

Applied biomechanics within the Kinesiology discipline in higher education

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Abstract

Background and Study Aim Biomechanics is a fundamental component of Kinesiology, offering critical insights into the mechanics of human movement. As the demand for comprehensive educational programs in Kinesiology grows, understanding the role and effectiveness of biomechanics within these programs becomes increasingly important. The aim of the study is to investigate and highlight the role and importance of biomechanics in the context of higher education, with an emphasis on the discipline of Kinesiology.

Material and Methods This study involved 71 students from the Department of Physical Education and Sport at Pitesti University Center. It included 43 students specializing in Physical Education and Sport (PES) and 28 in Sports and Motor Performance (SMP). The research utilized the university's e-learning platform to monitor teaching and evaluation activities within the Kinesiology discipline. The evaluation of fundamental Kinesiology knowledge was assessed through various indicators. Google Forms-Questionnaire sought to gauge student opinions on the thematic content of Biomechanics as applied to Kinesiology and to evaluate the teaching staff. The nonparametric Kruskal-Wallis Test was employed to analyze differences in means across the groups.

Results The study revealed a diverse interest in sports across the Physical Education and Sport (PES) and Sports and Motor Performance (SMP) programs. Soccer, basketball, and handball were the most popular among students. Comparative analysis of academic performance showed no significant differences between the groups in various assessments ($p > 0.05$). The overall student feedback on the “Fundamentals of Biomechanics of Physical Activities and Sports” course was predominantly positive. Over 50% of the students rated it as very good. Areas for improvement in teaching methods were also identified to enhance the academic experience.

Conclusions This study highlights the effective integration of biomechanics within the Kinesiology discipline at the higher education level. Findings suggest that well-structured educational programs can enhance students' understanding and application of biomechanics. This contributes positively to their academic and professional development in sports sciences. Continuous curriculum assessment and refinement are crucial for maintaining the relevance and effectiveness of such programs.

Keywords: comparative analysis, teaching activity, thematic content, evaluation, opinions, performance standards.

Introduction

The integration of biomechanics within

kinesiology programs in higher education is increasingly significant, playing a crucial role in enhancing the understanding and application of physical activity principles. This interdisciplinary approach not only enriches the academic landscape by fostering a deeper comprehension of movement mechanics but also equips students

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with analytical skills crucial for addressing complex challenges in sports and health sciences. In the context of higher education, kinesiology acts as an essential bridge between theoretical knowledge and practical application in physical activities, sports, and health, making it a pivotal area of study [1]. Kinesiology, as an expansive academic discipline, supports various professions and tackles significant public health concerns through its comprehensive content [2, 3, 4]. The concept of “pedagogy” in kinesiology, particularly sports pedagogy, has recently gained recognition in the English-speaking academic community, aligning with its longstanding acknowledgment in Europe [5]. Research in physical education and sports pedagogy, central to kinesiology, demands rigorous academic inquiry to maintain its relevance and efficacy [6]. The commitment to integrating research, physical activity, and professional practice within kinesiology programs underscores the importance of inclusion and public service in higher education [7]. Biomechanics, as a fundamental aspect of kinesiology, plays a pivotal role in grounding theoretical knowledge into practical applications [8].

The integration of biomechanics within kinesiology programs in higher education is increasingly significant, playing a crucial role in enhancing the understanding and application of physical activity principles. The profound impact of biomechanics in kinesiology underscores its indispensability in bridging theoretical knowledge with practical applications in physical activities, sports, and health.

Biomechanics courses are commonly offered at the undergraduate level, particularly within engineering (e.g., mechanical and biomedical) and health sciences fields. As an introductory course, it applies mechanical principles to human movement analysis, providing a foundational understanding of the interactions between human movement and the physical environment. This knowledge is crucial for optimizing efficiency in daily activities, the work environment, sports, and physical exercises [9]. Students learn to apply and integrate anatomical and biomechanical concepts across a diverse range of activities and populations, including various ages, abilities, and conditions ranging from acute injuries to chronic disabilities and differing fitness levels [10]. Essential for the professional development of specialists in physical education, a robust foundation in biomechanics enhances their practical applications. However, deficiencies in this foundational knowledge can lead to challenges in its practical application, indicating a potential need for enhancements in the pedagogical approaches used to teach biomechanical concepts in undergraduate courses [11, 12, 13]. Given its broad applications and impact on professional practice, the study of biomechanics is fundamental in preparing

students for real-world challenges in physical activities and health-related fields.

Biomechanics, an interdisciplinary field, is fundamentally concerned with the dynamics of movement and the forces applied to the human body [14, 15, 16]. Over the past decade, the domain has expanded to include the observation, measurement, analysis, evaluation, and interpretation of human movement [17]. A critical examination of the pedagogical history in biomechanics is crucial, highlighting the need to balance functional anatomy with mechanics and emphasizing the importance of both qualitative and quantitative analyses. Interdisciplinary cooperation is essential to develop biomechanical principles that integrate smoothly with other subdomains of kinesiology and physical education [18, 19]. Additionally, addressing methodological and statistical issues highlighted in early articles and commentaries is vital to bolster confidence and advance knowledge within the field [20]. This enhanced understanding underscores the need for ongoing collaboration and refinement within biomechanics education to effectively translate complex theoretical concepts into practical applications.

The National Association for Sport and Physical Education has established learning objectives for biomechanics at the undergraduate level. However, teaching methods that overly emphasize applied physics could potentially discourage student interest in biomechanics. Thus, it is critical to balance the focus on mechanics to engage students effectively [21]. Evidence suggests that active learning approaches significantly enhance student engagement and mastery of biomechanical concepts within the introductory courses [22]. Moreover, advancements in sports biomechanics training not only benefit the field but also enhance the practical application of this knowledge in professional settings. Graduates from diverse sports backgrounds who enroll in the Postgraduate Certificate in Education (PGCE) in Physical Education often face challenges in covering all areas of the National Curriculum for Physical Education. Specifically, there is a need for these student-teachers to improve their understanding and application of biomechanical principles within the PGCE program [23]. Addressing these educational gaps is crucial for equipping future physical education teachers with the necessary biomechanical expertise to enhance their teaching effectiveness and ensure comprehensive educational outcomes.

Technological advances in motion research over the past 40 years have significantly transformed biomechanics into an integral subdiscipline within kinesiology. These advancements have not only diversified research focus but also expanded the knowledge base by intersecting with other domains [24, 25]. This evolution highlights the

revolutionary potential of integrating natural laws with biomechanical and motor control principles, fostering strong deductions and interdisciplinary collaborations that reshape our understanding of human movement [26].

Such advancements underscore the fundamental importance of biomechanics in assessing and improving athletic performance, preventing injuries, and enhancing quality of life through physical activity. Despite the reliance on advanced technologies to study movement, there remains a tendency to overly focus on static and kinetic aspects, often neglecting the crucial dynamic component of movement. This dynamic aspect adds a holistic perspective by considering integrated stresses and individual decision-making processes that influence each person's movement, thus emphasizing the need for a balanced approach in biomechanical research [27].

To address these educational challenges, the "Fundamentals of Biomechanics" course is designed to provide deep, conceptual understanding of both biological and mechanical domains involved in movement. Engaging students in active learning and laboratory activities helps them connect personal experience with biomechanical concepts, thereby enhancing movement efficiency and reducing injury risks. It is crucial that biomechanics education fosters not only theoretical knowledge but also practical application, ensuring that future specialists can effectively translate academic insights into real-world benefits [28, 29].

Biomechanics and kinesiology are pivotal in understanding and enhancing human movement. These disciplines equip professionals with critical insights into movement patterns and their origins in living organisms, enabling effective application in various health-related fields [30]. Physical therapy students, for instance, rely heavily on principles of biomechanics and kinesiology to evaluate joint function, diagnose issues, and monitor rehabilitation progress [31].

Despite their growing importance in both academia and industry, there is evidence that many graduates from biomechanics and exercise science programs lack adequate preparation for professional challenges. This gap highlights the need for enhanced educational practices in the classroom to improve learning outcomes and ensure that students are well-equipped to apply their knowledge practically [32]. Addressing this issue requires effective strategies for teaching and applying biomechanical concepts that could significantly benefit students and professionals in the field [33].

This focus aligns closely with the curriculum of the "Kinesiology" course [34], which has been continuously developed to incorporate both theoretical and practical perspectives [35]. The course emphasizes the application of

biomechanics as a scientific research approach at the undergraduate level, making it a fundamental component of sports science education. Students explore biomechanical aspects of specific movements tailored to various sports disciplines such as basketball [36, 37], dance sport [38, 39], handball [40, 41], judo [42, 43], football [44], gymnastics [45], kayak [46, 47], and swimming [48, 49]. This comprehensive study equips them with the necessary knowledge to pursue careers as coaches, kinesiologists, or researchers in the fields of sports and human performance.

The relevance of biomechanics within the kinesiology curriculum highlights the crucial need to understand and correctly apply biomechanical principles. This understanding is essential not only for academic purposes but also for the practical application in the professional training of future health and physical performance specialists. This integration ensures that graduates are well-prepared to contribute effectively to the field.

Despite the extensive integration of biomechanics into kinesiology education, gaps remain in understanding how effectively these principles are applied in real-world scenarios, particularly in educational settings. Current literature often lacks comprehensive evaluations that connect theoretical biomechanics training to tangible outcomes in student proficiency and professional readiness. This indicates a critical need for further empirical investigation to bridge these gaps, ensuring that biomechanical training effectively meets the evolving demands of health and sports science professions.

Purpose of the Study. The purpose of the study was to investigate and highlight the role and importance of biomechanics in the context of higher education, with an emphasis on the discipline of kinesiology.

Materials and Methods

Participants

The study involved students from the Department of Physical Education and Sports at the Faculty of Science, Physical Education, and Informatics within the University Center of Pitești, National University of Science and Technology Politehnica Bucharest. A total of 71 subjects (79.8% of enrolled students) participated, with 43 specializing in Physical Education and Sports (PES) and 28 in Sports and Motor Performance (SMP). All participants provided informed consent to voluntarily participate in the study, in accordance with the Helsinki Declaration. The research was approved by the Ethics Committee of the Doctoral School of Sports Science and Physical Education at the University Center of Pitești (ID: 13/16.02.2024).

Research Design

The study was designed to assess the integration of Applied Biomechanics within the Kinesiology discipline. It specifically focused on its application in Sports Science and Physical Education programs. Conducted from October 2022 to September 2023, the research involved undergraduate students. They specialized in Physical Education and Sports (PES) and Sports and Motor Performance (SMP) at the University Center of Pitești.

The academic structure of the course during the 2022-2023 year included 14 weeks of instruction, with each week comprising 2 hours of lecture and 2 hours of seminar. The course evaluations were conducted in two phases: the initial examinations in February 2023 and re-examinations in September 2023. Course monitoring and content delivery were supported by the university's e-learning platform.

Each semester was structured to provide 125 hours of total engagement: 56 hours as per the curriculum (split equally between lectures and seminars) and 69 hours dedicated to individual study. The course was credited with 5 academic credits.

Specifically, the topic "Fundamentals of Biomechanics in Physical Activities and Sports" was allocated 2 hours of lecture and 2 hours of seminar per week. The discipline codes for the courses were UP.01.F.3.O.11.01 for PES and UP.00.F.3.O.12.01 for SMP, ensuring structured and detailed academic delivery focused on the core aspects of biomechanics within physical education.

To enhance the theoretical understanding of the "Applied Biomechanics" course, the curriculum incorporated examples from a variety of specialized journals. These included Applied Sciences by MDPI, Springer Nature publications, the Brazilian Journal of Physical Therapy, the International Journal of Environmental Research and Public Health by MDPI, the International Journal of Sports Physiology and Performance published by Human Kinetics, the Journal of Athletic Training, the British Medical Bulletin from Oxford, and Sensors by MDPI.

During seminar sessions, practical application of biomechanical principles was emphasized through the analysis of exercises from diverse sports disciplines such as women's and men's artistic gymnastics, football, weightlifting, and swimming starts. This analysis was facilitated by the use of specialized software like Kinovea and Physics ToolKit. Techniques were further examined through the application of the postural orientation method, providing a comprehensive approach to movement analysis within the discipline [45].

Seminar activities included the preparation of two thematic papers to deepen students' engagement and application of biomechanics in

sports disciplines:

Paper 1 (Requirements):

1. Cover Page: Last name, first name, specialization, chosen sport discipline, and topic.
2. Content:
 - Introduction: Argumentation about the chosen topic, including its importance, topicality, and motivation, supported by 2-3 recent sources (from 2022) from Google Scholar.
 - Biomechanics of the Chosen Sport Branch: Overview using 3-4 recent sources from Google Scholar (from 2022).
 - Biomechanics of the Chosen Sport Event: Detailed analysis.
 - Biomechanical Analysis of a Technical Skill/Element: In-depth examination.
3. Conclusions: Summary of insights and findings.
4. Bibliography: Formatted in APA style, sourced primarily from Google Scholar.

Paper 2 (Requirements):

1. Motivation for Sport Selection or Practice: Explanation of choice and its significance.
2. Specific Motor Fitness: Description and exemplification of general and specific physical training, including events/exercises for testing/verification.
3. Technical Training: Systematization and exemplification of training processes.
4. Therapeutic/Medical Kinesiology: Focus on prophylaxis, traumatology with a bibliography of at least 5 sources.
5. Bibliography: Comprehensive listing of all sources used.

This formatting enhances readability and ensures that the academic requirements are clearly articulated for students, aligning with the educational goals of the kinesiology program.

Evaluation Methods and Assessment Criteria:

To assess students' fundamental knowledge in the discipline, the course adhered to the specified requirements and evaluation rules within the credit system and class grading protocol:

- *S1 (60% of Final Grade):* This is the aggregate of fractions from periodically evaluated activities. It includes:
 - A1 (20%): Paper 1;
 - A2 (20%): Paper 2;
 - A3 (20%): Minimum 60% attendance in practical activities (Seminars). Each paper is graded on a scale of 1 to 10 points, with the final contribution calculated by multiplying the obtained score by the respective percentage.
- *Final Evaluation (FE) (40%):* Consists of a written examination assessing correctness, complexity of knowledge, logical coherence,

and assimilation of specialized language.

- *Final Grade (FG)*: Computed by summing fractions from periodic evaluations (S1) and the final examination (FE). The final score is rounded off in favor of the student, ensuring that the minimum grade for the final evaluation is 5 points.

Additionally, to gather feedback on the course content “Fundamentals of Biomechanics of Physical Activities and Sports,” a Google Forms questionnaire was administered. The survey, comprising six indicators, was also used to evaluate the teaching staff’s effectiveness, providing insights into the teaching and evaluation processes [35].

Statistical Analysis

Statistical indicators such as mean and standard deviation were computed using KyPlot version 6.0 software (©1997-2020, KyensLab Inc). To assess mean differences between multiple irregular samples, the nonparametric Kruskal-Wallis Test was employed. A p-value of less than 0.05 was considered statistically significant.

Results

The study assessed the fundamental knowledge in the discipline of Kinesiology among 71 students, divided into two programs: Physical Education and Sports (PES), consisting of 43 students (37.2% female, 62.8% male), and Sports and Motor Performance (SMP), with 28 students (35.7% female, 64.3% male). Analysis of seminar participation and periodic evaluations indicated active engagement with the teaching activities, specifically through contributions to Paper 1 (A1), Paper 2 (A2), and seminar attendance (A3).

In terms of sports involvement, 37.3% of the students participated in recreational sports, while 62.7% were involved in competitive sports. Experience levels varied significantly: 29.1% of the participants had more than ten years of experience, 18.2% between eight to ten years,

20% for seven to eight years, and 10.9% for six years or fewer.

A survey was conducted among 30 students from two programs, Physical Education and Sports (PES) and Sports and Motor Performance (SMP), to gather opinions on the “Fundamentals of Biomechanics in Physical Activities and Sports” course. The distribution of sports interests varied between programs. In PES, the focus was more varied with 30% of students interested in football, 17% in handball, 13% in athletics and basketball, 7% each in tennis, swimming, and karate, and 3% in combat sports like judo and MMA. In contrast, SMP students showed a preference for basketball (29%), football (25%), handball (18%), and minor interests in kayaking, judo, athletics, tennis, and swimming (Figures 1A and 1B).

The evaluation of students’ knowledge in Kinesiology adhered to the subject matter program’s requirements and evaluation rules within the credit system. The results, which are presented in Table 1, highlight comparative performance across the study programs, indicating the level of knowledge assimilation and compliance with the academic standards.

Comparative Analysis of Student Performance

The statistical analysis of the course evaluations revealed subtle differences in academic performance between the Physical Education and Sports (PES) and Sports and Motor Performance (SMP) programs. For Paper 1 (A1), SMP students achieved a slightly higher average score by 3.5%, with 77% meeting the requirements, although this was not statistically significant ($p > 0.05$). Similarly, for Paper 2 (A2), SMP again scored higher by 1.5%, with 67% meeting the requirements ($p > 0.05$).

Attendance (A3) showed a higher average participation rate at PES by 8%, which may be attributed to the less intensive sports activities engaged by these students compared to those at SMP ($p > 0.05$). Overall, PES students slightly

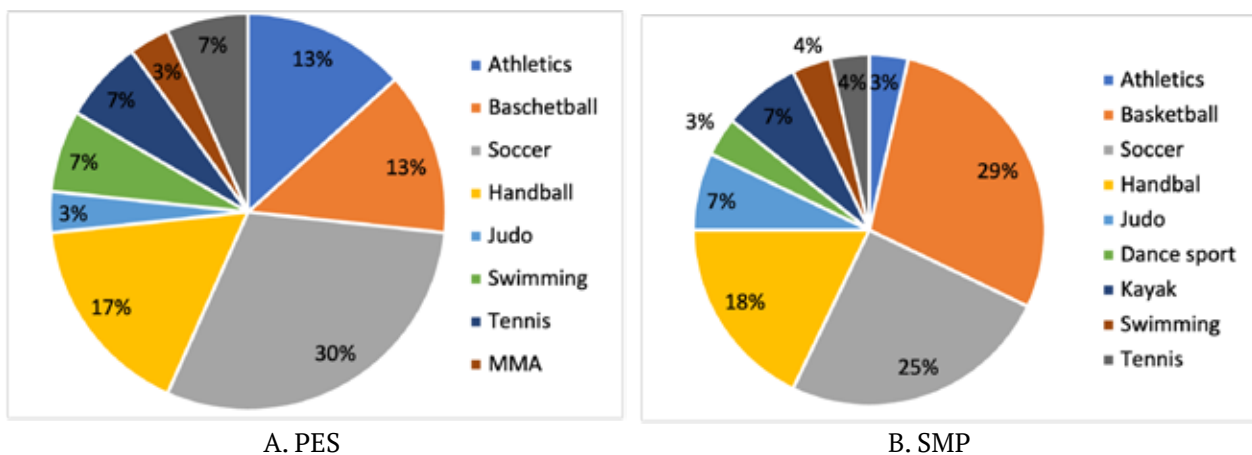


Figure 1. Weight of sports events used within the course theme: PES - Physical Education and Sports; SMP - Sports and Motor Performance.

Table 1. Results of the evaluation of fundamental knowledge in the discipline of Kinesiology, n = 71

Variables		PES (n = 43)	SMP (n = 28)	Chi - Square	p-Value
A1 (20%)	pts	1.47 ±0.25	1.54 ±0.05	1.03	0.309
A2 (20%)	pts	1.31 ±0.40	1.34 ±0.47	0.18	0.668
A3 (20%)	pts	1.14 ±0.41	0.98 ±0.37	1.57	0.209
S1	pts	3.91 ±0.83	3.86 ±0.90	0.03	0.868
FE (E, 40%)	pts	2.95 ±0.42	3.00 ±0.54	0.21	0.649
S2	pts	6.89 ±1.14	6.87 ±1.26	0.08	0.781
Final grade	grade	7.25 ±0.96	7.04 ±1.35	0.03	0.855

Values are expressed as means ± standard deviations. Nonparametric Kruskal-Wallis Test

outperformed SMP in periodically evaluated activities (S1), with 65.2% achieving the required standards compared to 64.3% at SMP ($p > 0.05$).

The final examination scores averaged 7.5 points, with SMP scoring marginally higher by 0.13 points ($p > 0.05$). When considering both periodic evaluations and final examination scores (S2), the differences were minimal, showing only a 0.02 point difference ($p > 0.05$). The final grades reflected a higher mean score at PES by 0.21 points ($p > 0.05$), indicating better overall performance, possibly due to greater seminar participation and fewer absences at PES compared to SMP.

Assessment of Minimum and Maximum Performance Standards

An analysis of performance standards revealed minor differences between the Physical Education and Sports (PES) and Sports and Motor Performance (SMP) programs. For achieving minimum performance standards, 11.6% of PES students and 14.3% of SMP students met the criteria. In terms of maximum performance standards, 34.9% of PES students and 32.1% of SMP students reached the highest benchmarks. While there are variations, the overall performance and adherence to requirements show substantial equivalence between the two programs.

Student Opinions on Course Content

To gauge student perceptions of the “Fundamentals of Biomechanics in Physical Activities and Sports” course, a questionnaire was conducted. The summarized opinions on the course content are detailed in Table 2. This feedback is crucial for understanding student satisfaction and areas for improvement in the curriculum delivery.

The student feedback on the course content was largely positive. A substantial 50.9% of the participants rated the course as very good. Specifically, 63.3% praised the application of general principles of mechanics and biomechanics highly, and 52% were very satisfied with the teachings on kinematic and dynamic characteristics.

47% of the respondents found the applied biomechanics content in the Kinesiology discipline

to be very good, highlighting the relevance and quality of the information provided. Additionally, 50% of the students noted that the integration of sports biomechanics and physical exercises was very beneficial for enhancing adaptive effects, and 46.7% believed it significantly reduced risks associated with physical activities.

The relevance of biomechanical knowledge across various disciplines was highly regarded by 49.9% of the students, who acknowledged its importance in optimizing sports performance and preventing injuries. Furthermore, 66.7% of the respondents found the use of quantitative and qualitative methods in movement analysis to be very efficient. The use of video techniques and image analysis was rated very good by 43.3% of the students, appreciating both the quantitative tools (software) and qualitative aspects (feedback to athletes).

Overall, the feedback indicates strong student appreciation for the course content and teaching methodologies, underscoring their significance in professional training within the Kinesiology discipline.

Evaluation of Course Effectiveness and Teaching Quality

In assessing performance standards within the course “Fundamentals of Biomechanics in Physical Activities and Sports,” 37.7% of students rated their achievement of minimum performance standards as “very well,” while nearly half of the participants (49.9%) rated their achievement of maximum performance standards similarly. These findings indicate that both the content and teaching methodologies of the course are highly regarded by students and deemed essential for their professional training in kinesiology.

Furthermore, to evaluate the effectiveness of teaching activities within the Kinesiology discipline, a questionnaire was distributed among students who interacted with the teaching staff during lectures and seminars throughout the semester. The overwhelmingly positive feedback is detailed in Figure 2, suggesting that the educational approaches employed are well-received and contribute significantly to student learning outcomes.

Table 2. Weight of the opinions of subjects regarding the content of the course “Fundamentals of Biomechanics of Physical Activities and Sports” in the Kinesiology discipline (n=30).

No.	Content	Grades (%)			
		3	4	5	
1	General foundations of mechanics and biomechanics	16.7	13.3	63.3	
2	Kinematic characteristics of motion	linear	16.7	23.3	50
		angular	16.7	16.7	60
3	Dynamic characteristics of motion	inertial	20	20	46.7
		force	23.3	13.3	53.3
		energetic	16.7	23.3	50
4	Basic knowledge of biomechanics applied in Kinesiology	16.7	33.3	63.3	
5	Scientific disciplines used in biomechanics	mathematics	33.3	16.7	66.7
		physics	16.7	26.7	43.3
6	Qualitative and quantitative analysis in scientific research	33.3	16.7	66.7	
7	The content of biomechanics	linear	23.3	20	50
		angular	20	30	43.3
8	Elements of sports biomechanics and exercise biomechanics	favoring factor ...	6.7	40	50
		elimination factor ...	13.3	33.3	46.7
9	Disciplines that utilize knowledge from biomechanics, aiming at	performance increase...	6.7	26.7	53.3
		prevention of accidents...	33.3	30	53.3
		reducing decline...	33.3	36.7	43.3
10	Which of the presented options do you consider more effective in analyzing movement?	qualitative	22.2		
		quantitative	11.1		
		qualitative and quantitative	66.7		
11	Video techniques and image analysis	quantitative (software)	20	36.7	43.3
		qualitative (feed-back)	20	36.7	43.3
12	The importance of the content of the discipline taught and its necessity in professional training	3.3	36.7	60	
13	Assessment of the level of meeting the minimum performance standard	definition of basic notions	16.7	33.3	50
		systematization and general classifications	3.3	66.7	30
		limited operationalization	26.7	40	33.3
14	Assessment of the level of meeting the maximum performance standard	integrative concepts ...	6.7	30	63.3
		presentation of information ...	20	36.7	43.3
		identifying and presenting models	10	36.7	53.3

Notes. 3 – moderate opinion, 4 – good and 5 – very good

These results reflect a robust foundation within the study program, although continuous improvements and adjustments are necessary to enhance educational delivery and student satisfaction.

Student Feedback on Kinesiology Teaching Practices

The study surveyed 36 students from the Physical Education and Sports (PES) and Sports and Motor Performance (SMP) programs. The participants demonstrated a high level of satisfaction with the teaching practices in the Kinesiology discipline. Specifically, 68.6% positively rated the quality of teaching activities, 66.7% were satisfied with the use and efficiency

of teaching methods, and 61.1% appreciated the teacher-student relationship and efforts in training students for their personal development. Furthermore, 66.7% praised the objectivity and transparency of evaluations, and 72.2% noted the effective training in extracurricular activities provided by the faculty.

These results indicate strong aspects of the educational approach within the Kinesiology program. However, they also suggest areas for improvement to enhance the academic experience comprehensively. Actively incorporating student feedback into educational strategies is crucial for continual enhancement of the teaching and learning process.

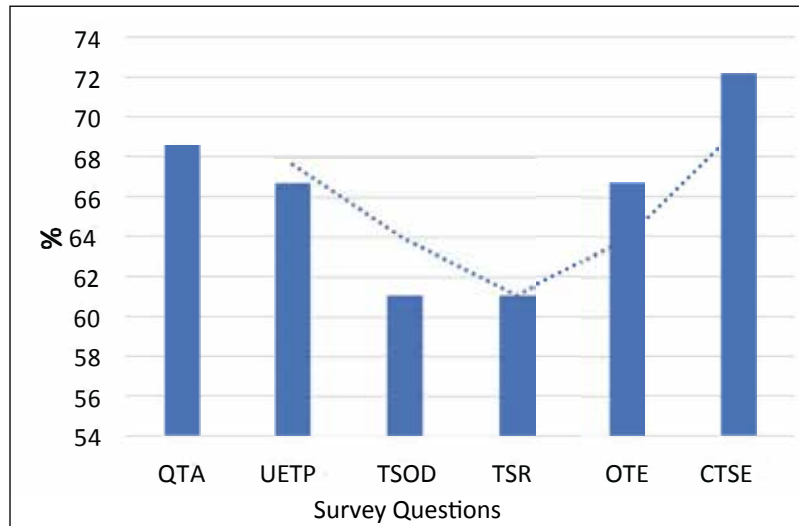


Figure 2. Students' assessment regarding the teaching activity conducted in the Kinesiology discipline: QTA - Quality of Teaching Activity; UETP - Use and Efficiency of Teaching Tools in the Learning Process; TSOD - Training the Student for Their Own Development; TSR - Teacher-Student Relationship; OTE - Objectivity and Transparency in Evaluation; CTSE - Capacity to Train the Student in Extracurricular Activities.

Discussion

The primary aim of this study was to assess the fundamental knowledge of Kinesiology among university students and to explore its impact on the quality of education within the disciplines of Physical Education and Sports (PES) and Sports and Motor Performance (SMP). Our findings reveal significant differences in thematic preferences between the two study programs, which could have profound implications for educational strategies.

The analysis of covered topics indicates a higher proportion of sports events in PES, with 30% of students participating in soccer, 17% in handball, 13% in athletics and basketball, 7% in tennis, swimming, and karate, and 3% in combat sports such as judo and MMA. Conversely, in the SMP program, 29% of subjects are interested in basketball, 25% in soccer, 18% in handball, 7% in kayaking and judo, and 4% in athletics, tennis, and swimming. These data reveal significant differences in thematic preferences between students from the two study programs, reflecting the diversity of interests and specific focus in the field of kinesiology (Fig. 1).

Additionally, concerns related to the content of the topics were addressed by studying the biomechanical aspects of movements specific to certain sports, practiced and preferred by the research subjects. Basketball, one of the most popular and widely viewed sports globally, provides a case in point. To enhance players' shooting accuracy, efficiency, and running speed before shots, it is crucial to analyze some biomechanical principles. Furthermore, modifications to footwear are suggested to reduce the risk of injury and improve sports performance in basketball [36, 37].

Proprioceptive training has shown significant benefits in improving agility skills in dance sports, particularly evident in tests like the "Eight" Figure with Flexion and Lateral Steps. These findings support the integration of this training type into regular dance practice to enhance performance and reduce injury risks [38, 39]. In sports biomechanics, similar emphasis on optimal performance and injury prevention is observed in different sports contexts.

A study on handball goalkeepers revealed that expert goalkeepers anticipate and initiate movement earlier than their less experienced counterparts during long-distance throws, demonstrating the importance of experience and training in reaction times and kinematics [40]. Another research found that training for vertical (VDJ) and horizontal jumps (HDJ) significantly enhances sprint and change of direction (COD) performance. Notably, VDJ was more effective in improving vertical jump abilities, whereas HDJ was beneficial for short-distance and COD performance improvements [41].

In judo, biomechanical assessments and skill-specific evaluations have been crucial. Detailed measurements and targeted tests help refine training control and enhance performance. Studies have also emphasized the critical role of biomechanical factors like flexibility and Kumikata in selecting and performing specific judo techniques [42, 43].

The advancement of technology has made biomechanical analysis a crucial component in competitive football training, highlighting the need for precise biomechanical studies to better understand the impact of mechanics on football performance [50]. Future research should continue to delineate the role of biomechanics in sports, aiming to clarify its contributions to

enhancing athletic performance and reducing injuries.

In the teaching of the Kinesiology course, a pivotal study was introduced that applied macro-learning methods to train female gymnasts [45]. This study utilized video-computerized methodologies and postural reference points to significantly enhance kinematic and dynamic parameters across gymnastics apparatus like vaults and uneven bars. The effectiveness of this approach was validated through scientific citations and increased academic interest, suggesting its applicability across various sports disciplines [45].

Further, an innovative observational model for analyzing kayaking sprint techniques was proposed, breaking down the motion into distinct phases for more nuanced analysis. This model was beneficial in identifying performance discrepancies related to the spinal column's sagittal position and hamstring extensibility among rowers of varying skill levels, underscoring the influence of individual and anthropometric factors on equipment setup [46, 47].

In swimming, a study focused on the biomechanics of dive starting revealed that regular practice significantly boosts performance, emphasizing the necessity for coaches to incorporate dive start drills in training regimes. This research also explored various biomechanical variables like stroke length, rate, and kinematics, and their interplay in optimizing swimming performance. Understanding these variables offers students and professionals insights into strategic performance enhancement [48, 49].

These examples highlight how biomechanics is integrated into sports science education, providing students with the tools to become knowledgeable coaches, kinesiotherapists, or researchers, equipped to apply biomechanical principles effectively in sports and human performance contexts.

The high participation rate of 79.8% from the enrolled students provides a robust basis for evaluating performance within the Kinesiology programs. The sample's gender balance and diverse involvement in grassroots and performance sports enhance the relevance and diversity of the analysis. By assessing fundamental competencies through seminar activities and indicators A1 (Paper 1), A2 (Paper 2), and A3 (attendance and seminar activity), we gain a comprehensive view of the students' understanding and skills in Kinesiology (Table 1).

The comparative analysis of statistical results shows no significant differences in performance and academic requirements fulfillment, although there are noteworthy trends. In SMP, students showed slightly higher averages in Paper 1 and Paper 2, yet these differences were not statistically significant. Similarly, PES students exhibited a

higher average in attendance by 8%, which also lacked statistical significance. This pattern may reflect the more intensive engagement of PES students in elite sports activities.

In terms of periodic evaluations (S1) and final evaluations (FE), both programs demonstrated comparable achievements. Notably, even though SMP students had marginally higher averages in final evaluations, these differences were not statistically significant. However, PES students achieved marginally higher final grades, likely due to their lower absence rates and more active participation in practical seminar activities.

The analysis of minimum and maximum performance standards shows only slight variations between the programs, with a marginally higher percentage of PES students achieving the maximum standard. These findings suggest that while both programs perform well, there are subtle differences in how students meet academic and practical requirements, underlining the need for tailored educational strategies to optimize learning outcomes and practical applications in the field of Kinesiology.

Innovative teaching methodologies in biomechanics have shown promising results in enhancing student learning outcomes. Bagesteiro [9] highlights an active-experimental learning approach for undergraduate kinesiology students, which significantly improved their critical thinking skills and proficiency with biomechanical analysis tools. This method facilitated better data interpretation and understanding of human movement mechanics, demonstrating the value of hands-on, experiential learning in this field.

Similarly, Hsieh and Knudson [12] identified key factors influencing the success in learning biomechanical concepts, including exam performance, interest in the subject, and prior knowledge in physics. These factors underscore the importance of engaging and well-structured coursework that aligns with students' academic backgrounds and interests.

Further, Ives and Knudson [51] advocate for a more integrated approach within physical exercise science programs, emphasizing the need to incorporate diverse academic disciplines of kinesiology, such as biomechanics and motor behavior. This integration is crucial for preparing students comprehensively, enhancing their professional capabilities in various sports and health-related domains.

Esposito et al. [52] delve into students' perceptions of their training in kinesiology, revealing a general appreciation for academic training despite some reported discrepancies in the knowledge and skills acquired. The study points out that while a significant portion of students attain qualifications from national sports federations, a smaller percentage obtain credentials from other institutions, indicating a

variance in certification standards and possibly in educational content and quality.

Knudson and Wallace [19] explore student perceptions and epistemological beliefs about active learning exercises in biomechanics. While most students view these methods positively, the link between these perceptions and actual mastery of biomechanical concepts remains unclear, suggesting an area for further research.

These studies collectively highlight the critical need for educational strategies that not only provide robust theoretical knowledge but also emphasize practical, applied learning. By enhancing curricular offerings and pedagogical approaches in biomechanics within kinesiology programs, educational institutions can better equip students to meet the challenges of professional practice in sports and health sciences.

The feedback from students on the “Fundamentals of Biomechanics in Physical Activities and Sports” course reflects a generally positive reception and substantial appreciation for the material presented. Notably, 50.9% of students rated the course content as “very good,” and 29.7% deemed it “good,” indicating strong approval of the curriculum’s relevance and value in the field of kinesiology (Table 2).

Students particularly praised the course’s effective teaching of general mechanics and biomechanics principles, with 63.3% labeling it “very good.” The kinematic and dynamic aspects of the course were also well-received, with 52% of responses rating these components highly. This positive feedback underscores the course’s success in conveying complex concepts in a manner that enhances students’ understanding and application in sports and physical activities.

Additionally, nearly half of the students (47%) expressed a “very good” opinion about the specific content related to applied biomechanics within the discipline, highlighting its essential role and coherent integration into the curriculum. The application of sports biomechanics and physical exercises was particularly appreciated for its role in augmenting adaptive effects and mitigating risks associated with physical activities, with 50% and 46.7% of students, respectively, finding these aspects highly beneficial.

The use of motion analysis methods, including video techniques and image analysis, was also favorably reviewed, with 43.3% of students recognizing the quantitative and qualitative value of these tools in enhancing athletic performance. This feedback suggests that such technologies are crucial for a deeper understanding and improvement of sports techniques and strategies.

These findings collectively demonstrate the course’s effectiveness in delivering biomechanics education that is not only academically rigorous but also practically relevant, thereby supporting

students’ professional development in the field of kinesiology.

The results from the questionnaire offer insightful evaluations of the teaching staff within the Kinesiology discipline, illustrating a generally positive student perception of educational quality and engagement (Figure 2) [35]. Notably, the high ratings for “Quality of Teaching Activity” (QTA) and “Use and Efficiency of Teaching Tools in the Learning Process” (UETP) affirm the teaching staff’s commitment to delivering content effectively using appropriate methodologies and educational tools. These efforts clearly resonate with the students, enhancing their learning experience.

Moreover, the appreciation shown for “Training the Student for Their Own Development” (TSOD) and “Capacity to Train the Student in Extracurricular Activities” (CTSE) underscores the proactive engagement of faculty in fostering not only academic but also personal and professional growth among students. This holistic approach to education is crucial for preparing students to meet real-world challenges.

Another positive aspect reflected in the feedback is the “Objectivity and Transparency in Evaluation” (OTE), where a significant majority perceive the evaluation processes as fair and transparent. This perception is vital for maintaining trust and integrity within the academic framework.

However, the relatively lower scores for “Teacher-Student Relationship” (TSR) suggest an area that could benefit from enhanced interaction and communication. Improving this dynamic could foster a more inclusive, supportive, and collaborative educational environment, which is essential for maximizing student engagement and satisfaction.

Overall, while the feedback is predominantly positive, highlighting the effectiveness and dedication of the teaching staff, there remains an opportunity to strengthen the teacher-student relationship, further enhancing the educational experience within the Kinesiology discipline.

The evaluation of diverse teaching models within biomechanics has underscored the pivotal role of physical education and sports pedagogy within the broader context of kinesiology [33]. These studies advocate for an expansive view of pedagogy that not only enriches the academic discipline but also enhances the practical application of biomechanical principles [6]. Such an approach is particularly crucial for students who aim to become physical education teachers, highlighting the need for improved pedagogical strategies to enhance their understanding and application of biomechanical concepts [23].

Tinning emphasizes the significance of sports pedagogy in kinesiology, advocating for a generative approach to pedagogy that

facilitates both the production and reproduction of knowledge across various subdomains of this field [5]. Additionally, the study by Woods et al. explores how well the interests and competencies of doctoral students in kinesiology align with the demands of academic roles in higher education. This study reveals the necessity for a comprehensive set of skills that prepare students for diverse academic responsibilities [53].

In summary, the integration of research findings and relevant literature emphasizes the crucial role of biomechanics in kinesiology within higher education settings. It highlights the need for a profound understanding of biomechanical principles and their effective implementation to improve educational outcomes and student performance in physical education and sports. This comprehensive approach is essential for developing well-rounded professionals capable of contributing to the advancement of kinesiology as an academic and practical discipline.

Conclusions

This research has highlighted the crucial role of fundamental knowledge in Kinesiology in shaping the quality of higher education within the fields of Physical Education and Sports (PES) and Sports and Motor Performance (SMP). The study has successfully utilized a detailed analytical approach based on the curriculum and evaluation criteria to assess and enhance the educational process effectively.

Our findings underscore the importance of adapting educational strategies to the diverse needs of students across different study programs. While the data suggest no significant disparities in performance across these programs, the variability observed points to the potential benefits of personalized educational interventions. These tailored strategies could better address individual academic needs and promote more equitable learning outcomes.

Feedback from students regarding the course content and instructional methods in Kinesiology has been predominantly positive, reflecting the curriculum's relevance and effectiveness in conveying complex biomechanical concepts and their applications in sports and health sciences. The appreciation noted for the teaching methodologies further emphasizes the impact of innovative pedagogical approaches on student engagement and comprehension.

Nonetheless, the insights gathered also indicate areas that could benefit from further refinement, particularly in enhancing interactive and communicative aspects of teaching to foster a more engaging and supportive learning environment. Strengthening the professor-student relationship and incorporating a broader array of teaching methods may better accommodate the varied learning styles and preferences within the student body.

Overall, the study advocates for ongoing efforts to refine educational practices in Kinesiology, ensuring they remain dynamic and responsive to both the academic and practical needs of students preparing for careers in physical education and sports science.

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Conflict of interest

There is no conflict of interest to declare.

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