

WHERE HERITAGE MEETS ENGINEERING: INNOVATING BASQUE PELOTA EQUIPMENT (SOKA)

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INTRODUCTION

Basque pelota is a traditional sport deeply rooted in the cultural heritage of the Euroregional territory. Its different disciplines rely on highly specialized equipment (such as cestas and paddles) manufactured through artisanal processes based on empirical knowledge transmitted over generations. While this craftsmanship represents a unique cultural asset, the limited integration of engineering tools has constrained systematic performance analysis, optimization, and technological evolution. This project proposes the application of digitalization, simulation, and advanced manufacturing technologies to better understand, preserve, and enhance traditional Basque pelota equipment, bridging heritage and engineering innovation.

OBJECTIVES

The main goal of SOKA project (Science-based Optimization of traditional Kirol (sports) Apparatus) is to develop a Euroregional collaborative framework that integrates engineering and advanced technologies into the analysis, design and manufacturing of Basque pelota equipment, improving performance, safety, sustainability and long-term development of the sport.



MATERIALS & METHODS

Digitalization: Traditional equipment was digitized using high-resolution 3D scanning. The resulting point clouds were processed to generate accurate CAD models. **Geometrical and Structural Analysis:** Reverse engineering techniques were applied to analyze curvature, thickness distribution, and structural features. **Mechanical Simulation:** Finite Element Analysis (FEA) was conducted to evaluate stress distribution, deformation, and dynamic response under impact loading conditions representative of real gameplay. **Prototype Development:** Optimized geometries were manufactured using additive manufacturing technologies, exploring alternative materials and internal structures. **Experimental Validation:** Prototypes were mechanically tested and compared with traditional equipment in terms of stiffness, energy transfer, vibration behavior, and ergonomics.

RESULTS

The digitalization process enabled the accurate reconstruction of traditional Basque pelota equipment, particularly cestas, generating high-resolution CAD models that faithfully represent their complex geometries. The comparison between scanned models and physical samples confirmed a high level of geometric precision, allowing reliable reverse engineering and further computational analysis. Mechanical simulations revealed the distribution of stresses and deformations during ball impact, identifying critical areas subjected to higher mechanical loads. The results highlighted how subtle variations in curvature, thickness, and structural configuration significantly influence stiffness, energy transfer, and vibration behavior. Prototypes developed through additive manufacturing successfully reproduced the essential functional geometry of traditional equipment while allowing controlled modifications in internal structure and material distribution. Preliminary mechanical testing demonstrated that such prototypes can achieve comparable stiffness and impact response, with the additional advantage of improved repeatability and potential for customization according to player-specific requirements. Overall, the results confirm that engineering-based methodologies can complement traditional knowledge, enabling objective analysis, performance optimization, and design reproducibility without compromising the identity of the sport.



CONCLUSIONS

The integration of engineering tools into Basque pelota equipment development is technically feasible and offers significant potential for innovation. Digitalization and simulation provide a scientific understanding of traditionally empirical designs, enabling performance optimization while preserving cultural identity. Additive manufacturing represents a promising complementary tool for prototyping, customization, and sustainable production. This interdisciplinary approach strengthens the link between heritage and technology, contributing to the modernization, preservation, and international projection of Basque pelota within the Euroregional context.