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# MyofAPPcial: Construct validity of a novel technological aid for improving clinical reasoning in the management of myofascial pain syndrome

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## Abstract

**Background:** Physiotherapists encounter challenges in diagnosing myofascial trigger points (MTrPs), which are crucial for managing myofascial pain but difficult due to their complex referred pain patterns. We aimed to assess if an interactive software (MyofAPPcial) can enhance the ability of physical therapists specialized in musculoskeletal disorders (as clinicians and as researchers and educators) to identify referred pain patterns associated with specific MTrPs and to explore their opinion about incorporating this technology regularly into their professional setting.

**Methods:** After developing the app, a descriptive cross-sectional survey study was conducted. Participants were asked about their demographic characteristics, professional experience, two knowledge tests (first without and later with MyofAPPcial support) and the 18-item mHealth app usability questionnaire.

**Results:** Fifty-nine participants completed the survey (47.5% clinicians and 62.5% researchers/educators). Groups were comparable in terms of age, gender and professional experience ($p > .05$). However, clinicians coursed shorter specific MPS trainings ($p = .007$) and handle more cases a week ($p < .001$). In the first knowledge test, participants in both the groups were more accurate in identifying pain maps of highly prevalent MTrPs than those with a moderate or low prevalence ($p < .001$), with no differences between the groups for individual items (all, $p > .05$) nor the total score ($p > .05$). In the second knowledge test, perfect scores were obtained for all items in both the groups. Finally, MyofAPPcial scored high satisfaction and app usefulness, with no difference between clinicians and researchers/educators (except greater convenience of use for researchers/educators $p = .02$).

**Conclusions:** MyofAPPcial enhances physiotherapists' ability to accurately identify MTrPs, with a good acceptation among clinicians and researchers/educators.

**KEYWORDS**

machine learning, medical education, myofascial pain syndrome, myofascial trigger points

## 1 | INTRODUCTION

Myofascial pain syndrome (MPS) is a noninflammatory and regional musculoskeletal pain condition affecting approximately a 37% of adults aged 30–60 (65% in women, 37% in men) and reaching a prevalence of 85% in older adults.[1] It is characterized by the presence of myofascial trigger points (MTrPs), hyperirritable spots in muscle or fascia causing pain, referred pain, motor dysfunction and autonomic phenomena.[2,3] These MTrPs are painful upon stimulation, often feature a referred pain pattern and are classified as active or latent, depending on their relevance to the patient's clinical presentation (active MTrPs reproduce the patient's symptoms upon stimulation, while latent MTrPs do not).[4,5] In fact, even if a key difference between active and latent MTrPs is that active MTrPs are related to spontaneous and continuous pain over time while latent MTrPs are painful only if stimulated, the presence of spontaneous pain during the clinical examination is not essential as several pain conditions exhibit fluctuating symptoms, meaning that patients may be asymptomatic at the moment of the visit.[4]

Although the clinical manifestations, the most affected muscles and risk factors are well known,[6–9] the subjacent pathophysiology remains uncertain. For this reason, even if multiple diagnostic modalities have been proposed for evaluating MTrPs (e.g. ultrasound imaging modalities, microdyalisis, electromyography and magnetic resonance imaging),[5,9] the current reference standard is the manual palpation.[10] However, manual palpation is highly subjective and depends on the pain response of the patients and the examiners' clinical experience, palpation skills and training.[11] Consequently to the lack of a reference standard, a review of the diagnostic criteria applied in published clinical trials concluded that up to 23 combinations of diagnostic criteria have been applied to diagnose MPS, finding that only 22% of the studies adhered to the recommended diagnostic criteria (spot tenderness, referred pain and local twitch response), reproducing either totally or partially the symptoms of the patient.[5]

Given the diverse referred pain patterns elicited by each MTrP and the plethora of pain patterns identified within the existing literature, clinicians often face significant challenges in correlating a patient's described pain distribution with a specific muscle.[12,13] This complexity not only hampers the diagnostic process but also adds layers of difficulty to initiating the appropriate manual palpation techniques for diagnosis, especially in clinicians with less experience in this field.[14] The nuanced understanding required to match pain patterns with potential myofascial origins demands not only a deep anatomical knowledge but also a refined skill set in manual palpation and memorization of +300 pain distribution maps,[15] making accurate diagnosis a sophisticated and often time-consuming endeavour. This intricacy underscores the necessity for enhanced diagnostic tools and training programs to aid clinicians in guiding the complexities of MPS diagnosis, facilitating a more precise and efficient pathway to define treatment strategies.

Therefore, this study aimed to assess if a novel interactive software (MyofAPPcial), designed to assist in identifying referred pain patterns associated with specific MTrPs by comparing patient data with a comprehensive image database using machine learning, can enhance the ability of physical therapists specialized in musculoskeletal disorders across various sectors (research, education and clinical practice) to correctly identify referred pain patterns associated with specific MTrPs described in the literature[14] and to explore their opinion about incorporating this technology regularly into their professional setting, its utility and ease of use. As secondary objectives, the study aimed to compare the accuracy rates of clinicians versus educators/researchers in identifying MTrPs associated with the pain distribution maps provided, considering MTrPs that are highly, moderately and rarely prevalent in clinical settings and to compare their opinion.

# 2 | METHODS

## 2.1 | Study design

A descriptive cross-sectional survey study was conducted between November 2023 and April 2024 through a nationwide online survey targeting physical therapists engaged in the management of MPS either in the clinical practice and research and education fields.

Adherence to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES)[16] was ensured to maintain the quality of the report as provides standardized guidelines that ensure thorough and transparent reporting including detailed information on survey design, administration, data analysis and ethical considerations. Furthermore, the study protocol received revision and approval from the Local Ethics Committee of Rey Juan Carlos University. An informed consent document was prepared, detailing the survey duration (approximately 6 min), data storage locations, information regarding the researchers conducting the study and the survey's objectives.

## 2.2 | Participants

To participate in the study, physical therapists needed to be licensed by a Professional Association of Physical Therapists and currently practising in Spain. Clinically employed physiotherapists were eligible if they worked in private clinics, public health services (including primary and specialized care), or mutual insurance companies, with a focus on musculoskeletal rehabilitation. Researchers and educators were also eligible if they were employed at private or public universities and specialized in musculoskeletal rehabilitation.

Two references were used to estimate the appropriate sample size for this study. First, published studies with similar design and outcomes analysed groups of users ranging between 17[17,18] and 26 individuals,[19] with total sample sizes reaching up to 49 participants.[20] In addition, we followed the guidelines proposed by Viechtbauer et al.,[21] which suggest calculating the sample size based on the probability of detecting at least one occurrence of a problem with a specified level of confidence. For this study, the probability of encountering an unforeseen issue in a study participant was estimated at 5%, requiring a sample size of 59 participants to detect the problem with 95% confidence. This approach demonstrated to be appropriate for ensuring that our study has sufficient power to identify potential challenges in the implementation phase, thereby enabling necessary adjustments before conducting future clinical studies.

## 2.3 | Machine learning-based computer-aided software: MyofAPPcial tool

The 'MyofAPPcial' application was developed to be launched in the Apple Store (Apple Computer, Cupertino, CA, USA) and Google Play (Google, Mountain View, CA, USA). After accepting a brief information in a first welcome screen about how the app works, the user can start the data collection. First, a front view of a standardized body is displayed with a tool bar for selecting (1) the shadowing tool, (2) the size, (3) an option to undo the last trace, (4) an option to clear the body chart and (5) an option to continue to the back view of the body chart and finish the data collection. The front and back body charts views (Figure 1) consist of a canvas composed by two layers: a deep and a superficial one. The deep layer is a completely blank layer that serves as the base for shading the pain extent and distribution. It provides a clear, unobstructed view of the areas where pain is reported by the user. The superficial layer is placed on top of the deep layer and contains the actual body chart view. It is designed to be partially transparent within the body chart area. This transparency allows the user to see the deep layer underneath, which helps in accurately shadowing and visualizing the pain distribution. Outside the body chart area, the superficial layer is white, which hides any marks or pixels that might be drawn beyond the body chart boundaries, maintaining a clean and focused visualization of the pain area.

After completing the body chart, the app uses a machine learning process to compare the pattern described by the patient with a database of +300 images describing the pain distribution described for each MTrP. These maps are used to match the pain distribution reported by the patient with established patterns of pain associated with specific MTrPs described in the literature.[15] By comparing the patient's pain distribution with these maps, practitioners can determine which MTrPs might be involved and guide their physical examination accordingly. The validity of these maps was determined through empirical research and clinical validation.[15] This involves comparing the pain patterns depicted in the maps with those observed in actual patients and ensuring that the maps accurately reflect the pain distributions reported in clinical practice. These pain patterns have been validated through experimental research involving the injection of hypertonic saline into skeletal muscle, demonstrating that pain induced in specific muscles through such injections resulted in consistent referred pain patterns for each MTrP. In addition, the pain patterns observed in these studies were found to be deep, well-defined, and consistent among different

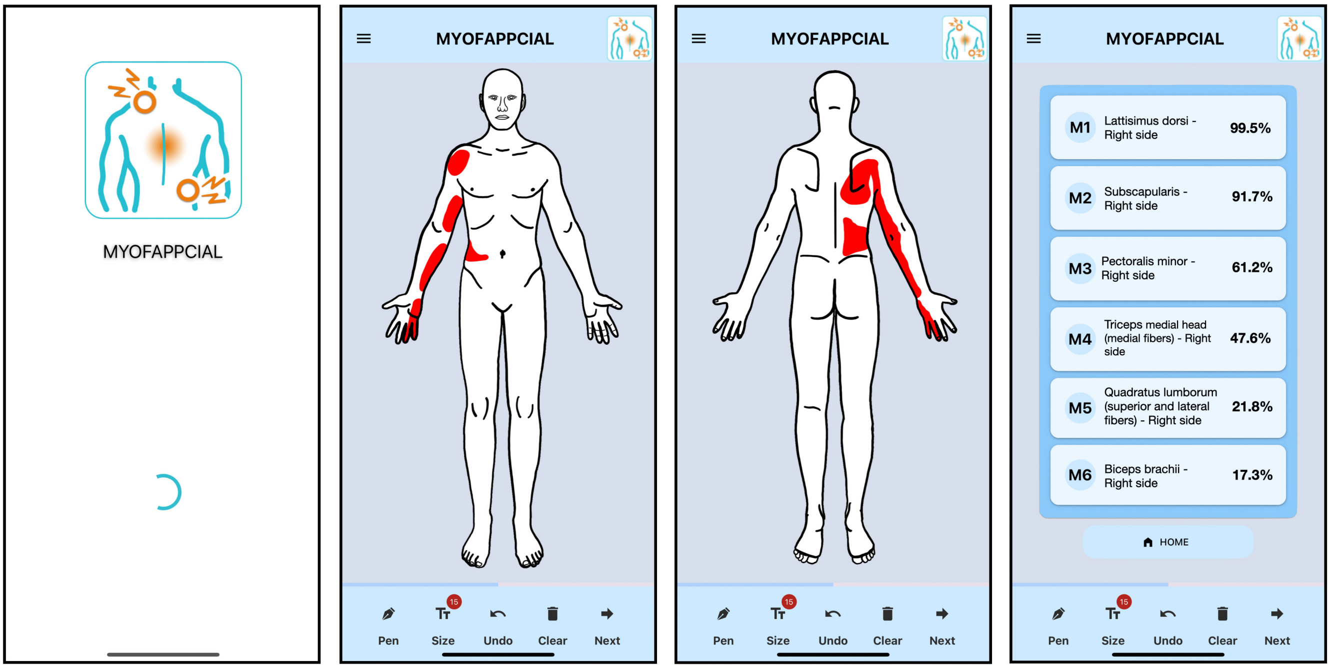


**FIGURE 1** Illustration of MyofAPPcial interface: Login screen, body charts and muscles list.

individuals, leading to the conclusion that referred muscle pain associated with MTrPs follows a predictable and similar pattern in different people.[22]

In clinical practice, the physical examination is guided by the patient's clinical history. The selection of muscles to palpate for identifying trigger points is primarily based on the pain distribution reported by the patient. During the examination, symptoms are provoked to determine if they reproduce the reported pain. This helps confirm whether the identified points are active or latent MTrPs.[15]

In the machine learning process, the input, which includes specific features such as the pain location and extent, is used as input data for a pre-trained model. This model has been trained on a labelled dataset using the pain patterns described in MPS manuals[15] where each image is associated with a MTrP and side. By analysing the input data against this labelled dataset, the model predicts the most likely muscles responsible for the described pain pattern. After this analysis, the app displays a list with the six structures showing the most likely muscles explaining that pain distribution and providing the similarity rate with the database (ready to export in a excel file if desired).

Since the application was not commercialized during the data collection, all surveyed participants received the same 12.9″ digital tablet (iPad Pro M2, Apple Computer, Cupertino, CA, USA) containing the app installed and one digital stylus (Apple Pencil 2nd generation, Apple Computer, Cupertino, CA, USA) for 48 h for testing it and prior to complete the survey.

## 2.4 | Survey development

The development of the survey instrument unfolded in two phases. Initially, the lead researcher crafted a preliminary version which was disseminated via the Google Forms platform (https://docs.google.com/forms/) for a pilot test involving a select group of 15 physiotherapists ($n=5$ working in the clinical setting, $n=5$ working in the research setting, and $n=5$ working in undergraduate and post-graduate education). This step aimed to identify and rectify any issues related to comprehension, usability and technical functionality prior to commencing the study. With no significant problems identified, the survey was finalized and made publicly available for data collection.

The survey was structured in a welcome note, an informed consent, a demographic information section including two items (age and gender), a clinical experience section including four items (years of clinical experience, hours of training in MPS, work setting and frequency of MPS cases handled per week), two sections including nine different hypothetical cases which correspond with pain distribution maps described in the literature and associated with specific MTrPs[15] (surveyed were asked to write in an open-text box the MTrP associated with that pain distribution, firstly without the software and later using the software), a section for rating the app using the mHealth app usability questionnaire (MAUQ), an open-ended feedback section and one acknowledgment paragraph for their participation. Table 1 summarizes the variables assessed and how were operationalized.

**TABLE 1** Summary of the survey structure.

| Variable | Operational definition |
|---|---|
| Demographic information | |
| Age | Quantitative—Years |
| Gender | Categorical—Male/female/not declared |
| Professional experience | |
| Years of clinical experience | Categorical—0–2 years/3–5 years/5–10 years/>10 years |
| Hours of training in MPS | Categorical—<59 h/60–99 h/>100 h |
| Work setting | Categorical—Clinical practitioner/researcher and educator |
| Frequency of MPS cases handled per week | Categorical—<5 cases/5–15 cases/15–25 cases/25–35 cases/>35 cases |
| Knowledge test | |
| Knowledge test without software support | Categorical—Correct/wrong (9 items) |
| Knowledge test with software support | Categorical—Correct/wrong (9 items) |
| mHealth app usability questionnaire (MAUQ) | |
| MAUQ—overall satisfaction | 7-point Likert scale—(5 items) |
| MAUQ—ease of use | 7-point Likert scale—(6 items) |
| MAUQ—access to information | 7-point Likert scale—(4 items) |
| MAUQ—convenience of use | 7-point Likert scale—(3 items) |

The MAUQ is an 18-item questionnaire developed to evaluate the usability of mobile health applications.[23] It is distributed across four subscales reflecting specific aspects of usability such as satisfaction and usefulness (user's overall satisfaction with the app and its perceived utility), ease of use (how intuitive and straightforward the app is to use, including learning to use the app and navigating between screens), access to information and errors (how well the app provides access to the necessary information and how it handles errors, including recovery from mistakes) and convenience of use (including comfort in using the app in the users' working setting, the appropriateness of the time involved in using the app, and the likelihood of continued use). All responses are rated in a 7-point Likert scale for responses, ranging from 1 (strongly disagree) to 7 (strongly agree) and final scores are calculated as the mean average of all items. This questionnaire was selected since it showed a high internal consistency (Cronbach's $\alpha = 0.89$), stablished content validity (Item-level Content Validity Index >0.79) and excellent inter-rater reliability ($\kappa = 0.78$–$1.02$), indicating that this questionnaire is relevant, clear and comprehensible.[24]

Regarding the knowledge test, it was divided in two different sections (first, surveyed participants were asked to complete this knowledge test without the use of the software and later using the software). In each one, nine maps representing the pain distribution patterns caused by nine MTrPs were provided: three highly prevalent, three moderately prevalent and three rarely prevalent among musculoskeletal conditions (the selection was made based on descriptive studies and reviews reporting the prevalence of active MTrP[1,25–29]). By including pain maps with different levels of prevalence, the study also aims to analyse how familiar clinicians and researchers/educators are with these pain distribution patterns. This aspect of the study evaluates their ability to identify and interpret both common and less common pain patterns, providing insight into their familiarity and experience with MTrP-related pain maps. In addition, this varied selection allows for a broad assessment of the MyofAPPcial software's performance across different types of MTrPs, from those commonly encountered in clinical practice to those less frequently observed. This ensures that the software's utility is tested across a spectrum of pain distribution patterns.

Considering that referred pain maps associated with each MTrP are well-documented in the literature,[15] in the context of this study, a correct identification of the MTrP is determined based on whether it matches the pain map described for that specific MTrP in the literature. Answers were considered correct only if the correct muscle, portion and side was entered in the open-text box. During the second attempt, participants had to replicate the pain distribution pattern in the app and select, from the list of 6 muscles provided, the structure showing the highest similarity rate.

## 2.5 | Statistical analysis

Data collected via Google Forms were transferred to the SPSS software v.29.0.1.1 for Mac OS for analysis. The initial step involved employing Kolmogorov–Smirnov tests and histograms to assess the normality of the quantitative data distribution (age and MAUQ scores). A $p$-value >.05 was considered as a normal distribution. Subsequently, descriptive statistics for the physiotherapists' responses were compiled for the entire cohort and segmented according to their working setting. This decision was made to analyse if there are knowledge differences between settings (as researchers/educators might be more familiar with theoretical concepts less familiar in the clinical setting) and to identify the field where the app could be most appreciated. Pearson's chi-square tests were used to compare (1) the gender representation, professional experience, training in MPS and frequency of MPS cases handled per week between clinicians and researchers/educators; (2) success rate for the correct identification of MTrPs before and after the use of MyofAPPcial; and (3) success rate for the correct identification of MTrPs between clinicians and researchers/educators. Student's *t*-tests were applied to determine age and MAUQ scores differences between clinicians and researchers/educators. All statistical procedures were two-tailed and executed with a 95% confidence interval, considering *p*-values <.05 indicative of statistical significance.

## 3 | RESULTS

A total of 59 completed surveys were received (comprising 68% females; average age: 41.4 years, with a standard deviation of 6.4 years), with any response being excluded for the analyses. As physical therapists were not sent individual invitations; instead, the survey was advertised on the websites and social media platforms, it was impossible to determine the total number of professionals who saw these announcements, making the calculation of response and click-through rates unfeasible.

As summarized in Table 2, 47.5% of the surveyed sample were clinical practitioners ($n=28$) and 62.5% were researchers and educators. No statistically significant differences were found between both the groups ($p>.05$) in terms of age, gender or professional experience. However, the results revealed that researchers and educators had undertaken longer MPS postgraduate trainings in comparison with clinical practitioners ($p=.007$). While 75% of clinicians received trainings <59 h, more than the half of researchers completed trainings of, at least, 60 h. Additionally, a significant difference ($p<.001$) was found regarding the handling frequency of cases suffering MPS. While only 40% of researchers handle less than 15 cases a week, >80% of clinicians handle more this volume.

Table 3 contains the results of the brief knowledge test assessing their ability to link standard pain distribution pattern templates to the specific structures allocating MTrPs. The results revealed that, without the use of a software, there were statistically significant differences between the success ratio of identifying the pain distribution map of highly, moderately and rarely prevalent MTrPs in each group (both, $p<.001$). In both the groups, participants were more accurate identifying pain maps of highly prevalent MTrPs than those with a moderate or low prevalence. After analysing the success ratio difference for each item between both the groups without the use of MyofAPPcial, no significant differences were found for any individual item (all, $p>.05$) or the total score ($p>.05$).

**TABLE 2** Surveyed physiotherapists' profile: Demographic and professional information.

| | Total sample ($n=59$) | Clinical practitioners ($n=28$) | Researchers and educators ($n=31$) | *p* value |
|---|---|---|---|---|
| Demographic characteristics | | | | |
| Age (years) | 41.4 ± 6.4 | 41.6 ± 6.8 | 41.2 ± 6.1 | .68 |
| Females (%) | 67.8 | 71.4 | 64.5 | .25 |
| Professional characteristics | | | | |
| Professional experience (%) | | | | .85 |
| 0–2 years | 35.6 | 39.3 | 32.3 | |
| 3–5 years | 30.5 | 28.6 | 32.3 | |
| 5–10 years | 28.8 | 28.6 | 29.0 | |
| +10 years | 5.1 | 3.6 | 6.5 | |
| Training in myofascial pain syndrome (%) | | | | |
| <59 h | 61.0 | 75.0 | 48.4 | <.01 |
| 60–99 h | 16.9 | 14.3 | 19.4 | |
| >100 h | 22.0 | 10.7 | 32.3 | |
| Frequency of myofascial pain syndrome cases handled (%) | | | | |
| 0–5 cases/week | 15.3 | 3.6 | 25.8 | <.001 |
| 5–15 cases/week | 23.7 | 10.7 | 35.5 | |
| 15–25 cases/week | 25.4 | 21.4 | 29.0 | |
| 25–35 cases/week | 25.4 | 42.9 | 9.7 | |
| +35 cases/week | 10.2 | 21.4 | .0 | |

In the second knowledge test with MyofAPPcial support (Table 3), results revealed perfect scores in both the groups for each item. While providing traditional between-group differences *p*-values is not possible in this case, the data strongly suggests that MyofAPPcial support leads to perfect performance in this context, a substantial improvement over the no software support condition.

Finally, the opinion of MyofAPPcial users rating their satisfaction and the app usefulness, ease of use, access to the information, errors and convenience of use is available in Table 4. The overall satisfaction reported was 5.85 points out of 7, indicating a very good acceptation among the users. The satisfaction, usefulness, ease of use and convenience were the main strengths aspects of the app with average scores of >6 points. The most notable limitation was the app use with poor or not available internet connection (1.98 points). The comparison between both the groups also provided interesting information. The significant differences found for the convenience of use perceptions ($p = .02$) demonstrated that, even if both groups reported more than 6 points in this subscale, the potential utility of this app would receive more acceptation among researchers and educators in comparison with clinicians. However, both groups reported comparable scores in terms of satisfaction, usefulness, ease of use, access to the information and errors (all, $p > .05$).

# 4 | DISCUSSION

## 4.1 | Key findings

The objective of this study was to investigate whether physiotherapists specializing in musculoskeletal disorders across various environments (research, education and clinical practice) could enhance their accuracy for correctly identifying MTrPs associated to specific pain distribution patterns (which each one is described to be different for each MTrP in patients with MPS) by using a novel software compatible with mobile phones and tablets using iOS or Android. For this purpose, this is the first study examining a software's impact on physiotherapists' ability to pinpoint MTrPs using interactive pain distribution maps and determining their willingness to incorporate this technology into their regular practice.

In general, the participants who completed the survey and the knowledge test were considerably heterogeneous in terms of professional experience, training in MPS and frequency of weekly cases handled. The findings indicated that most physiotherapists, regardless of their work environment, successfully identified the pain distribution maps of highly prevalent MTrPs. However, physiotherapists generally have serious flaws to identify the pain distribution maps of moderately and rarely prevalent MTrPs as reflected by the low success rates in the test. Although no significant differences were found, researchers and

**TABLE 3** Surveyed physiotherapists' success rate for identifying correctly the myofascial trigger point location.

| | No software support ($n = 59$) | | | MyofAPPcial support ($n = 59$) | | |
|---|---|---|---|---|---|---|
| | Clinical practitioners ($n = 28$) | Researchers and educators ($n = 31$) | *p* value | Clinical practitioners ($n = 28$) | Researchers and educators ($n = 31$) | *p* value |
| Highly prevalent MTrPs | | | | | | |
| Item 1 (success ratio) | 85.7 | 93.5 | .57 | 100.0 | 100.0 | 1.00 |
| Item 2 (success ratio) | 71.4 | 80.6 | .60 | 100.0 | 100.0 | 1.00 |
| Item 3 (success ratio) | 78.6 | 83.9 | .85 | 100.0 | 100.0 | 1.00 |
| Moderately prevalent MTrPs | | | | | | |
| Item 4 (success ratio) | 46.4 | 61.3 | .38 | 100.0 | 100.0 | 1.00 |
| Item 5 (success ratio) | 57.1 | 58.1 | 1.00 | 100.0 | 100.0 | 1.00 |
| Item 6 (success ratio) | 50.0 | 54.8 | .91 | 100.0 | 100.0 | 1.00 |
| Rarely prevalent MTrPs | | | | | | |
| Item 7 (success ratio) | 14.3 | 22.6 | .63 | 100.0 | 100.0 | 1.00 |
| Item 8 (success ratio) | 7.1 | 16.1 | .51 | 100.0 | 100.0 | 1.00 |
| Item 9 (success ratio) | 17.9 | 25.8 | .67 | 100.0 | 100.0 | 1.00 |
| Total score | | | | | | |
| Average (success ratio) | 47.6 | 55.2 | .70 | 100.0 | 100.0 | 1.00 |

*Note*: Values are mean ± standard deviation for test scores.

educators achieved slightly better results in this context, possibly due to their greater familiarity with these theoretical concepts, which are infrequently seen in clinical practice.

The feedback from the surveys not only highlights the app's practical benefits but also validates the pressing need for such technological solutions in physiotherapy practice. Both clinicians and researchers/educators, expressed a high level of satisfaction and found the diagnostic app generally useful across multiple dimensions of their professional activities. Overall satisfaction with the app was consistently positive, indicating its potential to enhance patient care by aiding in the identification of MTrPs. Most notably, the support provided during diagnosis was highly valued, highlighting the app's role in improving diagnostic confidence. The ease of use of the app was another strong point, with users reporting it was straightforward to operate and learn. This suggests that the app's design is user-friendly, contributing to its effective integration into clinical and academic settings. However, while the interface and information organization were well-received, there was a slight preference among those with more academic roles, possibly due to their familiarity with navigating digital tools in theoretical and educational contexts.

Interestingly, despite the overall positive feedback, the app's performance was significantly weaker in scenarios of poor or no internet connectivity. This limitation is critical, as it can hinder the app's utility in less technologically equipped environments or in situations where reliable internet is an issue. In terms of errors and information access, users felt that the app handled mistakes well, allowing for easy correction and continuation of use. This aspect of the app is essential for maintaining workflow efficiency and minimizing frustration during use. Finally, the app was considered convenient for professional use, with most users indicating a willingness to use the app again. This reflects the app's successful alignment with the practical needs and time constraints of its users, suggesting it is a viable tool for ongoing use in clinical and educational settings.

Finally, we included an open-ended feedback section in the survey allowing participants to express their thoughts and experiences more freely. By doing so, we aimed to supplement our quantitative findings with in-depth qualitative data, achieving a mixed-methods approach within the survey framework. However, none of the participants provided a response in this open-ended feedback section. A likely reason explaining this is that participants might have felt that the closed-ended questions sufficiently captured their views, reducing the perceived need to provide additional comments.

### 4.2 | Implications for the clinical practice

Pain is a complex experience as described by the International Association for the Study of Pain (IASP)[30] and consequently, accurate assessments are needed. Contemporary guidelines advocate for evaluating both sensory and affective characteristics of pain.[31,32] This includes not only the intensity of pain,[33] but also its affect (how disturbing or unpleasant the pain is perceived)[34] and its perceptual qualities (the subjective experience of how the pain feels).[35] Various patient-reported outcome measures are used to assess these attributes, each offering different levels of validity, reliability, specificity and sensitivity.[36] Moreover, the collection of data on the temporal characteristics of pain (i.e. pain onset, variability and modifying factors) is deemed highly valuable for diagnosis.[37] Finally, the assessment of pain extent (the overall area affected by pain) and distribution (areas where the pain is felt) provides crucial information for recognizing shifts from localized to more generalized and widespread pain[38,39] and may help in determining the underlying causes of pain and its clinical impact.[40]

Pain drawings can serve as a standardized and effective tool for assessing an individual's pain distribution and extent, providing a reliable and valid method for clinical evaluation.[41] Additionally, the use of digital instruments recently developed showed to be highly reliable (intraclass correlation coefficient = .983; standard error of measurement = .26%; minimal detectable changes = .72% and coefficient of variation = .17%) as demonstrated by several advantages compared with classic paper-and-pencil methods such as higher accuracy and reliability (higher reliability based on intraclass correlation coefficients and better accuracy to discriminate real changes over the time from measurement errors based on minimal detectable changes), ease and agility of use (facilitating quicker assessments suitable for both clinical and research settings) and enhanced diagnostic utility as digital methods provide immediate automatic calculations of pain extent (eliminating the need for manual processing).[42] Moreover, these tools improve data management by streamlining data collection and integration with electronic health records, enhancing patient care continuity and outcome tracking.[42]

Understanding the pain distribution in MPS is essential to discriminate the underlying structure allocating the active MTrP causing pain.[43] Muscle referred pain is a key indicator described as a result of central sensitization that begins with peripheral events and is exacerbated and maintained through enhanced sympathetic activity and dysfunctional descending pain inhibition.[44] This process allows for an understanding that the anatomical basis of referred pain is located in the spinal cord (central nervous system), and results from the activation of dormant axonal connections from peripheral nerves, which are stimulated by painful input from the periphery (a phenomenon that can occur within seconds) and connect to dorsal horn neurons.[45]

In addition, referred pain can be used as a discriminator of nociceptive (traditionally proposed by the IASP) or nociplastic pain phenotypes.[7,46] Nociceptive pain patterns are typically discrete and confined to specific regions.[7] Although categorized as regional, somatic pain can manifest as dull, deep and poorly localized, contrasting with the superficial and precise sensation of a pinprick.[7] This type of pain often intensifies or alleviate with specific movements, diets or psychological.[47] Despite potentially presenting as dull and poorly localized pain, a patient can usually pinpoint an area of discomfort with a single finger. When an examiner palpates these muscles, they can often detect a small, intensely painful spot that triggers a referred pain pattern in a distant area. This referred pain is neuroanatomically aligned, stemming from the activation of dormant neurons in the spinal cord and adhering to known peripheral nerve patterns.[48,49] For instance, MTrPs in a muscle served by the $C_5$ nerve typically refer pain within the distribution of the $C_5$ nerve, although due to the branching of afferent nerves in the spinal cord, the pain may also present in the areas served by the $C_4$, $C_5$ and $C_6$ nerves and dermatomes. In cases of MPS attributed to MTrPs, patients typically exhibit a nociceptive pain phenotype. Recent research indicates that referred pain from active MTrPs can replicate symptoms common to several chronic localized pain conditions, such as neck, upper thoracic, shoulder, lateral elbow and patellofemoral pain.[7]

Nociplastic pain, on the other hand, is more generalized or widespread compared to nociceptive pain and is found in certain musculoskeletal pain syndromes such as fibromyalgia (which is considered the reference standard of central sensitization).[50] Patients with fibromyalgia typically experience widespread pain, a primary characteristic of the condition, along with other symptoms.[51] Preliminary studies have suggested that the widespread pain identified in fibromyalgia may be reproduced by referred pain from multiple active MTrPs (which are highly prevalent in this condition).[52] These findings have led some researchers to question whether fibromyalgia might stem from multiple MTrPs or if the MTrPs seen in fibromyalgia represent a manifestation of central sensitization.[7] In this context, it is posited that myofascial MTrP pain and fibromyalgia may represent two extremes on the same clinical spectrum.

Considering the importance of pain extent and distribution in MPS, these findings are directly relevant to our work, as they reinforce the need of technology and data-driven approaches in enhancing an accurate identification of MTrPs based on the pain patterns. Improving the ability to match pain patterns with MTrP may involve improvements in clinical decision-making and treatment plans. Furthermore, the differences in MPS knowledge between clinicians and researchers/educators underscore the need for targeted educational initiatives to bridge this gap, ensuring that both groups can effectively utilize tools like MyofAPPcial in clinical practice.

### 4.3 | Limitations

Although this study represents a significant initial effort in developing a technological diagnostic aid for MPS, several limitations must be acknowledged. The primary limitation of this study is its focus on exploring potential acceptance among physiotherapists in different work settings, while the actual utility of the developed application remains speculative. The study included only reference distribution maps in its methodology, which may not fully represent the complex and varied pain distributions that patients may describe. These reference maps are standardized and may not capture the individual variations often seen during the clinical practice, needing further research to test how the machine learning algorithm is successful in this case. Consequently, further empirical research involving the application's use in real-world settings is necessary to evaluate its true diagnostic accuracy comprehensively. This step is crucial to ensure that the tool can reliably assist clinicians in identifying and managing MPS effectively, accommodating the wide range of pain patterns that patients may present.

Even if a heterogeneous sample participated in the study, another significant limitation which may impact the generalizability of the findings is the relatively small sample size. Therefore, the results should be interpreted cautiously until they can be validated by a larger sample size that include a broader spectrum of participants from various geographic locations and practice settings. In addition, the inability to determine the exposure and response rates introduces a risk of bias. If the survey was only seen by a subset of the target population or if certain groups were more likely to respond, the results might not be representative of the entire population of physical therapists.

## 5 | CONCLUSION

This study evaluated the efficacy of the MyofAPPcial, a novel machine learning-based application, in improving the physiotherapists' ability (including a sample of heterogeneous sample of researchers, educators and clinicians)

**TABLE 4** MyofAPPcial users' opinion: Evaluation of satisfaction, usefulness, ease of use, access to the information, errors and convenience of use.

| | Total sample ($n$ = 59) | Clinicians ($n$ = 28) | Researchers and educators ($n$ = 31) | Between-group differences |
|---|---|---|---|---|
| Satisfaction and usefulness (1–7) | **6.14 ± .15** | **6.09 ± .19** | **6.19 ± .09** | **−.10 (−.31, .11) $p$ = .34** |
| Overall, I am satisfied with this app | 6.04 ± .57 | 5.93 ± .52 | 6.15 ± .63 | −.22 (−.51, .07) $p$ = .16 |
| The app would be useful for improving the patients' health and well-being | 6.09 ± .49 | 6.12 ± .51 | 6.06 ± .47 | .06 (−.19, .31) $p$ = .67 |
| Using the app I felt supported during the diagnosis | 6.35 ± .26 | 6.40 ± .27 | 6.30 ± .21 | .10 (−.02, .22) $p$ = .08 |
| The app helped me identifying the location of myofascial trigger points | 6.08 ± .60 | 5.96 ± .49 | 6.20 ± .64 | −.24 (−.53, .05) $p$ = .11 |
| This app has all the functions and capabilities I expected it to have | 6.16 ± .48 | 6.06 ± .43 | 6.26 ± .51 | −.20 (−.44, .04) $p$ = .09 |
| **Ease of use (1–7)** | **6.04 ± .30** | **6.07 ± .24** | **6.02 ± .37** | **.05 (−.22, .32) $p$ = .72** |
| The app was easy to use | 6.15 ± .64 | 6.03 ± .50 | 6.06 ± .62 | −.03 (−.32, .26) $p$ = .48 |
| It was easy for me to learn to use the app | 6.01 ± .55 | 6.35 ± .44 | 5.96 ± .50 | 0.39 (0.15, 0.63) $p$ = .13 |
| The navigation was consistent when moving between screens | 6.27 ± .39 | 6.19 ± .39 | 6.35 ± .44 | −.16 (−.37, .05) $p$ = .13 |
| The interface of the app allowed me to use all the functions (such as completing appropriately the body charts, using the toolbar, or exporting the data) offered by the app | 6.01 ± .55 | 5.90 ± .50 | 6.12 ± .58 | −.22 (−.50, .06) $p$ = .13 |
| I like the interface of the app | 5.51 ± .75 | 5.69 ± .89 | 5.33 ± .65 | .36 (−.04, .76) $p$ = .08 |
| The information in the app was well organized, so I could easily find the information I needed | 6.26 ± .23 | 6.23 ± .20 | 6.29 ± .27 | −.06 (−.18, .06) $p$ = .28 |
| **Access to the information and errors (1–7)** | **5.01 ± 1.89** | **5.01 ± 2.08** | **5.01 ± 2.01** | **.00 (−.78, .78) $p$ = 1.00** |
| Whenever I made a mistake using the app, I could recover easily and quickly | 5.94 ± .72 | 6.03 ± .80 | 5.85 ± .66 | .18 (−.20, .56) $p$ = .36 |
| I could use the app even when the Internet connection was poor or not available | 1.98 ± .48 | 1.95 ± .41 | 2.01 ± .49 | −.06 (−.29, .17) $p$ = .59 |
| This app provided an acceptable way to receive health care services, such as accessing reliable information about the location of myofascial trigger points based on pain distribution maps | 5.69 ± .85 | 5.55 ± .73 | 5.83 ± .86 | −.28 (−.69, .13) $p$ = .19 |
| The app adequately acknowledged and provided information to let me know the progress of my action | 6.42 ± .17 | 6.52 ± .23 | 6.33 ± .09 | .19 (−1.10, 1.48) $p$ = .27 |
| **Convenience of use (1–7)** | **6.18 ± .12** | **6.11 ± .11** | **6.25 ± .09** | **−.14 (−.26, −.02) $p$ = .02** |
| I feel comfortable using this app in my working setting | 6.18 ± .67 | 6.06 ± .50 | 6.30 ± .74 | −.24 (−.56, .08) $p$ = .28 |
| The amount of time involved in using this app has been fitting for me | 6.27 ± .34 | 6.23 ± .29 | 6.31 ± .40 | −.08 (−.26, .10) $p$ = .41 |
| I would use this app again | 6.09 ± .47 | 6.03 ± .43 | 6.15 ± .53 | −.12 (−.37, .13) $p$ = .36 |
| Total score (1–7) | **5.85 ± 1.01** | **5.82 ± 1.02** | **5.88 ± 1.03** | **−.06 (−.23, 0.11) $p$ = .47** |

to identify MTrPs based on referred pain patterns filled out in interactive body charts. The application facilitated perfect accuracy in associating MTrPs with the respective referred pain patterns described in the literature among both groups, significantly enhancing their success ratio (specially for moderately and rarely prevalent MTrPs). Although all users reflected a high degree of satisfaction, researchers and educators reported a better convenience of use, supporting its use especially as an educational tool for MPS trainings.

Therefore, while the MyofAPPcial application shows remarkable potential in improving the diagnostic accuracy of physiotherapists across different professional backgrounds, the clinical utility of this tool needs to be tested in a real environment to determine its diagnostic accuracy.

## AUTHOR CONTRIBUTIONS

All the authors equally contributed on (1) concept/idea/research design, (2) acquisition of data, (3) analysis and interpretation of data, (4) writing/review/editing of manuscript, (5) final approval of the manuscript, (6) providing facilities and (7) providing subjects.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

All data derived from this study are presented in the text.

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