
Human-Centered Design in Optimizing Fitness Benches

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ABSTRACT

Fitness benches serve as a cornerstone for free weight training, a practice that offers significant fitness gains but can raise safety concerns, particularly for beginners and women. This study explores the design and functionality of traditional benches used for foundational exercises like the bench, incline, and shoulder press. It emphasizes the potential of ergonomics to revolutionize bench design by prioritizing user comfort and safety, thereby mitigating injury risks. Furthermore, the study examines the demand for innovative bench designs catering to the needs of fitness enthusiasts seeking safer and more effective training solutions. In conclusion, the research highlights the crucial role that optimized fitness bench design plays in maximizing the benefits of free weight training while minimizing the inherent risks.

Keywords: Fitness bench design, Free weight training, Safety, Performance optimization

INTRODUCTION

The contemporary emphasis on health and wellness has fueled a surge in gym memberships and a renewed focus on strength training. Recent research by Thompson (2023) identifies a significant rise in basic fitness routines, with free weight training ranking as the second most popular trend in 2023. This trend coincides with the observed expansion of gym facilities in recent years.

Free weight training, characterized by exercises such as bench presses, shoulder presses, and squats using barbells and dumbbells, offers distinct advantages. Studies like Schwanbeck et al. (2020) suggest that free weight exercises promote greater muscle engagement and facilitate more effective full-body workouts, making them a preferred choice for individuals seeking comprehensive training.

However, the inherent risks associated with free weight training cannot be overlooked. A significant portion of users experience injuries, particularly in the shoulder and elbow regions. Research by Kerr et al. (2010) highlights the ongoing need to identify the root causes of these injuries.

Ergonomics, a discipline renowned for successfully reducing muscle fatigue by designing ergonomic chairs in office settings (Mehrparvar et al., 2014), presents promising solutions within the fitness and health domain. Integrating ergonomic principles into the design of fitness benches makes it possible to create safer and more comfortable training environments for gymgoers. This approach not only enhances the user experience but also paves the way for innovative advancements within the fitness industry.

Literature Review

Ergonomics in fitness equipment design, particularly for weight training benches, is pivotal in enhancing user safety and optimizing performance outcomes. Research indicates that mechanical variations in equipment design significantly influence muscle activation patterns and the risk of strain injuries, highlighting the necessity for ergonomic considerations that minimize biomechanical stress (Lavender et al., 2009).

Expanding upon these ergonomic principles, the study by Kim et al. (2015) explores the effectiveness of a posture correction exercise program in reducing musculoskeletal pain. Their research demonstrates that structured exercise regimens to correct posture significantly alleviate pain in key areas such as the shoulders, mid-back, and lower back. Recent studies like that of Lu et al. (2020) have explored how even short durations of poor posture can adversely affect muscle function before physical activities. Their findings indicate that poor posture can significantly increase muscle fatigue, affecting overall physical performance. This study underscores the importance of maintaining correct posture during exercise and in the moments leading up to it, highlighting the potential negative impacts of ergonomic neglect in fitness equipment design.

Further extending these considerations, Zheng, Mo, and Xu (2021) evaluate user satisfaction with public fitness equipment across dimensions including safety, practicality, and enjoyment. Their findings suggest that improvements in material design, safety features, and user interfaces can significantly enhance user engagement and satisfaction, integrating Norman's three-level experience design theory (Zheng, Mo & Xu, 2021).

The demand for more human-centered gym equipment aligns with broader trends in health and wellness, where the emphasis is on personalized approaches that accommodate individual fitness levels and physical conditions (Thompson, 2023). As such, integrating ergonomic principles into the design of fitness benches is seen not only as a response to user demand but also as a proactive step towards more holistic, health-oriented fitness practices.

METHODOLOGY

Literature Review Process

This stage involved a comprehensive exploration of scholarly articles, industry analyses, and case studies related to the design of fitness benches, the application of ergonomics in gym equipment, and user interactions within gym environments. The methodology included:

- **Database Exploration:** Academic platforms such as PubMed, Google Scholar, and JSTOR were searched to locate pertinent peer-reviewed articles and industry insights.
- **Selection Criteria:** Publications were chosen based on their relevance to design, ergonomics, and user experiences within the context of sports science, emphasizing studies published in the last five years to capture recent advancements and trends.

- **Analysis of Gathered Data:** The collected literature was meticulously reviewed to distill essential findings, explore various ergonomic design strategies, and pinpoint research gaps in the current landscape.
- **Comparative Review:** A detailed comparison of fitness bench design philosophies was conducted across different research pieces to evaluate their efficacy and user reception.

Primary Data Collection

Primary data collection was conducted through structured surveys and in-depth interviews with gym users to complement the insights from the literature review.

Survey Design and Distribution

- **Objective:** The survey's primary purpose was to evaluate the awareness, experiences, and preferences regarding ergonomics in fitness benches among a diverse group of gym users. Understanding user perspectives is crucial for informing design decisions and prioritizing safety and user satisfaction.
- **Sample Size and Demographics:** The survey was strategically distributed to a sample of 78 participants across the campus. This sample encompassed a heterogeneous group, including fitness enthusiasts, athletes, students, and gym staff. This diversity ensured a broad range of user perspectives and experiences with fitness benches.
- **Questionnaire Structure:** The survey instrument featured a combination of quantitative and qualitative components. Using a Likert scale, quantitative sections measured user awareness of ergonomic design principles in gym equipment. Through open-ended questions, the qualitative sections explored user experiences with various fitness bench models and solicited preferences for improvement. This mixed-methods approach allowed for the collection of both objective data (awareness levels) and subjective experiences (personal anecdotes and preferences).

Interview Methodology

- **Participant Selection:** Following the survey administration, 30 participants were chosen for in-depth interviews. Selection criteria prioritized individuals who reported significant engagement with fitness benches or possessed relevant expertise (e.g., gym staff and personal trainers). This approach ensured a focus on participants with valuable insights and practical experiences with ergonomic considerations in fitness bench design.
- **Interview Format:** Semi-structured interviews were conducted, allowing for a blend of pre-determined questions to guide the conversation and the flexibility to explore emerging themes organically. This approach fostered rich dialogue and captured detailed user experiences that may not have surfaced through a purely structured format.

- **Key Focus Areas:** Conversations centered around participants' specific experiences with fitness benches, their considerations regarding ergonomic design, perceived advantages and disadvantages of current bench designs, and their recommendations for improvement. By focusing on these critical areas, the interviews aimed to gather in-depth, user-centered data that can be utilized to inform the development of more ergonomic and user-friendly fitness benches.
- **Data Analysis:** The interview data was transcribed verbatim and subjected to thematic analysis. This analysis involved identifying prevalent patterns within the responses, capturing individual stories that illustrate broader themes, and extracting actionable insights regarding user experiences with ergonomic features in fitness benches. The thematic analysis identifies key themes from the data, providing valuable insights into user needs and preferences.

RESULTS

The results of this study, engaging a cohort predominantly composed of young adults, provide insightful revelations into the patterns, preferences, and challenges associated with free weight training among a diverse group of individuals at the University of Illinois at Urbana-Champaign. The findings underscore a significant engagement in free weight training, reflecting its popularity and its perceived benefits to regular practitioners. Through a detailed analysis of participant demographics, exercise habits, and feedback on fitness equipment, particularly benches, this section delves into the nuanced understanding of how free weight training is integrated into fitness routines, the obstacles faced by users, and the potential for enhancements in equipment design to elevate the overall training experience.

Participants were asked about their prior experience with free weight training. A significant 67.39% (31 out of 46 participants) reported engaging in free weight training, highlighting its popularity and perceived importance among the group (see Table 1).

Table 1. Experience with free weight training.

Have you ever engaged in free weight training?		
Yes	31	67.39%
No	15	32.61%
Overall	46	100%

Demographic data revealed a young cohort, predominantly consisting of college students and university employees aged between 18–25 years (see Table 2).

Table 2. Participants demographics.

Gender	Age	Count	%
Female	Under 18	2	9.5%
	18–25	16	76.19%
	26–35	1	4.76%
	36–45	1	4.76%
	Over 45	1	4.76%
Male	Under 18	0	0.00%
	18–25	14	82.35%
	26–35	2	11.76%
	36–45	1	5.88%
	Over 45	0	0.00%

Analysis of fitness experience duration among participants indicated a strong inclination towards trying free weight training. Notably, among those with over six months of fitness experience, only 7% had not tried free weight training, suggesting its integral role in fitness routines (see Table 3).

Table 3. Duration of fitness experience.

For how long have you been engaging in workout sessions?					
Free weight experience	Less than 3 months	3–6 months	6–12 months	More than a year	Total
Yes	5	4	4	14	27
No	9	2	0	3	14
Total	14	6	4	17	41

The study also explored workout frequency and the duration of participants' fitness journeys. It was found that individuals with over a year of experience worked out approximately 2.94 times weekly, significantly more than those new to fitness, who averaged 1.35 sessions per week (see Table 4).

Table 4. Workout frequency and duration.

How long have you been participating in workout routines?					
Frequency/ week	Less than 3 months	3–6 months	6–12 months	More than a year	Total
Less than once	7	1	0	1	9
1–2 times	4	2	1	6	13
3–4 times	3	3	1	6	13
More than 5 times	0	0	2	4	6
Total	14	6	4	17	41

Data on exercise preferences and challenges faced by participants revealed that chest presses (both barbell and dumbbell variations) and shoulder presses were the most favored exercises. Among participants with free weight training experience, 95% engaged in shoulder press exercises. The main issues

highlighted were limited body support and constrained space for movement (see Table 5).

Table 5. Common exercises and challenges.

	Bench Press	Dumbbell Press	Shoulder Press	Incline Bench Press	Decline Bench Press	Smith Machine Press	JM Press	None	Total
Limited Muscle mobility	4	2	4	2	2	2	2	0	16
Limited Body Support	4	8	7	2	2	3	1	2	29
Limited space for free movement	5	5	8	3	1	4	1	0	27
The limited angle of the bench	1	1	2	2	0	0	0	0	6
Unstable/uncomfortable bench	5	5	7	5	5	2	0	3	31
Overall	18	21	28	14	10	11	4	5	

When asked about desired improvements for fitness benches, ergonomic support emerged as the top expectation, alongside the need for increased stability. These areas were identified as key opportunities for innovation in fitness equipment design (see Table 6).

Table 6. Desired bench improvements.

Features	Numbers
Stability of Bench	22
Adaptability suitable for one's physical conditions	14
Design that is easy to understand and use	13
Ergonomic support like back and neck support	26
Auxiliary and protection mechanisms, like force assist	15

Interviews focused on participants' experiences with free weight training, including safety concerns, familiarity with ergonomic fitness equipment, and suggestions for design improvements to enhance usability and safety, especially for women and beginners (see Table 7).

Table 7. Summarized overview of the interview protocol.

Exercise Experience	Bench Observation	Future Suggestion
Do you feel there are risks in free weight training? If yes, could you tell me what it is?	How familiar are you with ergonomics seats? Have you heard about ergonomics in fitness equipment?	Could you pinpoint certain design aspects that need attention to enhance safety and usability, particularly for women and novices?
Could you pinpoint certain design aspects that do not work well for you?	Can you discuss a specific instance where different fitness benches played a vital role in your workout?	Can you share your thoughts on how incorporating ergonomics in fitness bench designs might benefit individuals focusing on sports and health?

Participants expressed concerns over safety risks associated with incorrect equipment usage and the lack of tailored support for women’s body shapes. Constructive suggestions included introducing adjustable and ergonomic features to accommodate users’ needs better and promote effective, injury-free workouts.

Table 8. Participants’ concerns and suggestions.

Concerns		
“Initially, I made a lot of mistakes since nobody told me how to use it correctly. Gripping, setting up, and putting down back weights can be risky if incorrect. Injuries happen all the time. We need professionals to assist us, or we need to watch enough tutoring videos.”	“For the hinge under the bench, only it gets old, or if the bolts are loosened, the bench wobbles, sometimes making it dangerous. Some benches have narrow support that can also be dangerous to use.”	“The curve of a woman’s body is more undulating than that of a man, so it is difficult for women to protect their waist when facing a flat stool. Additionally, excessively high benches make it more difficult for women to stabilize their posture with their legs when they work out.”
Suggestions		
“For bench press, no matter the flat or upper angle, the design of a narrow seat back is important to give flexibility to scapulas and your elbow can reach deeper to perform full range of motion which is crucial to muscle growth.” Male student	“Perhaps adjustable parts of the bench that can prevent strains or injuries by supporting the user in that specific point without affecting the workout’s effectiveness.” Female faculty	“Ergonomic support can definitely promote a healthier body and good natural postures. It will help enhance strength and speed performance since it follows the instinct of bodies.” Female student

The findings from Tables 7 & 8 underscore the need for safer, more inclusive free weight training practices, emphasizing the importance of ergonomic design and professional guidance to address the unique challenges faced by users, particularly in ensuring the safety and effectiveness of exercises for individuals with varying levels of experience and physical needs.

Market Insights: Opportunities in Fitness Equipment Innovation

Our comprehensive market analysis has revealed significant opportunities for innovation in the fitness equipment sector, focusing on enhancing fitness benches’ comfort and ergonomic design. These insights are grounded in a robust combination of academic research and user feedback, pinpointing a critical market niche for developing fitness benches that prioritize ergonomic features.

Identification of Ergonomic Design Gaps

Investigations into current fitness bench designs have identified notable ergonomic shortcomings, particularly in terms of accommodating diverse body types, such as those of female users. Academic sources, alongside user interviews, have highlighted a recurring issue with benches’ padding and

dimensions, where approximately 7% of respondents reported specific discomfort in the hip area due to inadequate width and cushioning support (Refer to citation 5 for detailed analysis).

Another ergonomic design flaw is observed in the approximately 4 inches gap between the seat and back pad of adjustable benches. Although this gap does not compromise the exercises' effectiveness, it severely impacts user comfort, potentially discouraging extended use.

Preferences for Ergonomic Enhancements

User feedback has strongly emphasized the preference for enhanced ergonomic features, advocating for more sophisticated and body-adaptive support, especially in the back and neck areas. This preference is supported by research, such as the studies by McKean, which highlight the critical importance of neck and spinal support during various exercises, including shoulder and bench presses. Implementing ergonomic supports that facilitate correct posture alignment and stability can significantly amplify the benefits of exercises while minimizing the risk of injuries.

A specific ergonomic concern raised pertains to the standard height of fitness benches. Many users, particularly women, find the average bench height of 20 inches problematic for achieving proper leg support, suggesting a need for adjustable height features. A comparative review of leading brands like Rogue, Life Fitness, and Hammer Strength has confirmed a widespread lack of such adjustability in bench designs, pointing to a significant area for product differentiation and innovation.

Design Concepts and Development Strategies

Enhanced Stability with Reduced Bench Height: The current standard bench height often complicates force application for specific demographics, notably beginners and women, during exercises such as the bench press. A design modification (see Figure 1) proposes the reduction of bench height to a range of 13–15 inches, improving leg support and core stabilization for these groups, which could be achieved by either lowering the fixed height of benches or incorporating adjustable height mechanisms to accommodate various user needs.

Back and Neck Support Improvements: Insufficient back and neck support during exercises that involve back arching, such as shoulder and bench presses, has been identified as a common issue. Enhanced design features might include an ergonomic backrest with a combination of a skeletal frame for rigidity, enveloped in memory foam and covered with a durable, woven fabric. This structure should offer support and flexibility, with a surface material that prevents slipping during use.

Adaptive Seating for Varied Body Types: The diversity in user body types necessitates a more adaptable seat design. The proposed solution is a seat cushion that mirrors the properties of MUJI's adaptable beanbag sofas, using materials that compress underweight and shape, to the user while still providing sufficient support. This adaptability ensures comfort and stability for a broader range of body sizes.

Proportion and Adjustable Gap Between Seat and Backrest: Reevaluating the gap between the seat and back pad in bench designs could significantly enhance user comfort. An adjustable backrest could cater to the various body sizes of users, making the equipment more inclusive and comfortable for all users.

Innovative Auto-Adjust Feature for Safer Workouts: A novel auto-adjust feature could significantly reduce the risk of injury for beginners or those with less stable core strength. This feature would allow the bench to tilt backward for exercises requiring a decline and return smoothly to the original position. Ideally, this mechanism would be powered by computer-controlled hydraulics or springs, ensuring seamless and safe adjustments during workouts.

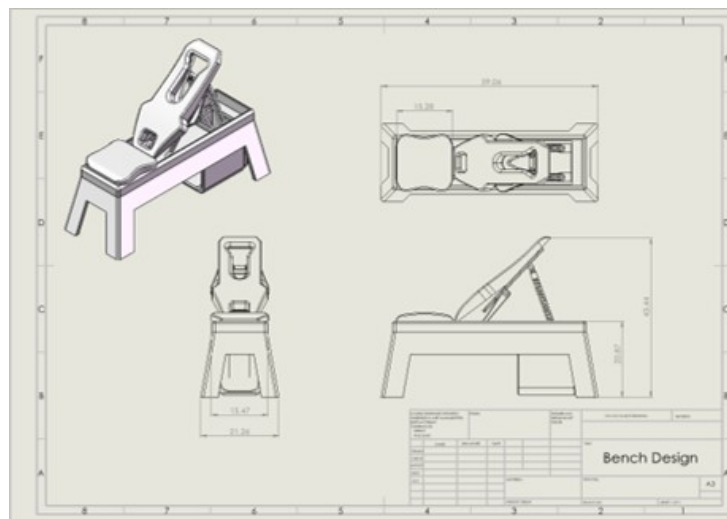


Figure 1: Design concept of ergonomics fitness bench.

LIMITATIONS

Our HCD analysis did not follow the expected coding and analysis of data compared to more traditional qualitative studies, an important distinction because HCD research is not scholarly-based but practitioner-based. An HCD approach allows for more flexibility and space for ethical interpretation, collaborative discussions, and applied contributions to prototype design. Although the convenience sampling was diverse in terms of race, academic discipline, and other variables, additional interviews could have been conducted for greater saturation.

CONCLUSION

The rapid expansion of the fitness market and the increasing focus on personal health emphasize the essential role of self-managed healthcare in improving physical and mental well-being. Fitness, serving as a means to enhance life's quality and happiness, must inherently prioritize the safety of

its users. Ergonomics, a discipline that has grown with the development of human society, has demonstrated its value in office furniture design. While applying ergonomic principles to fitness bench design in the fitness equipment sector is still in its early stages, our thorough academic and market research supports the belief that advancements in ergonomics can significantly enhance the safety and comfort of free weight training equipment users. Additionally, potential users are interested in such improvements.

In this rapidly growing market, integrating ergonomic design into fitness equipment is a necessity and a strategic innovation that promises to transform the traditional fitness experience. By catering to the physical needs and movement nuances during strength training, ergonomic design has the potential to revolutionize the fitness experience, moving it towards a more user-centric approach. This paradigm shift aims to ensure users' overall health and comfort without compromising the quality of their training. Despite the long history of traditional fitness equipment and the transformative introduction of technologies like the Smith machine, which has made exercises such as squats less intimidating, ergonomics is set to become a key factor in enhancing fitness safety.

Looking ahead, it is clear that the concept of human-centered design will play an increasingly significant role in developing fitness equipment, ensuring that the pursuit of fitness becomes a safe, enjoyable, and sustainable journey for everyone.

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