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Testing the usability of the Garuda Unesa Speed (GUS) table tennis racket developed using Makassar ebony veneer

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ABSTRACT

Developing table tennis rackets using local materials is crucial to support national sports innovation and athlete performance. This study aimed to evaluate the usability and performance of the Garuda Unesa Speed (GUS) table tennis racket developed using Makassar ebony wood veneer. The evaluation focused on three main aspects: design, functional purpose, and safety. A total of 37 respondents consisting of non-elite athletes, elite athletes, and table tennis experts participated in the trial. A comparative experimental method was used, and data were analyzed using one-way ANOVA and Tukey HSD post hoc tests. Results showed significant differences in design perception ($F = 13.275$, $p < 0.001$) and functional purpose ($F = 8.642$, $p = 0.001$), but no significant differences were found in safety aspects ($F = 2.182$, $p = 0.128$). Elite athletes consistently gave lower scores than the other groups. The GUS racket was well received by both general and expert users, particularly for its balance of design and ease of use. Although elite athletes exhibit higher performance demands, the racket meets basic usability standards and has potential for further development in a professional context. This study is unique in integrating local wood materials with a user-driven evaluation approach in racket development. Its contribution lies in demonstrating that natural material innovations can be validated for high-performance sports equipment, and supporting the advancement of sports technology research.

KEYWORDS

Test Usage; Table Tennis Racket; GUS; Makassar Ebony Veneer

1. INTRODUCTION

Table tennis has evolved from a recreational game into a global competitive sport that demands quick reactions and excellent technique (Utama et al., 2023) . The quality and structure of the racket, especially the blade, are key factors in determining player performance (Miyazawa et al., 2020) . Various studies have shown that blade thickness, weight, shape, stiffness, and energy absorption capacity affect spin, speed, and control in play (Pott et al., 2013; Fan et al., 2024) .

In recent decades, modern racket production has extensively utilized composite and modified wood (Yıldızbaş et al., 2022; Amin et al., 2017). Indonesia boasts a wealth of high-quality export hardwoods (Sasidharan, 2021). However, few scientific studies have examined their application in high-quality sports equipment. In particular, the use of local wood in table tennis rackets has not been scientifically tested for usability, safety, or performance. Therefore, this creates a significant gap in the academic and industry literature (Safari 2016; Suherman & Ali, 2017).

Makassar ebony from Sulawesi is known for its hardness, density, and good aesthetic appearance. However, to date, there have been no scientific trials assessing the actual performance characteristics of this wood in racket design. This lack of scientific evidence is a barrier to integrating local materials into world-class athletic equipment.

To address these limitations, this study aims to evaluate the usability and performance of the Garuda Unesa Speed (GUS) table tennis racket, designed with Makassar ebony veneer. Trials were conducted on three user groups: elite athletes, non-elite athletes, and table tennis experts. This aimed to obtain assessments from various perspectives of experience and expertise. This approach allowed for validation of the application of local materials based on functional perceptions and comparative testing.

This research is significant because it encourages the use of local Indonesian wood in sports science, contributes to innovation in national sports manufacturing, and supports long-term independence in sports equipment. The research findings are expected to bridge the gap between the potential of traditional materials and modern performance demands. Furthermore, this study contributes to a user-based product validation approach and offers a model for utilizing local materials for competitive sports.

2. METHODS

2.1. Participants

This study employed a comparative usability testing design to evaluate the usability of Garuda Unesa Speed (GUS) table tennis rackets manufactured using Makassar ebony veneer.

A total of 37 participants were recruited from four table tennis communities: ONIC Club, PPOP Ragunan, the Unesa Table Tennis Student Activity Unit, and Pitstop Club. The sample comprised three groups: 16 non-elite athletes, 16 elite athletes, and five table tennis experts. Elite athletes were defined as individuals who had participated in national-level table tennis competitions within the preceding two years. All participants were aged 18–35 years, had no current injuries, and were actively involved in table tennis training or coaching. Data collection took place between December 2024 and January 2025.

2.2. Instrument

The evaluation focused on three dimensions: design, functional performance, and product safety. Usability was assessed using a 10-item questionnaire with a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

The questionnaire's content validity was assessed through expert judgment involving five experts in sports science and training. Each item was evaluated in terms of clarity, relevance, and appropriateness to the intended construct. Internal consistency was evaluated using Cronbach's alpha, which yielded a coefficient of 0.872, indicating good internal consistency.

2.3. Procedure

Prior to the implementation, the research team obtained written consent from all participants and club representatives. Each participant participated in a standardized GUS racket trial session, which included forehand smashes and blocks, lasting 10–15 minutes. All movements were monitored to ensure consistency of execution. Afterward, participants were asked to complete a questionnaire on-site. All activities were documented through photos and videos.

2.4. Statistical Analyses

Data were analyzed using IBM SPSS Statistics (version [specify version]). Parametric statistical methods were employed to examine differences among the three participant groups. The normality of the data was assessed using the Kolmogorov–Smirnov test, while homogeneity of variances was evaluated using Levene’s test. One-way analysis of variance (ANOVA) was performed

to identify statistically significant differences among elite athletes, non-elite athletes, and table tennis experts in their assessments of product design, functional performance, and product safety. When significant differences were identified, Tukey's honestly significant difference (HSD) post hoc test was conducted to determine which pairs of groups differed significantly. Statistical significance was set at $p < 0.05$.

3. RESULTS

Table 1 presents the results of the Kolmogorov–Smirnov (K–S) normality test, which was used to determine whether the distribution of the GUS (Garuda Unesa Speed) total scores significantly deviated from a normal distribution.

Table 1 Kolmogorov–Smirnov normality test

Variable	N	Mean	SD.	KS	*p* value
GUS (Total Score)	37	3,808	0.501	0.120	0.194

The mean GUS total score was 3.808, with a standard deviation of 0.501. The Kolmogorov–Smirnov test yielded a statistic of 0.120 and a p-value of 0.194.

Since the p-value (0.194) is greater than the significance threshold of 0.05, the test did not identify a statistically significant deviation from normality. Therefore, the data can be considered consistent with a normal distribution, supporting the use of parametric statistical methods, provided that the other relevant assumptions are also satisfied.

Table 2 presents the results of Levene's test, which was used to assess the homogeneity of variance assumption for the GUS total scores across the three participant groups: elite athletes, non-elite athletes, and table tennis experts.

Table 2. Levene's test for homogeneity of variance

Variable	Levene Statistics	df1	df2	*p* value
Total Score	0.773	2	34	0.470

Levene's test yielded a statistic of 0.773, with degrees of freedom \(df_1 = 2\) and \(df_2 = 34\), and a p-value of 0.470. Since the p-value is greater than the significance threshold of 0.05, the test indicates that there is no statistically significant difference in the variances among the three groups. Therefore, the assumption of homogeneity of variance was satisfied, supporting the use of one-way ANOVA.

Table 3 presents the results of one-way analysis of variance (ANOVA), which examined differences among elite athletes, non-elite athletes, and table tennis experts in their assessments of the GUS racket across three product aspects and the total score.

Table 3. One-way ANOVA results for racket design, functional purpose, safety, and total usability scores

Aspect	F-value	*p* value
Design	13.275	< 0.001
Purpose	8.642	0.001
Safety	2.182	0.128
Total Score	11.582	0.000

ANOVA results showed significant differences between groups in the assessment of design aspects ($F = 13.275$; $p < 0.001$), functional purpose ($F = 8.642$; $p = 0.001$), and total score ($F = 11.582$; $p < 0.001$). No significant differences were found in the safety aspect ($F = 2.182$; $p = 0.128$). These findings indicate that the user's background influences their perception of racket quality.

Below, a Tukey HSD follow-up test showed that elite athletes consistently scored lower than non-elite and expert athletes, particularly in design and function. There were no significant differences between the non-elite and expert groups ($p>0.05$). This pattern was consistent across both individual aspect scores and the total score, indicating that experienced users have higher performance expectations than other groups.

Table 4. Tukey HSD Post Hoc results

Aspect	Group Comparison	Mean Difference	*p* value
Design	Non-Elite vs Elite	0.513	0.001
	Elite vs Expert	0.860	0.000
	Non-Elite vs Expert	0.348	0.178
Purpose	Non-Elite vs Elite	0.656	0.002
	Elite vs Expert	0.744	0.015
	Non-Elite vs Expert	0.088	0.936
Safety	Non-Elite vs Elite	0.500	0.155
	Elite vs Expert	0.563	0.316
	Non-Elite vs Expert	0.063	0.985
Total	Non-Elite vs Elite	0.569	0.001
	Elite vs Expert	0.784	0.001
	Non-Elite vs Expert	0.215	0.548

These results reflect differences in user needs based on experience level and indicate the need for design refinements to meet professional athlete standards. Figure 1 shows the final GUS table tennis racket made from Makassar ebony veneer.

Figure 1. Final Product

4. DISCUSSION

This study demonstrated significant differences in perceptions of GUS table tennis rackets among elite, non-elite, and expert athletes. The results showed that non-elite and expert athletes gave high ratings to design and functionality, while elite athletes gave lower scores to the same aspects. This difference reflects professional athletes' higher performance expectations for technical features such as blade responsiveness, weight distribution, and vibration feedback. This trend is consistent with the findings of a recent study that suggests experienced athletes have a higher sensitivity to micro-details in sports equipment (Ardian et al., 2025).

From an ergonomic perspective, positive ratings from both non-elite athletes and experts indicate that the GUS racket meets basic standards for grip comfort, design balance, and ease of use. The consistency of scores between these two groups reflects a strong foundation for general use and intermediate training levels. Experts particularly highlighted the compatibility of the racket's blade architecture and handle profile. This aligns with recent literature encouraging inclusive sports equipment design to meet the needs of beginners to semi-professional users (Chauhan & Pal, 2022).

However, the low scores from elite athletes indicate the need for improvements in high-performance adaptation. Professional athletes require rackets that transfer energy precisely, minimize

vibration, and provide rapid response when used in high-speed play. Studies in sports engineering emphasize the importance of optimizing blade stiffness, handle damping, and material composition to meet these standards (Yildizbaş et al., 2022; Zhou et al., 2021). GUS rackets, while considered structurally robust, may not meet these expectations. Further development could consider the addition of hybrid veneer layers or variable stiffness zones.

The selection of Makassar ebony as the primary veneer material demonstrates significant potential for locally-based sports innovation. Its natural characteristics, such as high stiffness, density, and grain consistency, make it comparable to high-end woods used in international racket production. Recent materials engineering literature supports the use of high-density tropical woods to improve energy restitution and structural integrity in sports equipment (Sugiharto et al., 2025). Furthermore, the use of local materials aligns with the principles of sustainability and self-sufficiency of the national sports industry (Chauhan & Pal, 2022).

In terms of safety, the lack of significant differences between user groups was a key finding. All participants rated the racket as structurally sound and comfortable during intensive training sessions. This suggests that, despite criticism from elite athletes regarding performance, the racket generally meets basic ergonomic and strength standards. However, some qualitative observations from elite athletes noted the need for increased durability for prolonged play, a finding echoed in the literature on material fatigue in composite sports equipment (Ripberger et al., 2025).

From a methodological perspective, this study contributes by adopting a user-centered comparative evaluation approach, differing from most purely laboratory studies. By involving users with varying levels of experience, this study offers a more comprehensive picture of product performance and acceptance. This participatory approach is increasingly recommended in the development of athlete-centered sports equipment (Seçkin et al., 2023). This model can also serve as a reference for testing sports products based on local materials. Modifications to sports equipment based on technical training also have a significant impact on performance (Yogi et al., 2023). Even sensorimotor coordination has a significant influence on the equipment's response to athlete performance (Pratama et al., 2025).

Despite its important contribution, this study has several limitations. The use of a questionnaire as the primary tool introduces subjectivity into the assessment, which may affect consistency between groups. Furthermore, the testing was conducted in a semi-controlled environment, not reflecting real-life game dynamics, which may lead to different perceptions. Further

research is recommended using biomechanical tracking (such as racket speed and shot angle), kinetic output measurements, and long-term durability testing. Furthermore, exploring other user demographics, such as junior athletes or people with disabilities, could broaden the reach and design of more inclusive products.

5. CONCLUSIONS

Usability testing of the Garuda Unesa Speed (GUS) table tennis racket using Makassar ebony veneer showed that the product was well-received by both non-elite athletes and table tennis experts, particularly in terms of design and functional purposes. Meanwhile, elite athletes gave lower ratings, reflecting higher performance expectations based on experience with international-standard equipment. These findings underscore the importance of user segmentation in sports equipment development. The absence of significant differences in safety aspects indicates that the racket has reached a threshold of ergonomics and structural strength suitable for general use. Practically, the GUS racket offers an alternative for use in sports training and development, while encouraging the use of local Indonesian hardwoods in sports equipment production. Theoretically, this study contributes to sports equipment development by integrating user-based evaluation approaches and product innovation based on local materials. The study demonstrates that natural hardwoods such as Makassar ebony can be scientifically validated to meet athletic performance needs, thereby expanding the application of materials science in the context of high-standard sports equipment. This cross-disciplinary contribution enriches the empirical basis for further research on sports technology using local materials. Future research is recommended to include objective performance testing, biomechanical analysis of the stroke, and long-term durability testing to complement the perception data. Expanding usability validation to other user segments, such as youth athletes or athletes with disabilities, could also encourage more inclusive and sustainable sports equipment design.

6. REFERENCES

1. Amin, M. H. M., Arifin, A. M. T., Hassan, M. F., Haq, R. H. A., Rahman, M. N. A., Ismail, A. E., Rahim, M. Z., Ibrahim, M. R., Yunos, M. Z., & Ismail, R. M. H. M. (2017). An evaluation of mechanical properties on kenaf natural fiber/polyester composite structures as table tennis blade. *Journal of Physics: Conference Series, 914*(1), 1-9. https://doi.org/10.1088/1742-6596/914/1/012015
2. Ardian, R., Szczepocki, M., & Ciptadi, Z. D. P. (2025). The impact of playing method for shooting ability: A study on female basketball athletes. *Khatulistiwa Journal of Sport Science, 1*(1), 34–41.
3. Chauhan, Y. S., & Pal, U. S. (2022). Innovative evolution of technology used among racket sports: An overview. *Journal of Sports Science and Nutrition, 3*(2), 175–179. https://doi.org/10.33545/27077012.2022.v3.i2c.117

4. Chelliah, B., Ravi, A., & Muthurasu, N. (2021). Teak plantations and wood production. Springer.
5. Fan, Q., Duan, H., & Xing, X. (2024). A review of composite materials for enhancing support, flexibility and strength in exercise. *Alexandria Engineering Journal, 94*, 90–103. https://doi.org/10.1016/j.aej.2024.03.048
6. Pott, A., Mütherich, H., Kraus, W., & Verl, A. (2013). IPAnema: A family of cable-driven parallel robots for industrial applications. In T. Bruckmann & A. Pott (Eds.), Cable-driven parallel robots (Mechanisms and Machine Science, pp. 119–134). Springer. https://doi.org/10.1007/978-3-642-31988-4_8
7. Pratama, O. P. A., Wijaya, M. B., Saputri, D., Rahman, A., Wicaksono, G. B., Kristiono, A. A., Tiyas, I. H., & Dewi, I. S. (2025). The relationship between eye-hand coordination and basketball players' shooting results: A meta-analysis study. *Sports Journal Review, 1*(1), 39–50. https://journals.khatec.id/index.php/sjr/article/view/25
8. Ripberger, A., Onder, Y., Plunkett, O., et al. (2025). Definition of feel-related impact parameters of tennis rackets and correlations with racket properties. *Sports Engineering, 28*, 1–12. https://doi.org/10.1007/s12283-025-00502-x
9. Safari, I., Suherman, A., & Ali, M. (2017). The effect of exercise method and hand-eye coordination towards the accuracy of forehand topspin in table tennis. *IOP Conference Series: Materials Science and Engineering, 180,* 1-10. https://doi.org/10.1088/1757-899X/180/1/012207
10. Seçkin, A. Ç., Ateş, B., & Seçkin, M. (2023). Review on wearable technology in sports: Concepts, challenges and opportunities. *Applied Sciences, 13*(18), 1-39. https://doi.org/10.3390/app131810399
11. Sugiharto, W., Nurhasan, N., Kartiko, D. C…, & Arbaan, J. M. (2025). Biomechanical analysis of table tennis racket performance using Makassar ebony veneer: A comparative study. *Journal of Coaching and Sports Science, 4*(1), 128–141. https://doi.org/10.58524/jcss.v4i1.724
12. Utama, B., Widodo, H., & Ariani, N. (2023). Validity and reliability of table tennis performance measuring eye-hand coordination. *International Journal of Human Movement and Sports Sciences, 11*(1), 176–183. https://doi.org/10.13189/saj.2023.110121
13. Yıldızbaş, A., Özlüsoylu, İ., & İstek, A. (2022). Table tennis blade production and features. *Bartın Faculty of Forestry Journal, 24*(2), 394–404. https://doi.org/10.24011/barofd.1085278
14. Yogi, Y., Perdana, R. P., Suptiatna, E., & HaÃ¯dara, Y. (2023). Modification of hand muscle strength training equipment: study of the development of a ball stick for handball shooting. *Tanjungpura Journal of Coaching Research, 1*(2), 31–37. https://doi.org/10.26418/tajor.v1i2.64819
15. Zhou, X., Wang, L., Huang, D…, Wu, J. (2021). Smart table tennis racket with tunable stiffness for diverse play styles and unconventional technique training. *Advanced Materials Technologies, 6*(10), 1-9. https://doi.org/10.1002/admt.202100535

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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