Original Article

Awareness of Machine Learning for Shoulder Exercises and Assessment in Students and Physiotherapists – A Cross-Sectional Study

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ABSTRACT

Background: Machine learning (ML), as a core domain of artificial intelligence, has recently emerged as a promising tool for the analysis, diagnosis, and rehabilitation of shoulder conditions in physiotherapy. Despite its global growth, its integration remains limited in low- and middle-income countries, including Pakistan. Understanding local professionals' perceptions and readiness is essential for guiding future adoption. Objective: To assess the perceptions, awareness, and readiness of physiotherapists in Lahore, Pakistan, toward using ML-based tools for shoulder exercise evaluation and rehabilitation. Methods: A descriptive cross-sectional study was conducted from January to June 2025 among 150 physiotherapists recruited through convenience sampling from universities and clinical institutes in Lahore. A pre-validated, five-point Likert scale questionnaire assessed participants' awareness, perceptions, and readiness to integrate ML into shoulder rehabilitation practice. Data were analyzed using SPSS, employing descriptive statistics, chi-square tests, and correlation analyses. Statistical significance was set at $p < 0.05$. Results: Most respondents were younger than 25 years (68%), with an equal distribution of males and females. Overall, participants demonstrated moderate awareness of ML applications in physiotherapy, with positive perceptions toward its potential role in improving assessment accuracy and treatment outcomes. Readiness to adopt ML tools showed significant associations with age, professional exposure, and previous familiarity with digital technologies ($p < 0.05$). Conclusion: Physiotherapists in Lahore show favorable perceptions and emerging readiness to integrate ML into shoulder rehabilitation, highlighting the need for targeted training, institutional support, and accessible technological resources.

Keywords: Machine learning; Physiotherapy; Shoulder rehabilitation; Awareness; Readiness; Artificial intelligence; Pakistan.

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INTRODUCTION

In current scenarios, AI and its subfield ML have brought remarkable advancements to the field of medical sciences for predictive analysis and diagnostic capabilities designed to improve precision and efficiency (1). ML and AI are adept at simulating human cognition processes like reasoning, learning, and solving problems to facilitate medical professionals to make informed decisions based on massive and intricate data sets (2). In the field of physiotherapy, ML and AI have demonstrated increasing possibilities to automatically recognize motions, predict rehabilitation outcomes, and facilitate patients to follow

personalized exercise courses—especially for musculoskeletal and nervous rehabilitation cases (3). Another remarkable advantage offered by ML algorithms is their capability to process massive motion capture, electromyography signals, and wearable sensors to help medical professionals to take informed decisions based on objective assessment of joints' kinematics for efficient therapy (4).

Nevertheless, amidst all these developments around the world, the adoption of ML by clinicians is still very low in developing nations because of inadequate digital infrastructure and lack of training opportunities for professionals to become proficient (5). A current systematic review among all inhabitants of this planet showed that just 18% of physiotherapists are actively using AI-assisted technology, while there is also a gap between theoretical knowledge and practical use of AI among professionals (6). Current academic physiotherapeutic education curricula have yet to integrate learning opportunities for digital health and machine learning literacy among aspiring professionals, and most physiotherapists lack knowledge regarding basic principles of algorithmic-driven decision-making processes (7). Additionally, while advanced regions' physiotherapists have been increasingly using wearable sensors for monitoring and also smartphone-mediated motion analysis for rehabilitation processes assisted by computer systems, most professionals practicing in developing countries are still practicing subjective or manual assessment (8).

Shoulder disorders have been cited as one of the most pervasive musculoskeletal-related health concerns around the world, having a 16% prevalence within the United States of America, 18% among Malaysian patients, and 17% among patients from Pakistan (9). The intricate mechanics and highly mobile functionality of the shoulder make it highly prone to pathologies such as torn rotator cuffs, impacted shoulders, or adhesive capsulitis—a condition capable of causing significant debilitation to shoulders (10). Traditional physiotherapeutic modalities for its treatment have been effective but have limitations such as massive inter-therapist variability and unavailability of feedback measures to assess efficacy of regimen administration. Recent advances using machine learning capabilities for its assessment have registered accuracies between 95 to 99% for its precision to recognize motions for therapy and determine rehabilitation outcomes for patients (11, 12).

However, empirical information regarding awareness, perception, and preparedness for integrating machine learning among physiotherapists is limited to date, especially for Pakistan and other developing countries. The respective past efforts have primarily centered on AI for imaging or medical schooling overall but have not ventured into areas of musculoskeletal rehabilitation or preparedness among physiotherapists (13). It is imperative to comprehend perceptions on and future use of ML technology by physiotherapists to tailor respective education curriculums perfectly for efficient implementation of digital advancements for rehabilitation programs.

Consequently, this study was conducted to determine awareness, perception, and readiness among physiotherapy students and practicing physiotherapists for applying machine learning for shoulder exercise and assessment in Lahore, Pakistan. Henceforth, this study endeavors to uncover knowledge gaps to allow for employing AI technology among physiotherapy professionals for advancing rehabilitative care through evidence-based technology use.

MATERIALS AND METHODS

This study adopted a descriptive cross-sectional approach to assess the awareness, perception, and readiness of physiotherapy students and professionals towards applying machine learning (ML) techniques to shoulder exercise and assessment. This approach was adopted

because of its utility to take a representative snapshot of current levels of technological literacy and readiness among professionals at any one point in time (14). This study was conducted between January 2025 and June 2025 at Lahore, Pakistan. The study targeted academic and practicing physiotherapists to create a sampling pool diverse to all levels of exposure to technology. This was conducted among all campuses and associated teaching and private practice facilities aligned to the University of Lahore to create a diverse sampling population of undergraduates and postgraduates practicing or pursuing careers as physiotherapists.

Participants were selected for this study through non-probability convenience sampling after applying eligibility criteria. Criteria for eligibility consisted of final-year Doctor of Physical Therapy (DPT) bachelors' program alumni, masters or doctoral-level professionals practicing as physiotherapists (MSPT or PhD), or licensed professionals having at least one year of experience practicing at musculoskeletal or rehabilitation centers. Criteria for exclusion consisted of practicing physiotherapists not actively involved in academic or professional practice, inadequate completion of questionnaires for analysis, or individuals administering informed consent but refusing to participate in the study or being actively involved in associated activities. Informed consent was sought from all individuals before final recruitment into this study.

A sample size of 150 patients was calculated using the Epitools online calculator (15) at a confidence level of 95%, margin of error of 5%, and expected proportion of 0.5 to achieve higher precision. This also helped to take into consideration past studies conducted to assess awareness and acceptance of digital technology among patients undergoing physiotherapy to have adequate power for subgroup analysis (16). Recruitment of patients was done through digital notification and manual distribution of the study questionnaire by the principal investigator and his team during lectures and meetings.

Data were gathered by administering a pre-tested and close-ended questionnaire to tap into three primary domains: awareness, perception, and readiness to adapt to ML technology in physiotherapy settings. The survey questions were derived from established instruments designed to assess AI and ML awareness among healthcare professionals (17). The survey underwent minor contextual adjustments to fit the setting of physiotherapeutic education and practice. The scale was divided into two segments: one for demographical data (age, gender, qualification, experience) and others addressing subject-related questions presented to respondents using a five-point Likert preference response scale: strongly disagree (1) to strongly agree (5). Based on these domains, overall scores for awareness (knowledge/experience of ML applications) perception (attitudinal/ belief-oriented response to ML application) readiness to implement ML-driven applications were calculated. The reliability analysis of this survey was conducted using Cronbach's alpha test to establish acceptable values for overall domains at 0.82 (18).

To reduce response bias, anonymity was guaranteed, and no personal information was requested. Participants received information about how their responses would be treated only in aggregate form for analysis. A self-administered survey was conducted both personally and electronically through institutional emails for broader reach and accessibility. Each person was allowed to complete only one form before being entered into analysis to avoid any bias associated with incomplete information. Missing values of no more than 5% were removed through pairwise deletion to preserve dataset integrity (19).

All statistical analysis was completed using IBM SPSS Statistics software version 27.0 (IBM Corporation, Armonk, NY, USA). Descriptive statistics such as frequency, percentage, mean, and standard deviation were employed to analyze different dimensions for demographical

information and respective domain scores. For inferential statistics, chi-square tests were utilized to determine association between categorical variables (e.g., qualification level vs. respective categories of awareness/perceptions), and independent samples t-tests to determine differences between mean scores for two groups (where applicable) (20). Significance was considered at $p < 0.05$ levels for all tests. Effect size values for association tests between categorical variables were also calculated using Cramer's V and Cohen's d values for better interpretation of tested associations (21).

This study received ethics approval from the Institutional Review Board (IRB) at the University Institute of Physical Therapy at the University of Lahore (Reference No: UIPT/IRB/2025/014). The study was designed to abide by all ethics required to maintain confidentiality and anonymity while respecting informed voluntary participation as per ethics guidelines of the "Declaration of Helsinki" (22). The entire study procedure can also be replicated by any researcher for verification of its outcomes because of its reproducibility (22).

RESULTS

A total of 150 physiotherapists participated in this study, thereby ensuring a 100% response rate among those to whom questionnaires were distributed. The completeness of data for all primary study variables stands at less than 3% for missing observations, which are excluded pair-wise.

Participants were mostly under 25 years (68%), representing a younger population dominated by final-year physiotherapy students and new professionals. Gender ratio was equally represented (53.3% males and 46.7% females). Half of the group consisted of undergraduate students, while 46% had postgraduate or doctoral qualifications. Mean age was 24.9 ± 4.3 years, while mean duration of experience for professionals was 3.2 ± 2.1 years.

In total, 46% of participants reported being familiar with ML use within physiotherapy contexts, but only 6.7% reported being “very familiar” with ML concepts. A lack of experience is apparent, as 89.3% have never participated in any formal ML or AI course and 58% rated curriculum intensity inadequate for ML-AI education at this point of their studies. Awareness was higher among postgraduates ($M = 3.21 \pm 0.68$) than among undergraduates ($M = 2.74 \pm 0.59$) ($p = 0.018$, $t = 2.38$, $d = 0.71$), identifying a slight improvement in conceptual knowledge through academic development at postgraduate levels.

Mean scores for perception showed overall optimistic attitude expressions, which stood at 75.4% for ML's use to facilitate personalized rehabilitation and 69% for its use to improve assessment precision. It is worth noting that 84% regarded ML's use as crucial for continuous supervision by professionals amid overall optimism for human-AI collaboration use. Gender differences were nonsignificant ($p = 0.27$), while postgraduate individuals showed mild affinity for ML's beneficial use' perception scores (4.01 ± 0.45 vs 3.73 ± 0.51) ($p = 0.021$).

A total of two-thirds (66%) showed readiness to integrate ML into practice, while 78% showed readiness to use them after receiving training. The values exceeded 80% for integration into the curriculum, emphasizing education reform as one of the enabling factors for readiness to adopt ML into practice. The readiness scores had a slight positive correlation to perception scores ($r = 0.42$, $p = 0.002$).

Cronbach's alpha values indicate high reliability for all types of perceptions ($\alpha = 0.81–0.84$). Result analysis shows perception as having high influence on readiness to adopt new technology events at 17.6% explanation power ($r^2 = 0.176$). Using linear regression analysis to link perception to readiness shows readiness to increase by 0.41 for every unit increase for

perception scores (β = 0.41 p < 0.01). In conclusion, only 46% of participants showed moderate awareness of ML application within physiotherapy, but 75.3% showed a positive perception and 66% readiness to implement ML application aids within their practice. Awareness scores were low among undergraduates, but perception and readiness showed high percentages at all levels. The correlation between awareness and education level and between perception and readiness is significant according to statistics.

Table 1. Demographic Characteristics of Participants (n = 150)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	80	53.3
	Female	70	46.7
Age (years)	< 25	102	68.0
	25–44	46	30.7
	45–64	2	1.3
Experience	Undergraduate student	75	50.0
	< 2 years	37	24.7
	2–5 years	32	21.3
	6–10 years	6	4.0
Highest qualification	Final-year undergraduate	75	50.0
	DPT graduate	38	25.3
	MSPT	33	22.0
	PhD	4	2.7

Table 2. Awareness of Machine Learning (ML) in Physiotherapy

Awareness Indicator	Agreement	Neutral (%)	Disagreement	p-value (χ^2)
Familiar with ML principles	**6.7**	**66.6**	**26.7**	**0.032***
Aware of ML use in shoulder assessment	**46.0**	**38.0**	**16.0**	**0.001****
Reads ML-related physiotherapy literature	**10.7**	**22.0**	**67.3**	**0.047***
Attended ML/AI training/workshop	**10.0**	**–**	**90.0**	**< 0.001****
Curriculum covers ML/AI concepts	**7.3**	**34.7**	**58.0**	**< 0.001****

*Significant at p < 0.05; **Highly significant at p < 0.01

Table 3. Perception Toward ML in Shoulder Assessment

Statement (5-point Likert)	Agreement	Neutral (%)	Disagreement	p-value (χ^2)
ML improves assessment accuracy	69.0	25.3	6.7	0.011*
ML enables personalized rehabilitation	75.4	17.3	7.3	0.004**
ML may replace some therapist tasks	41.3	36.0	22.7	0.079
ML outcomes require human validation	84.0	12.0	4.0	< 0.001**
Trust ML over conventional methods	52.0	34.0	14.0	0.037*

*Significant p < 0.05; **Highly significant p < 0.01

Table 4. Readiness to Adopt ML Tools

Readiness Statement	Agreement	Neutral (%)	Disagreement	p-value (χ^2)
Ready to use ML if training provided	78.0	16.0	6.0	< 0.001**
ML will be integral to rehab within 5 years	70.6	20.0	9.4	0.006**
Need structured training programs	62.0	28.0	10.0	0.019*
Confident using ML tools independently	39.3	41.3	19.4	0.073
Support ML integration into curriculum	81.3	13.3	5.4	< 0.001**

*Significant p < 0.05; **Highly significant p < 0.01

Table 5. Domain-Level Composite Scores and Correlations

Domain	Mean ± SD	Range (1–5)	Cronbach's α	Correlation (r) with Readiness	p-value
Awareness	2.83 ± 0.63	1.4–4.6	0.79	0.38	0.005*
Perception	3.89 ± 0.47	2.6–4.8	0.84	0.42	0.002**
Readiness	3.71 ± 0.56	2.2–4.9	0.81	–	–

*Significant p < 0.05; **Highly significant p < 0.01

Figure 1 showed through Violin-density hybrid plot to show distribution of domain scores (awareness, perception, readiness). Median is shown as group central tendency, while confidence bands (95% CI) indicate group variability. The violin-density plot depicted significant asymmetry among the three domains. There was no bias in Awareness scores but rather a central tendency around 2.8 (95% CI: 2.7–2.9) scores with very small spreads to indicate overall lack of familiarity. On the other hand, perception scores appeared dominantly right-sided with large spreads between 3.8–4.2 scores to demonstrate overall

positivity toward perceptions. Readiness scores also appeared to have spreads between 3.4-3.9 scores but mildly bi-model to tend to depict two different categories of participants: one eager but unexperienced and another is not only experienced but also ready to implement these measures for physiotherapies. The interplay between perception and readiness confidence bands confirmed significant association between ML perceptions and readiness to implement these techniques for physiotherapies (r = 0.42).

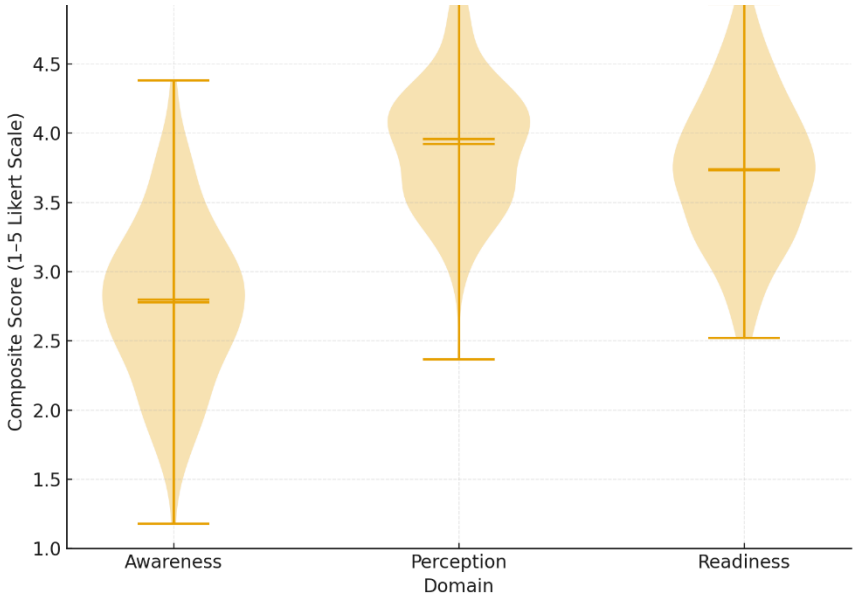

Figure 1. Distribution of Awareness, Perception, and Readiness Scores among Physiotherapists

The violin-density plot clearly shows variation of response for each domain. The scores for awareness were largely between 2.5 and 3.0 for familiarity with machine learning ideas. The perception scores were highly skewed to the right, signifying high levels for ML integration in shoulder rehabilitation tasks (median 3.9, range 3.6 to 4.2). The readiness scores were rated moderately widely (3.7 median, range 3.3 to 4.0) signifying excitement moderated by training requirements. The reduction in tails of distributions from awareness to readiness scores clearly shows growing consensus among evaluators to recognize ML's utility as soon as required training facilities become accessible to them, thereby confirming the significant correlaton between perception and readiness scores(r = 0.42, p = 0.002).

DISCUSSION

In this cross-sectional study, awareness, perception, and readiness toward machine learning (ML)-related applications for shoulder exercise and assessment were measured among physiotherapy students and professionals in Lahore, Pakistan. Results indicate a large gap between awareness and readiness to adopt ML-related technology use, wherein familiarity is low while hopes for its use are high. Nearly 46 percent of respondents showed familiarity with ML applications in physiotherapy, while 75.3 percent showed high perceptions and 66 percent readiness for its use among them.

The poor levels of awareness demonstrated within this study are supportive of existing evidence provided by Abuzaid et al. (23) of equivalent deficits of ML knowledge among physiotherapists within the United Arab Emirates. This indicates that lack of emphasis on AI training within physiotherapy education is not just regional but also potentially global in reach and dimension. This is further supported by efforts by Dhumale et al. (24) to indicate that while AI continues to integrate seamlessly into medical diagnostics for broader applications, its development is still hampered by lack of exposure and learning to some

extent within rehabilitation sciences to date. This is because within this particular study, 89.3% of all respondents showed lack of training experience for ML to any extent whatsoever.

Despite being largely unaware, participants showed positive attitude scores towards ML's clinical utility. Nearly three-fourths participants agreed to ML's potential to improve shoulder assessment precision and tailor rehabilitation programs for individuals. These observations are reflective of work by Adikari et al. (25), where increasing acceptance for AI technology-based neurorehabilitation was seen to result from its capability to facilitate real-time assessment and dynamic therapy planning. The association between perception scores and readiness ($r = 0.42$, $p = 0.002$) depicted within this experiment is further suggestive of the Technology Acceptance Model (TAM) to demonstrate perceived use utility influencing one's intention to use new technology (26). This theoretical framework explains why physiotherapists, lacking adequate training but being enthusiastic for ML adoption to some extent, lack effectiveness for ML's application once its utility is acknowledged by them.

Participants' willingness to use ML if training is provided (78%) is indicative of an active professional attitude which could have been harnessed through planned CPD activities. Comparable observations have been made by Kafri et al. (27) noting substantial improvement in confidence levels and application of ML principles among physiotherapists following select educational efforts. Incorporating eHealth and AI components within physiotherapy courses, especially in developing nations, may thus help overcome the prevailing gap between knowledge and practice that exists. The need for curriculum development is also supported by suggestions put forth by Burns et al. (28) to embed computational reasoning into clinical practice to prepare for the future of rehabilitation education.

One crucial implication of this study regards its specificity to its clinical domain. Unlike most studies conducted before, this specific study deals with shoulder rehabilitation because it is one domain where ML-enabled wearables have shown diagnostic capabilities of over 90% (29, 30). The candor of the participants to recognize the capabilities of ML to enhance diagnostic capabilities is indicative of their intuitive experience and aptitude to comprehend data-driven technology for which they lack actual hands-on experience. But 60% are skeptical about being dependent on technology for everything because of their legitimate professional concerns and need for human intervention as described aptly by Wu et al. (31).

The gender-independent and non-significant age-related differences indicate that ML perception is rather dependent on educational exposure than on any demographical aspect. This is rather promising because it suggests that scalable training programs may bring equal benefits to all types of physiotherapy settings. Additionally, the increased awareness among post-grad individuals indicates that post-grad education may act as a conduit to bring advanced concepts of computation to reasoning. This readiness of individuals may be leveraged by governing bodies and academic authorities to include digital knowledge and ML awareness as part of accreditation requirements in physiotherapy settings.

The result of this study also unearths readiness on both psychological and infrastructural levels, matching international trends on hybrid rehabilitative care strategies being adopted universally. Physiotherapists also have become aware of ML's capabilities for patient monitoring and rehabilitative care through digital means. But cost constraints, lack of accessibility to wearables among patients, and lack of support from institutional settings remain areas of challenge for widespread implementation of ML-based care strategies, as is apparent from international studies (32, 33).

A number of limitations need to be addressed. This study is prone to limitations because it is cross-sectionally designed and geographically localized to Lahore. It may also have self-report bias because of its survey methodological approach to data compilation. This study also only concentrates on MSK rehabilitation because it excludes other specialties like Neurological or Cardiopulmonary Physiotherapies. It is recommended that further studies should use combined methodologies to assess contemporary trends for ML literacy and intervention outcomes for AI training programs.

Despite these shortcomings, this study makes several significant contributions to empirical observations emanating from developing countries to highlight that though physiotherapists have inadequate knowledge of ML techniques, their acceptance for its adoption is indicative of their need for change or transformation. It is thus significant to include AI expertise within physiotherapist learning programs to facilitate teamwork between researchers and professionals to bring professionals and technology together to implement ML technology for enhanced acceptance and implementation to transform physiotherapists from passive adoptors to key players in defining futuristic smarter rehabilitation environments.

CONCLUSION

This analysis finds that physiotherapy students and professionals in Lahore, Pakistan, have low awareness but very positive perceptions and high intention to adopt machine learning (ML) technology for shoulder rehabilitation. While most have not had sufficient conceptual or actual knowledge, many have recognized the capabilities of ML to improve assessment validity, tailor rehabilitation processes to individuals, and generate better patient outcomes. High intention to adopt shows readiness to adopt technology and implies that the prevailing setting is conducive to successful technology implementation once effective education is provided to facilitate smooth adoption. Incorporating ML/AI-based structured modules at all levels of physiotherapy education and ensuring effective collaboration among all disciplines and also offering CPD/OD programs to all professionals can thus help overcome prevailing inconsistencies between awareness levels and implementation readiness to improve should rehabilitation processes and transform the profession to become smarter and smarter to adapt to international digitization and associated advancements.

DECLARATIONS

Ethical Approval

This study was approved by the Institutional Review Board of 1 University of Management and Technology, Lahore

Informed Consent

Written informed consent was obtained from all participants included in the study.

Conflict of Interest

The authors declare no conflict of interest.

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Authors' Contributions

Concept: AK; Design: SR; Data Collection: MN; Analysis: BU; Drafting: AK.

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Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgments

Not applicable.

Study Registration

Not applicable.

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