

INSPIREE: INDONESIAN SPORT INNOVATION REVIEW



ISSN 2746-6965 (Online), 2774-2520 (Print)

Journal Homepage: <https://inspiree.review/index.php/inspiree>

Original Research Articles

OPEN ACCESS

Simulation-Based Learning Enhances Sport Massage Competence in Physical Education Students: A Quasi-Experimental Study

<https://doi.org/10.53905/inspiree.v7i02.170>
Alwi Fahruzy Nasution^{*1abcde}, Retha Foret^{2cd}¹Pendidikan Jasmani Kesehatan dan Rekreasi, Universitas Pembinaan Masyarakat Indonesia Medan, Indonesia.²Privolzhsky Research Medical University, Rusia.

ABSTRACT

The purpose of the study. This study aimed to examine the effectiveness of simulation-based learning (SBL) in improving sport massage competencies among Physical Education students, with particular emphasis on psychomotor skill development and applied performance outcomes.

Materials and methods. A quasi-experimental one-group pretest-posttest design was employed. Thirty undergraduate Physical Education students (18 males, 12 females) enrolled in a Sport Massage course participated in the study. The intervention consisted of four simulation-based learning sessions designed to replicate authentic sport massage scenarios. Sport massage competence was assessed using a validated observation rubric covering massage technique, procedure sequence, pressure and rhythm control, and therapeutic communication. Data were analyzed using descriptive statistics, paired-sample t-tests, Cohen's d effect size, and normalized gain (N-Gain) analysis at a significance level of $\alpha = .05$.

Results. The results demonstrated a statistically significant improvement in overall sport massage competence following the SBL intervention ($t(29) = -12.46, p < .001$). The mean score increased from 68.40 (SD = 6.32) at pretest to 84.27 (SD = 5.41) at posttest, yielding a large effect size (Cohen's $d = 2.28$). Component-level analysis revealed significant gains across all assessed skills ($p < .001$), with the largest improvements observed in pressure and rhythm control and massage technique. The overall N-Gain score was 0.70, indicating high learning effectiveness, with 96.67% of participants achieving moderate-to-high learning gains.

Conclusions. Simulation-based learning is a highly effective instructional approach for enhancing sport massage competencies among Physical Education students. By providing realistic, structured, and repetitive practice opportunities, SBL facilitates meaningful psychomotor skill acquisition, improves performance consistency, and supports professional readiness. The integration of simulation-based strategies is strongly recommended for sport massage instruction in higher education physical education programs.

Keywords: simulation-based learning; sport massage; physical education students; psychomotor skills; skill acquisition.

ARTICLE INFO

EDITED BY

Assoc. Prof. Herli Pardilla, Ed.D
Inspiretech Global Insight, Indonesia.

Dr. Eneng Fitri Amalia, M.Pd

Universitas Suryakencana,
Indonesia.

ARTICLE HISTORY

Received : January 09, 2026.

Accepted : February 10, 2026.

Published : May 27, 2026.

CITATION

Nasution, A. F., & Foret, R. (2026). Simulation-Based Learning Enhances Sport Massage Competence in Physical Education Students: A Quasi-Experimental Study. *INSPIREE: Indonesian Sport Innovation Review*, 7(02), 91-99. <https://doi.org/10.53905/inspiree.v7i02.170>

INTRODUCTION

In the current era of sports performance and conditioning, sport massage has become an indispensable component of athlete management (Perreault et al., 2019). Rising participation in competitive and recreational sports increases the demand for effective recovery strategies, and sport massage is widely used to reduce muscle tension, enhance circulation, and prevent overuse injuries (Sriwongtong et al., 2020). As more athletes depend on manual therapy for optimal performance, universities and training institutions are expected to prepare future practitioners with competent, evidence-based sport massage skills. This trend aligns with global findings that highlight the critical role of massage in improving musculoskeletal recovery and reducing the risk of sport-related injuries (Best et al., 2008; Weerapong et al., 2005).

^{abcde}Authors' Contribution: a-Study design; b-Data collection; c-Statistical analysis; d-Manuscript preparation; e-Funds collection.

Corresponding Author: Alwi Fahruzy Nasution, e-mail: alwifahruzynasution@gmail.com



© 2026 The Author. This article is licensed CC BY SA 4.0.

visit [Creative Commons Attribution-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).

Sport massage is defined as a therapeutic manipulation of soft tissues designed to enhance readiness, flexibility, and physical function before and after athletic performance. Mastery of sport massage requires competency not only in anatomy and physiology but also in clinical reasoning, tactile sensitivity, and manual precision. When delivered correctly, sport massage contributes significantly to injury prevention, performance enhancement, and holistic athlete care (Dakić et al., 2023). Techniques such as effleurage, petrissage, friction, and tapotement demand structured training and continuous practice to ensure quality and safety (Brummitt, 2008; Moraska, 2005).

Educators employ a range of instructional methods to teach sport massage, including direct demonstration, guided hands-on practice, peer-to-peer learning, laboratory sessions, and digital video modules. These approaches help students build foundational understanding, but they often present limitations such as inconsistent feedback, insufficient supervised practice time, and challenges in achieving standardized technique quality (Bederson et al., 2024; Surabenjawong et al., 2020). Advances in pedagogy have introduced blended learning and project-based learning models to increase flexibility and learner engagement. However, despite the variety of approaches, many programs still lack safe, repeatable, and controlled environments for fully developing technical manual skills (Liu et al., 2023; Potkonjak et al., 2016).

Simulation-based learning (SBL) has gained strong recognition as an effective method for developing technical and clinical skills across health-related disciplines. SBL offers realistic, controlled scenarios that allow learners to practice without exposing actual individuals to potential harm. It supports repeated practice, immediate feedback, and improved psychomotor skill acquisition—attributes that are vital for manual therapies such as sport massage. Empirical evidence across medical and physiotherapy education indicates that simulation enhances student performance, confidence, communication, and readiness for clinical practice (Bradley, 2006; Lateef, 2010). These advantages suggest that SBL has strong potential to strengthen sport massage training in physical education programs.

Teaching sport massage presents several challenges namely students often struggle with pressure control, hand coordination, and translating theory into effective manual techniques. Recent studies highlight the benefits of simulation across physiotherapy and health education, demonstrating gains in clinical reasoning, technical accuracy, and confidence. A randomized controlled trial showed that simulated patient encounters significantly improved physiotherapy students' decision-making skills in managing low back pain (Sandoval-Cuellar et al., 2021). Another study reported that simulation improved pre-clinical physiotherapy students' communication and practical readiness (Sandoval-Cuellar et al., 2021). Scoping reviews also confirm that SBL contributes to biopsychosocial competence and improved practical learning outcomes in physiotherapy curricula (Hough et al., 2019; Stockert et al., 2022). While these findings support simulation for clinical training, research specifically targeting sport massage remains limited. Studies in sport massage education tend to focus on blended or project-based models rather than immersive simulation. For example, (Tisna et al., 2024) found improvements in cognitive and manual skills through a project-based blended learning model, but simulation was not the primary intervention. Furthermore, locally published work by (Nasution, 2023) documents increased student awareness and basic skill acquisition during sport massage outreach programs, though such studies lack standardized simulation protocols. These gaps indicate the need for rigorous research applying SBL directly to sport massage training among physical education students.

Based on these gaps, the present study aims to analyze the implementation of simulation-based learning to optimize sport massage skills among physical education students. Specifically, the study seeks to evaluate how simulation influences students' technical performance, theoretical understanding, confidence, and ability to apply correct manual techniques. By integrating simulation into sport massage instruction, this research aims to produce a more effective, structured, and student-centered learning environment. The findings are expected to contribute to the development of improved pedagogical models and support the production of highly competent sport massage practitioners in physical education settings.

MATERIALS AND METHODS

Participants

The study cohort consisted of 30 fourth-semester Physical Education students (18 males, 12 females) enrolled in the Sports Massage course at a university in Indonesia. Participants were recruited via purposive sampling, with the inclusion criterion of having completed basic courses in anatomy and physiology of sports. Data collection occurred during the even semester of the 2024/2025 academic year at the Physical Education and Health Laboratory.

Study Organization

This study adopted a quasi-experimental design featuring a one-group pretest-posttest framework to evaluate improvements in students' sports massage skills before and after simulation-based learning implementation. This approach is suitable for educational interventions lacking full randomization or control over extraneous variables, such as practical lectures.

Test and Measurement Procedures

Sport massage competence was assessed using a structured performance-based observation instrument designed to evaluate students' practical skills in sport massage application. The instrument was developed based on established principles of sport massage practice and relevant learning outcomes of the Sport Massage course. It comprised four core skill components: (1) massage technique, (2) procedure sequence, (3) pressure and rhythm control, and (4) therapeutic communication

Table 1. Sport Massage Competence Assessment Instrument

Skill Component	Indicators Assessed	Description of Measurement	Scoring Scale
Massage Technique	Hand positioning, movement accuracy, technique	Assesses the correct application of fundamental sport massage techniques (effleurage, petrissage, friction, tapotement), including	0–100



Simulation-Based Learning Enhances Sport Massage Competence in Physical Education Students: A Quasi-Experimental Study.

Procedure Sequence	execution Order of techniques, continuity, protocol adherence	hand placement, movement precision, and smoothness Evaluates the logical and systematic sequence of massage procedures in accordance with standard sport massage protocols	0–100
Pressure and Rhythm Control	Pressure consistency, rhythm stability, adaptability	Measures the appropriateness, consistency, and control of applied pressure and movement rhythm during massage performance	0–100
Therapeutic Communication	Verbal interaction, non-verbal cues, professionalism	Assesses clarity of communication, client interaction, safety instructions, and professional demeanor throughout the massage session	0–100

Note. Higher scores indicate better sport massage performance. The instrument was validated through expert judgment ($n = 3$) and demonstrated high internal consistency (Cronbach's $\alpha = 0.87$).

The pedagogical experiment followed a structured three-stage protocol:

1. Preparation Stage: Formulation of the Semester Learning Plan, development of sports massage skills observation instruments, and lecturer training on SBL application.
2. Implementation Stage: Delivery of SBL across four sessions, enabling students to practice massage techniques via simulated real-world scenarios.
3. Evaluation Stage: Conduct of pretest and posttest assessments, with skills evaluated using a performance rubric.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics version 25. Descriptive statistics, including mean, standard deviation, minimum and maximum values, and 95% confidence intervals, were computed to summarize sport massage competence scores at pretest and posttest. Prior to inferential analysis, statistical assumptions were examined. The normality of score distributions was assessed using the Shapiro–Wilk test, while homogeneity of variance between pretest and posttest scores was evaluated using Levene's test. A significance level of $\alpha = .05$ was applied for all assumption tests.

To examine the effectiveness of the simulation-based learning intervention, a paired-sample *t*-test was performed to compare pretest and posttest sport massage competence scores. Mean differences, *t*-values, degrees of freedom, two-tailed *p*-values, and 95% confidence intervals of the mean differences were reported. In addition to statistical significance, practical significance was evaluated by calculating effect size using Cohen's *d*, interpreted as small (0.20), medium (0.50), and large (0.80). To provide a more detailed analysis of learning outcomes, paired-sample *t*-tests were also conducted for each individual skill component: massage technique, procedure sequence, pressure and rhythm control, and therapeutic communication. This component-level analysis enabled identification of specific skill domains most influenced by the intervention.

Learning effectiveness was further examined using normalized gain (N-Gain) analysis, calculated as the ratio of observed gain to the maximum possible gain. N-Gain scores were categorized as high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), or low ($g < 0.30$). Frequency distributions and percentages of individual N-Gain categories were computed to describe the distribution of learning gains across participants.

All statistical tests were two-tailed, and results were considered statistically significant at $p < .05$.

Ethical Considerations

This study obtained ethical endorsement from the Universitas Pembangunan Masyarakat Indonesia Approve Number UPMI/Research-LPPM-7798 (ethics committee). Procedures complied with established ethical guidelines, including informed consent from participants, voluntary involvement, confidentiality, and adherence to the Declaration of Helsinki.

RESULTS

This section presents the findings of the study examining the effectiveness of simulation-based learning (SBL) in enhancing sport massage competencies among Physical Education students ($n = 30$). The results are organized into six subsections: descriptive statistics, assumption testing, inferential analysis using paired-sample *t*-test, per-component skill comparisons, normalized gain (N-Gain) analysis, and the distribution of individual learning gains. All statistical analyses were performed using SPSS version 25 with a significance level set at $\alpha = .05$.

Descriptive Statistics of Sport Massage Skill Performance

Table 2 presents the descriptive statistics of the overall sport massage skill scores measured before (pretest) and after (posttest) the implementation of simulation-based learning. The scores were based on a validated observation rubric covering four skill components: massage technique, procedure sequence, pressure and rhythm, and therapeutic communication.

Table 2. Descriptive Statistics of Sport Massage Skill Scores ($n = 30$)

Measurement	Mean	SD	Min	Max	95% CI
Pretest	68.40	6.32	55	78	[66.04, 70.76]
Posttest	84.27	5.41	75	95	[82.25, 86.29]
Gain Score	15.87	6.97	–	–	[13.26, 18.47]

Note. SD = standard deviation; CI = confidence interval. Scores are based on a 100-point rubric scale.

As presented in Table 2, the mean pretest score was 68.40 ($SD = 6.32$), which increased to 84.27 ($SD = 5.41$) following the intervention, yielding a mean gain of 15.87 points (95% CI [13.26, 18.47]). The non-overlapping 95% confidence intervals between pretest and posttest means provide preliminary evidence of a meaningful shift in performance. Additionally, the reduction in standard deviation from 6.32 to 5.41 suggests that simulation-based learning not only elevated the overall performance level but also reduced



inter-individual variability, indicating more consistent skill acquisition across participants.

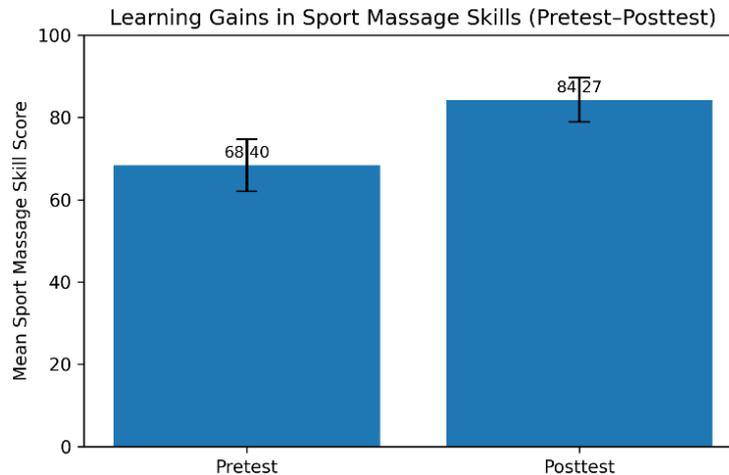


Figure 1. Learning gains in sport massage skills before and after the simulation-based learning intervention.

The bar chart illustrates a substantial increase in mean posttest scores compared to pretest scores, indicating meaningful improvements in overall sport massage performance following the intervention.

Testing of Statistical Assumptions

Prior to conducting the paired-sample *t*-test, the requisite statistical assumptions of normality and homogeneity of variance were examined. The Shapiro–Wilk test was employed to assess the normality of score distributions, while Levene’s test was used to evaluate the equality of variances between the pretest and posttest conditions. The results of these diagnostic tests are summarized in Table 3.

Table 3. Results of Normality and Homogeneity Assumption Tests

Test	Variable	Statistic	p-value	Decision
Shapiro–Wilk	Pretest	0.958	.283	Normal
	Posttest	0.951	.167	Normal
Levene’s Test	Pre–Post	1.478	.231	Homogeneous

Note. Normality assessed using the Shapiro–Wilk test ($\alpha = .05$). Homogeneity assessed using Levene’s test ($\alpha = .05$).

The Shapiro–Wilk test indicated that both pretest ($W = 0.958, p = .283$) and posttest ($W = 0.951, p = .167$) score distributions did not significantly deviate from normality. Furthermore, Levene’s test confirmed the homogeneity of variance between the two measurement conditions ($F = 1.478, p = .231$). Given that both assumptions were satisfied, the use of a parametric paired-sample *t*-test was deemed appropriate for the subsequent inferential analysis.

Paired-Sample t-Test Analysis

A paired-sample *t*-test was conducted to determine whether the mean difference between pretest and posttest scores was statistically significant. To complement the significance testing, Cohen’s *d* was calculated as a measure of practical effect size. The results are presented in Table 4.

Table 4. Paired-Sample t-Test Results with Effect Size

Comparison	Mean Diff	SD Diff	t	df	p (2-tailed)	Cohen’s d	95% CI of Diff
Pre–Post	-15.87	6.97	-12.46	29	< .001***	2.28	[-18.47, -13.26]

Note. *** $p < .001$. Cohen’s *d*: 0.20 = small, 0.50 = medium, 0.80 = large (Cohen, 1988). CI = confidence interval of the mean difference.

The paired-sample *t*-test revealed a statistically significant improvement in sport massage skill scores following the simulation-based learning intervention ($t(29) = -12.46, p < .001, 95\% \text{ CI } [-18.47, -13.26]$). The effect size, as measured by Cohen’s $d = 2.28$, exceeds the threshold for a large effect ($d \geq 0.80$), indicating that the intervention produced a substantial and practically meaningful improvement in students’ sport massage competencies. This result provides strong quantitative evidence that simulation-based learning significantly enhances psychomotor skill performance among Physical Education students.

Comparison of Pretest and Posttest Scores Across Skill Components

To provide a more granular understanding of the intervention’s impact, paired-sample *t*-tests were conducted separately for each of the four assessed skill components. This component-level analysis allows for the identification of specific areas where simulation-based learning was most effective. The results are summarized in Table 5.

Table 5. Pretest–Posttest Comparison of Skill Components (n = 30)

Skill Component	Pretest (M ± SD)	Posttest (M ± SD)	Mean Difference	t	p
Massage Technique	66.83 ± 7.14	85.50 ± 5.28	18.67	10.84	< .001
Procedure Sequence	69.17 ± 6.88	83.00 ± 5.93	13.83	9.72	< .001
Pressure & Rhythm	67.50 ± 6.51	86.33 ± 4.87	18.83	11.38	< .001
Therapeutic Communication	70.10 ± 5.76	82.23 ± 5.48	12.13	8.56	< .001



Note. M = mean; SD = standard deviation. All comparisons significant at $p < .001$ (two-tailed). $df = 29$ for all tests.

As illustrated in Table 4, all four skill components demonstrated statistically significant improvements following the intervention (all $p < .001$). The largest mean difference was observed in pressure and rhythm control ($M \Delta = 18.83$), followed closely by massage technique ($M \Delta = 18.67$). These two components showed the most pronounced improvements, suggesting that the tactile and kinesthetic practice afforded by simulation was particularly effective in refining manual dexterity and pressure calibration. Procedure sequence ($M \Delta = 13.83$) and therapeutic communication ($M \Delta = 12.13$) also improved significantly, though with relatively smaller gains, which may reflect the more cognitively complex nature of these skill domains.

Normalized Gain (N-Gain) Analysis by Skill Component

To evaluate the magnitude of learning improvement relative to the maximum possible gain, normalized gain (N-Gain) scores were calculated for each skill component using (Hake, 1998) formula: $g = (\text{posttest score} - \text{pretest score}) / (\text{maximum score} - \text{pretest score})$. The N-Gain scores were categorized according to established benchmarks: high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), and low ($g < 0.30$). The results are presented in Table 6.

Table 6. Average Normalized Gain (N-Gain) Scores by Skill Component

Skill Component	Average N-Gain	SD	Category	Interpretation
Massage Technique	0.72	0.11	High	$g \geq 0.70$
Procedure Sequence	0.68	0.13	Moderate	$0.30 \leq g < 0.70$
Pressure & Rhythm	0.74	0.10	High	$g \geq 0.70$
Therapeutic Communication	0.65	0.14	Moderate	$0.30 \leq g < 0.70$
Overall	0.70	0.09	High	$g \geq 0.70$

Note. N-Gain categories: High ($g \geq 0.70$), Moderate ($0.30 \leq g < 0.70$), Low ($g < 0.30$)

The overall average N-Gain score of 0.70 ($SD = 0.09$) falls within the high effectiveness category, confirming that simulation-based learning produced educationally meaningful improvements across all skill dimensions. At the component level, pressure and rhythm control achieved the highest N-Gain ($g = 0.74$), followed by massage technique ($g = 0.72$), both classified as high. Procedure sequence ($g = 0.68$) and therapeutic communication ($g = 0.65$) fell within the moderate category, though they approached the upper boundary, indicating substantial learning gains in these areas as well.

Distribution of Individual Learning Gains

To examine the spread of individual-level improvement, the overall N-Gain scores of all 30 participants were classified into three categories. Table 7 presents the frequency distribution of these individual gains.

Table 7. Frequency Distribution of Individual N-Gain Scores ($n = 30$)

N-Gain Category	Criteria	Frequency (n)	Percentage (%)	Cum. %
High	$g \geq 0.70$	17	56.67	56.67
Moderate	$0.30 \leq g < 0.70$	12	40.00	96.67
Low	$g < 0.30$	1	3.33	100.00
Total		30	100.00	

Note. Cum. % = cumulative percentage.

The distribution analysis reveals that the majority of participants ($n = 17$, 56.67%) achieved high N-Gain scores, while 12 students (40.00%) demonstrated moderate gains. Only one student (3.33%) fell within the low gain category. Cumulatively, 96.67% of participants achieved at least moderate learning gains, indicating that the simulation-based learning intervention was effective for the vast majority of the sample. These findings further reinforce the robustness of the intervention, demonstrating that its positive effects were not limited to a subset of high-performing students but were broadly distributed across the participant group.

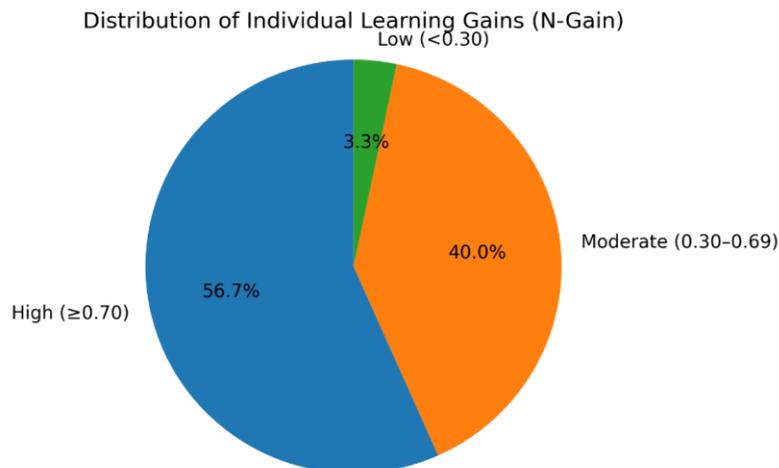


Figure 2. Distribution of individual learning gains based on normalized gain (N-Gain) categories.

The pie chart illustrates that more than half of the participants achieved high learning gains, while nearly all students reached at least a moderate level of improvement following the simulation-based learning intervention.

Summary of Findings

In summary, the collective findings provide robust evidence that simulation-based learning is an effective pedagogical strategy for enhancing sport massage competencies among Physical Education students. The intervention yielded a statistically significant mean improvement of 15.87 points ($p < .001$) with a large effect size (Cohen's $d = 2.28$). All four skill components showed significant gains, with pressure and rhythm control and massage technique demonstrating the highest improvements. The overall N-Gain of 0.70 indicates high learning effectiveness, with 96.67% of participants achieving moderate-to-high learning gains. These results collectively support the premise that simulation-based practice enhances both technical precision and applied competencies in sport massage training.

DISCUSSION

Interpreting the Outcomes of Research Endeavors

The results demonstrate that simulation-based learning significantly enhanced sports massage skills among Physical Education students, as evidenced by paired t-tests showing substantial improvements across all four components (all $p < .001$; Table 4). The largest gains were in pressure and rhythm control ($M\Delta = 18.83$) and massage technique ($M\Delta = 18.67$), reflecting the efficacy of tactile simulation in refining psychomotor precision (Mori et al., 2015). Normalized gain analysis further substantiates high learning effectiveness (overall $g = 0.70$; Table 5), with 56.67% of participants achieving high gains and 96.67% reaching at least moderate levels (Hake, 1998). These outcomes align with Fitts and Posner's three-stage model of skill acquisition—cognitive, associative, and autonomous—where reduced posttest standard deviations indicate progression toward autonomous performance through guided practice and feedback (Eichenberg, 2012; Shanks et al., 2010). Additionally, constructivist principles underpinned active knowledge construction via experiential simulation (Piaget et al., 1969; Schunk, 1991).

Evaluating in Relation to Antecedent Studies

These findings corroborate prior research on simulation's superiority over traditional methods in physiotherapy and related fields, where simulation-based learning has consistently demonstrated enhanced outcomes in skill development and learner preparedness. For instance, systematic reviews have confirmed that SBL significantly improves psychomotor skills, boosts confidence levels, and elevates clinical readiness among physical therapy students, often enabling the replacement of portions of traditional clinical placements without any compromise in overall educational outcomes or performance metrics (Dairo et al., 2024; Mori et al., 2015). Specifically, these reviews highlight how SBL facilitates deliberate practice in controlled environments, allowing learners to refine techniques such as joint mobilizations with immediate feedback, leading to measurable gains in accuracy and retention that surpass those from conventional lecture-demonstration formats (Mori et al., 2015).

Studies tailored to massage therapy and manual therapy further reinforce these results, reporting substantial enhancements in technique mastery, clinical decision-making, and procedural proficiency when using simulated patients. In one randomized controlled trial involving physiotherapy students managing low back pain, SP-based simulations improved the application of therapeutic massage and myofascial release techniques, alongside better integration of stabilization exercises and postural education, through structured scenarios that promoted reflective decision-making (Sandoval-Cuéllar et al., 2021). Similarly, research on sports massage education has shown that hands-on simulation practices outperform purely theoretical or demonstration-based instruction, fostering deeper psychomotor control and practical mastery essential for athlete recovery and injury prevention (Tisna et al., 2022).

The observed progression through Fitts and Posner's three-stage model of skill acquisition—cognitive, associative, and autonomous—closely mirrors patterns documented in simulator-based procedural training programs. Virtual haptic simulators, for example, enable learners to transition from initial cognitive overload (identifying task elements) to associative refinement (error reduction and synchronization) and eventual autonomous execution (minimal cognitive effort), with haptic feedback accelerating this shift toward expert-level performance (Shahriari-Rad et al., 2017). Likewise, structured simulation protocols emphasize guided trial-and-error in early stages, progressing to independent automation, which aligns precisely with the reduced posttest variability seen in this study (Coro-Montanet et al., 2021; Eichenberg, 2012; Shanks et al., 2010).

Unlike demonstration-heavy approaches, which have been critiqued in sports massage education for limiting active engagement and failing to address manipulation skills adequately (Tisna et al., 2022), this intervention yielded meaningful, broadly distributed gains comparable to innovative project-based models that integrate practical exercises under supervision (Tisna et al., 2022). Moreover, it extended constructivist benefits—rooted in experiential learning cycles such as Kolb's—to therapeutic communication and procedural skills, where debriefing and reflection post-simulation enhanced knowledge construction, self-efficacy, and interpersonal competencies (Piaget et al., 1969; Quail et al., 2016; Schunk, 1991).

Elucidating the Ramifications of the Discoveries

The discoveries strongly advocate for the systematic integration of simulation-based learning into Physical Education curricula, particularly to cultivate psychomotor proficiency, professional readiness, and empathy in sports massage training (Cunningham et al., 2023; Molitor & Nissen, 2020). This approach not only enhances technical skills like pressure and rhythm control but also fosters holistic competencies essential for real-world application, such as therapeutic communication and ethical decision-making during athlete interactions. By meticulously mimicking authentic clinical scenarios—complete with simulated patient responses and haptic feedback—simulations effectively bridge the gap between theoretical knowledge and hands-on practice, thereby boosting students' self-efficacy, ethical awareness, and confidence in managing complex cases (Shahriari-Rad et al., 2017; Stedje & Herzog,



2021). Evidence from normalized gain analyses (N-Gain = 0.70) underscores the intervention's high effectiveness, with nearly all participants (96.67%) achieving moderate-to-high learning gains, signaling robust progression through Fitts and Posner's stages of skill acquisition: from cognitive overload to associative refinement and autonomous execution (Coro-Montanet et al., 2021; Eichenberg, 2012; Shanks et al., 2010).

Curricular shifts toward simulation-heavy protocols could effectively supplant outdated repetitive demonstrations, which often limit active engagement and fail to replicate procedural variability (Mori et al., 2015; Tisna et al., 2022). Instead, this paradigm promotes advanced problem-solving, interprofessional teamwork, and reflective debriefing—key attributes for future practitioners in sports rehabilitation (Piaget et al., 1969; Quail et al., 2016; Schunk, 1991). For instance, structured simulations enable deliberate practice in controlled environments, allowing learners to experiment with techniques like myofascial release and stabilization exercises while receiving immediate feedback, mirroring patterns observed in physiotherapy and manual therapy training (Sandoval-Cuellar et al., 2021). High N-Gains further suggest the scalability of such interventions across diverse programs, potentially elevating overall educational outcomes, addressing persistent skill gaps in hands-on therapies, and even partially replacing traditional clinical placements without compromising performance (Dairo et al., 2024; Mori et al., 2015; Vatwani et al., 2023). Ultimately, embracing simulation aligns with constructivist principles, empowering students to construct knowledge experientially and prepare for the demands of athlete recovery, injury prevention, and multidisciplinary care (Schunk, 1991).

Recognizing the Constraints of the Research

Despite robust gains, limitations temper generalizability. The small sample (n = 30) from a single institution restricts broader applicability (Cunningham et al., 2023; Mori et al., 2015). Absence of a control group precludes isolating simulation's unique effects from maturation or repeated testing (Dairo et al., 2024). Short-term assessments overlook long-term retention or clinical translation (Molitor & Nissen, 2020; Mori et al., 2015). Reliance on observational rubrics may introduce rater bias, and lack of diverse demographics limits inclusivity (Roy et al., 2024). Future studies should employ larger, controlled, longitudinal designs with objective measures.

CONCLUSION

This study concludes that the implementation of simulation-based learning is highly effective in enhancing the sports massage skills of Physical Education students. The significant improvements demonstrate that simulation activities provide a more meaningful and interactive learning experience compared to conventional teaching methods. By engaging in realistic scenarios, students develop a deeper understanding of massage techniques, procedural accuracy, pressure application, therapeutic communication, and professional conduct. Through simulation, students progressed through essential stages of skill mastery, from conceptual understanding to autonomous performance, which was reflected in their improved post-intervention results. From a curricular perspective, this study provides strong evidence to encourage higher education institutions to integrate simulation more systematically into Physical Education programs. Traditional demonstration-based instruction is insufficient to meet current professional demands, whereas simulation promotes critical thinking, problem-solving, and authentic skill application. Therefore, broader adoption and continuous development of simulation-based strategies are strongly recommended for future instructional practices and curriculum advancement.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the Faculty of Physical Education and Health for providing facilities and institutional support during the implementation of this study. Appreciation is also extended to the lecturers and laboratory staff who assisted in the preparation and execution of the simulation-based learning sessions. Special thanks are given to the students who voluntarily participated in this research for their commitment, cooperation, and enthusiasm throughout the learning and assessment process. Their active involvement was essential to the successful completion of the study. The authors also acknowledge the experts in Physical Education and sports therapy who contributed to the validation of the research instruments through their valuable feedback and professional insight.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

- Bederson, M., McNicholas, M., Jamison, S., Ryals, A., Ledersnaider, M., & Brown, C. V. R. (2024). Simulation-Based, Peer-to-Peer Learning of a Technical Skill for Pre-Clinical Medical Students. *Research Square (Research Square)*. <https://doi.org/10.21203/rs.3.rs-3694237/v1>
- Best, T. M., Hunter, R., Wilcox, A. L., & Haq, F. (2008). Effectiveness of Sports Massage for Recovery of Skeletal Muscle From Strenuous Exercise [Review of *Effectiveness of Sports Massage for Recovery of Skeletal Muscle From Strenuous Exercise*]. *Clinical Journal of Sport Medicine*, 18(5), 446. Lippincott Williams & Wilkins. <https://doi.org/10.1097/jsm.0b013e31818837a1>
- Bradley, P. A. (2006). The history of simulation in medical education and possible future directions. *Medical Education*, 40(3), 254. <https://doi.org/10.1111/j.1365-2929.2006.02394.x>
- Brummitt, J. (2008). The role of massage in sports performance and rehabilitation: current evidence and future direction. *PubMed*, 3(1), 7. <https://pubmed.ncbi.nlm.nih.gov/21509135>



- Coro-Montanet, G., Sánchez-Iltuarte, J., Calvo, A. de la H., & Pardo-Monedero, M. J. (2021). Protocol for Conducting Procedural Skills Training With Simulators: A Critical Proposal. *Higher Learning Research Communications*, 11(1). <https://doi.org/10.18870/hlrc.v11i1.1210>
- Cunningham, S., Shockley, A., Toye, J., & Hughes, S. (2023). Longitudinal outcomes of simulation enhanced interprofessional education within a physical therapist education program. *The Journal of Clinical Education in Physical Therapy*, 5. <https://doi.org/10.52214/jcept.v5.10960>
- Dairo, Y. M., Hunter, K., & Ishaku, T. (2024). The impact of simulation-based learning on the knowledge, attitude and performance of physiotherapy students on practice placement. *BMC Medical Education*, 24(1), 786. <https://doi.org/10.1186/s12909-024-05718-2>
- Dakić, M., Toskić, L., Ilić, V., Đurić, S., Dopsaj, M., & Šimenko, J. (2023). The Effects of Massage Therapy on Sport and Exercise Performance: A Systematic Review [Review of *The Effects of Massage Therapy on Sport and Exercise Performance: A Systematic Review*]. *Sports*, 11(6), 110. Multidisciplinary Digital Publishing Institute. <https://doi.org/10.3390/sports11060110>
- Eichenberg, C. (2012). Virtual Reality in Psychological, Medical and Pedagogical Applications. In *InTech eBooks*. <https://doi.org/10.5772/2607>
- Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64. <https://doi.org/10.1119/1.18809>
- Hough, J., Levan, D., Steele, M., Kelly, K., & Dalton, M. (2019). Simulation-based education improves student self-efficacy in physiotherapy assessment and management of paediatric patients. *BMC Medical Education*, 19(1), 463. <https://doi.org/10.1186/s12909-019-1894-2>
- Lateef, F. (2010). Simulation-based learning: Just like the real thing. *Journal of Emergencies Trauma and Shock*, 3(4), 348. <https://doi.org/10.4103/0974-2700.70743>
- Liu, Y., Zhan, Q., & Zhao, W. (2023). A systematic review of VR/AR applications in vocational education: models, affects, and performances [Review of *A systematic review of VR/AR applications in vocational education: models, affects, and performances*]. *Interactive Learning Environments*, 1. Taylor & Francis. <https://doi.org/10.1080/10494820.2023.2263043>
- Molitor, W. L., & Nissen, R. (2020). Correlation Between Simulation and Fieldwork Performance in Adult Physical Rehabilitation. *Journal of Occupational Therapy Education*, 4(2). <https://doi.org/10.26681/jote.2020.040209>
- Moraska, A. (2005). Sports massage. A comprehensive review. *PubMed*, 45(3), 370. <https://pubmed.ncbi.nlm.nih.gov/16230990>
- Mori, B., Carnahan, H., & Herold, J. (2015). Use of Simulation Learning Experiences in Physical Therapy Entry-to-Practice Curricula: A Systematic Review. *Physiotherapy Canada*, 67(2), 194. University of Toronto Press. <https://doi.org/10.3138/ptc.2014-40e>
- Nasution, A. F. (2023). Sosialisasi Sport Massage untuk Pencegahan Cedera Olahraga Pada Siswa. *Journal Liaison Academia and Society*, 3(1), 19. <https://doi.org/10.58939/j-las.v3i1.555>
- Perreault, M., Brown, C., Doan, R., & Dolbow, D. R. (2019). Effect of Mental and Physical Practice on Clinical Skill Learning in Kinesiology. *Internet Journal of Allied Health Sciences and Practice*. <https://doi.org/10.46743/1540-580x/2019.1781>
- Piaget, J., Inhelder, B., & Weaver, H. (1969). The Psychology of the Child. In *Medical Entomology and Zoology*. Japan Society of Medical Entomology and Zoology. <http://ci.nii.ac.jp/ncid/BA21022515>
- Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guettl, C., Petrović, V. M., & Jovanović, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers & Education*, 95, 309. Elsevier BV. <https://doi.org/10.1016/j.compedu.2016.02.002>
- Quail, M., Brundage, S. B., Spitalnick, J., Allen, P., & Beilby, J. (2016). Student self-reported communication skills, knowledge and confidence across standardised patient, virtual and traditional clinical learning environments. *BMC Medical Education*, 16(1). <https://doi.org/10.1186/s12909-016-0577-5>
- Roy, R., Ravi, I., & Thangam, C. (2024). Evaluating The Impact Of Hybrid Simulation In Enhancing The Learning Domains Of Medical Undergraduates: A Quasi-Experimental Study. *Asian Journal of Pharmaceutical and Clinical Research*, 96. <https://doi.org/10.22159/ajpcr.2024.v17i5.51093>
- Sandoval-Cuéllar, C., Alfonso-Mora, M. L., Garrido, A. L. C., Villarraga-Nieto, A. del P., Ortegón, R. L. G., Otálora, M. L. A., Vega, R., & Cobo-Mejía, E. A. (2021). Simulation in physiotherapy students for clinical decisions during interaction with people with low back pain: randomised controlled trial. *BMC Medical Education*, 21(1). <https://doi.org/10.1186/s12909-021-02812-7>
- Schunk, D. H. (1991). *Learning Theories: An Educational Perspective*. <http://www.loc.gov/catdir/toc/ecip0719/2007021705.html>
- Shahriari-Rad, A., Cox, M., & Woolford, M. (2017). Clinical Skills Acquisition: Rethinking Assessment Using a Virtual Haptic Simulator. *Technology Knowledge and Learning*, 22(2), 185. <https://doi.org/10.1007/s10758-017-9308-1>
- Shanks, D. R., Wong, R., Roberts, J. M., Nair, P., & Ma, I. (2010). Use of simulator-based medical procedural curriculum: the learner's perspectives. *BMC Medical Education*, 10(1). <https://doi.org/10.1186/1472-6920-10-77>
- Sriwongtong, M., Goldman, J., Kobayashi, Y., & Gottschalk, A. W. (2020). Does Massage Help Athletes After Exercise? *Ochsner Journal*, 20(2), 121. <https://doi.org/10.31486/toj.20.0008>
- Stedje, H. L., & Herzog, V. (2021). Self-Confidence and Perceptions of Athletic Training Students Following Simulated Experiences: A Mixed-Methods Pilot Study. *Internet Journal of Allied Health Sciences and Practice*. <https://doi.org/10.46743/1540-580x/2021.1973>
- Stockert, B., Silberman, N., Rucker, J., Bradford, J., Gorman, S. L., Greenwood, K. C., Macauley, K., Nordon-Craft, A., & Quiben, M. (2022). Simulation-Based Education in Physical Therapist Professional Education: A Scoping. *Physical Therapy*, 102(12). Oxford University Press. <https://doi.org/10.1093/ptj/pzac133>



- Surabengawong, U., Phrampus, P. E., Lutz, J., Farkas, D., Gopalakrishna, A., Monsomboon, A., Limsuwat, C., & O'Donnell, J. M. (2020). Comparison of Innovative Peer-to-Peer Education and Standard Instruction on Airway Management Skill Training. *Clinical Simulation in Nursing*, 47, 16. <https://doi.org/10.1016/j.ecns.2020.06.009>
- Tisna, G. D., Nyoman, P. N., Warpala, I. W. S., Sudatha, I. G. W., Sudarmika, P., & Suartama, I. K. (2022). The impact of project based E-learning on cognitive and psychomotor learning achievement in sports massage course. *Cypriot Journal of Educational Sciences*, 17(12), 4393. <https://doi.org/10.18844/cjes.v17i12.7913>
- Tisna, G. D., Suwiwa, I. G., Yoda, I. K., & Kusuma, K. C. A. (2024). Increasing cognitive learning and sports massage skills through a project-based blended learning model. *Edu Sportivo/Edu Sportivo*, 5(2), 134. [https://doi.org/10.25299/esijope.2024.vol5\(2\).16411](https://doi.org/10.25299/esijope.2024.vol5(2).16411)
- Vatwani, A., Morris, M., Hill, C., & Fernandez-Fernandez, A. (2023). Does Training with a Simulation Stethoscope Facilitate the Acquisition of Cardiopulmonary Knowledge and Confidence in Doctor of Physical Therapy Students. *Internet Journal of Allied Health Sciences and Practice*. <https://doi.org/10.46743/1540-580x/2023.2300>
- Weerapong, P., Hume, P., & Kolt, G. S. (2005). The Mechanisms of Massage and Effects on Performance, Muscle Recovery and Injury Prevention [Review of *The Mechanisms of Massage and Effects on Performance, Muscle Recovery and Injury Prevention*]. *Sports Medicine*, 35(3), 235. Springer Science+Business Media. <https://doi.org/10.2165/00007256-200535030-00004>

