (c) Functionality Test-Folding Mechanism; (d) Functionality Test-Frame Joints; (d) Presentation to the Tennis Club Player, Mr. Muhammad Izzalif*

4. Conclusion and Recommendations

The project has successfully achieved all its primary objectives through the design and development of the Foldable Tennis Ball Picker. Data from the performance trials confirm the system's efficiency: the picker recorded an average retrieval time of 7.58 seconds, consistently outperforming manual collection by 2.26 seconds per session. Structurally, the device demonstrated durability, maintaining full functionality and alignment after 500 cycles of court testing.

Distinguishing itself from existing market solutions, this design introduces a high-capacity 70-ball storage compartment integrated with a unique folding mechanism that reduces the unit's volume by over 50%. Hence, it provides an innovative mechanical solution that eliminates the need for electrical components while significantly enhancing portability. In addition, the ergonomic design effectively minimizes physical strain for players and coaches, particularly during high-volume training sessions.

While the current prototype is highly effective, there is room for further optimization. Future iterations could focus on improving usage at uneven surfaces and expanding storage capacity beyond the current 70-ball limit. Furthermore, exploring high-grade composite materials may offer additional weight reduction without compromising structural integrity. These refinements, alongside minor structural adjustments to accommodate other ball sports, could facilitate broader commercial production and establish this innovation as a sustainable standard in ergonomic sports equipment.

Acknowledgement

The authors thank the Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia (UTHM), for supporting and facilitating the research and development programme.

Conflict of Interest

This publication has no conflicts or issues regarding the data, as it relies on references from the internet and research.

Author Contribution

The authors confirm their contribution to the paper as follows: ***Problem, conception, and design study****: Muhammad Izzad Asyraf Jamaludin, Rasyidi Badrun, Muhammad Adam Haris Mohd Fadhil, Mohd Najib Janon;* ***Prototype manufacturing and data collection****: Muhammad Izzad Asyraf Jamaludin, Rasyidi Badrun, Muhammad Adam Haris Mohd Fadhil;* ***Analysis and interpretation of results****: Muhammad Izzad Asyraf Jamaludin, Rasyidi Badrun, Muhammad Adam Haris Mohd Fadhil;* ***Draft manuscript preparation****: Muhammad Izzad Asyraf Jamaludin, Rasyidi Badrun, Muhammad Adam Haris Mohd Fadhil, Mohd Najib Janon, Hafsa Mohammad Noor, Tuan Mohd Hafeez Tuan Ibrahim. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Universiti Teknologi MARA (UiTM), "*EZBallRetriever: The Fast & Simple Tennis Ball Collector*," Final Year Project Report, UiTM, Malaysia, 2022, Available: https://ir.uitm.edu.my/id/eprint/116577/1/116577.pdf.
[2] C. Jen, "*What's The Call: Picking Up Stray Tennis Balls*," TennisLifeMag.com, Jun. 9, 2015, Available: https://tennislifemag.com/whats-the-call-picking-up-stray-tennis-balls/.
[3] R. R. Perry, "*Ball practice aid*," U.S. Patent 4 844 527 A, Jul. 4, 1989, Available: https://patents.google.com/patent/US4844527A/en.
[4] M. Latifinavid and A. Azizi, "*Development of a Vision-Based Unmanned Ground Vehicle for Mapping and Tennis Ball Collection: A Fuzzy Logic Approach*," Future Internet, vol. 15, no. 2, p. 84, Feb. 2023, Available: https://www.mdpi.com/1999-5903/15/2/84.
[5] Tennibot, "*Ball Collector*," Tennibot Official Website, 2024, Available: https://www.tennibot.com/tennis/ball-collector/.
[6] S. H. Chen, "*Tennis ball retriever and storage cart*," U.S. Patent 5 301 991 A, Apr. 12, 1994, Available: https://patents.google.com/patent/US5301991.
[7] Siboasi Ball Machine, "*Siboasi New Tennis Ball Picker S709 Product*," Siboasi Official Website, 2024, Available: https://www.siboasiballmachine.com/siboasi-new-tennis-ball-picker-s709-product/.
[8] R. J. Eggert, *Engineering Design*, 2nd ed. High Peak Press, 2010.
[9] Y. Haik and T. Shahin, *Engineering Design Process*, 2nd ed. Cengage Learning, 2011.
[10] G. E. Dieter and L. C. Schmidt, *Engineering Design*, 6th ed. McGraw-Hill Education, 2021.