# Comparing the Impact of Interactive versus Traditional E-Learning on Physiotherapists' Knowledge, Attitudes, and Clinical Decision Making in Low Back Pain Management: A Randomized Controlled Trial

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## Abstract

### Introduction
Despite the recommendations to use a bio-psycho-social framework, many physiotherapists still manage their patients mainly from a biomedical point of view. The purpose of this study was to analyze the impact of two different e-learning interventions on knowledge, attitudes and clinical decision making of physiotherapists managing low back pain (LBP) to increase guideline-consistent care.

### Methods
Physiotherapists were allocated (1/1) either to an experimental or a traditional e-learning intervention. Baseline and post-intervention assessment included the Health Care Providers' Pain and Impairment Relationship Scale (HC-PAIRS), Back Pain Attitudes Questionnaire (Back-PAQ), Neurophysiology of Pain Questionnaire (NPQ) and a clinical vignette. Participants had two weeks to complete the post-intervention assessment. Statistics were processed using ANCOVA and Fisher's t-tests.

### Results
419 physiotherapists were included in the analysis. Mean scores of HC-PAIRS, Back-PAQ and NPQ significantly improved post-intervention in both groups. There was a significant effect of the intervention type (experimental versus traditional) on the scores of HC-PAIRS ($p < .001$; $\eta^2_p = .243$) and Back-PAQ ($p < .001$; $\eta^2_p = .135$), but not on NPQ scores. Return to work recommendations assessed with the clinical vignette were significantly more guideline-consistent in the experimental group ($p < .001$) post-intervention.

### Conclusion
An interactive e-learning intervention which includes concrete clinical examples and focused on patient's reassurance, self-management and importance of screening psycho-social factors had more impact than a traditional e-learning intervention to enhance physiotherapists' knowledge, attitudes and clinical decision-making regarding LBP.

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## Keywords
Low back pain; return to work; computer-assisted instruction; physical therapists

# Introduction

Low back pain (LBP) is a common, complex and multidimensional condition. It is the leading cause of disability worldwide [1,2]. International guidelines have promoted a bio-psycho-social management approach [3–6], but implementation of these guidelines remains a challenge [7–10]. Many healthcare professionals (HCPs), including physiotherapists, continue to manage their patients using an outdated biomedical model [11–13]. This is reflected by physiotherapists using a guideline-inconsistent approach consisting of focusing on specific structural impairments [14], recommendations to undergo medical imaging [10,15], restrictive activity and work recommendations [16–18], and inadequate recommendations concerning medication [10,19]. Moreover, studies have found that physiotherapists question the relevance of guidelines and might lack clinical skills in the management of psychosocial factors, such as patient's illness perceptions or concerns [20,21]. HCPs' own attitudes and beliefs towards LBP are known to be associated with patient's beliefs and attitudes [22,23] that could negatively affect their prognosis [24].

There is an urgent need to develop cost-effective strategies to implement guideline-consistent care in clinical practice by targeting physiotherapists knowledge, attitudes and clinical decision making [1,25]. More precisely, it is important to explore which methods, which content of the guidelines and how they are presented is more impactful. Studies showed that physiotherapy associated with guideline-adherent recommendations results in better outcomes for patients with LBP [26–28]. Moreover, there is a lack of data concerning the effect of educational interventions on this HCPs' population. Traditional lectures or passive dissemination of guidelines seem to only marginally improve HCPs' knowledge, attitudes and clinical decision making, indicating that different educational strategies are needed [29–32]. Despite implementation strategies, theoretical guidelines on the management of LBP are difficult to integrate in clinical practice [8,9]. An explanation could be that the lack of interactive format does not permit HCPs to understand how to practically integrate the recommendations into practice. For example, guidelines recommend that patients are reassured about their condition, but do not provide specific examples of how this is achieved.

Studies have shown that e-learning interventions could be a promising solution to improve knowledge and clinical decision making in HCPs but more research is needed to evaluate their impact on physiotherapists [29,33–38]. E-learning interventions allow participants to engage with a range of media that may best support their learning, such as videos with clinical examples (e.g., clinical example of a patient-therapist communication) and is also much more accessible (e.g., from everywhere with an internet-connected device) and flexible (e.g., time and location of the learning) for HCPs [33]. Moreover, interactive e-learning interventions allow participants to control their learning (e.g., menus and arrows to navigate back and forward) and spend more time on content that is relevant to them.. There is however a lack of knowledge concerning the most impactful way to inform physiotherapists but also which contents of the guidelines that could lead to an efficient shift in knowledge, attitudes and clinical decision-making concerning LBP management.

Therefore, the objective of this study was to evaluate the impact of two different e-learning interventions, based on (inter)national guidelines and recommendations. Both the content and the way of delivery differed between the interventions to evaluate the impact of an experimental (interactive environment) versus a traditional (classical online lecture, without interactivity) e-learning intervention on the knowledge, attitudes and clinical decision making of physiotherapists managing LBP. It was hypothesized that the experimental e-learning intervention would be more efficient to enhance knowledge, attitudes and clinical decision making than the traditional one.

# Methods

## Trial design

The design of this study was a randomized, controlled, double blinded and web-based trial. The CONSORT statement for randomized controlled trial was used to report the data [39]. This study took place between August 2021 and August 2022 using an online setting. A local ethical committee approved the study (Ethical Committee of the Antwerp University Hospital – n°20/51/714). As this study evaluated the effect of interventions on healthcare practitioners, a registration on clinicaltrials.org was not necessary. Nevertheless, the study was registered on clinicaltrials.org for transparency (NCT05284669).

## Participants

Various strategies [40] were used to recruit physiotherapists in two countries (Belgium and France). Invitations to this study were shared in two languages (French and Dutch) by national associations (e.g. Axxon, Domus Medica, etc.), local networks of university departments and hospitals, registered physiotherapy associations. Eligibility criteria were French-speaking or Dutch-speaking active graduated physiotherapists from Belgium or France. Exclusion criteria consisted of physiotherapists not managing patients with LBP or not being in possession of an internet connected device.

## Settings

Physiotherapists willing to participate in the trial received an internet link to connect on an online platform (https://qualtrics.com). After reading the information concerning the study, they were asked to sign an online informed consent and to enrol in the study. In case they enrolled, they were asked to complete a baseline assessment, complete an e-learning package, and then to complete a post-intervention assessment using the online platform. Participants had two weeks to finish the e-learning and two weeks to complete the post-intervention assessment. An automated e-mail was sent one week after enrolment to remind participants to complete the study. Participants could contact the research team by email if they experienced technical problems with the process or the e-learning.

## Interventions

Two e-learning interventions (experimental and traditional) were jointly developed by a multidisciplinary international team of researchers and clinicians with complementary expertise in the management of LBP. This team involved physiotherapists, physicians (both general practitioners and specialized physicians), sociologists and professors in prevention of musculoskeletal disorders. The content of the two e-learning interventions was developed based on the same guidelines for the management of LBP [3–6] and a previous pilot study [33]. However, different topics were emphasized or illustrated more in detail in each intervention. This is depicted in Fig 1. Each e-learning intervention was divided in 3 thematic modules covering the main content from the guidelines (the duration of each module was 30 minutes). The first and second module were entitled *"Triage and evaluation of LBP"* and *"Management of LBP"*. The third module *"Understanding the complexity of pain"* was developed to deliver information regarding the recommendation *"reassure the patient concerning the benign nature of LBP"* [4]. Both e-learning interventions were available in French and Dutch. For education and research purpose, the e-learning interventions are available via these links:

| | **French version** | **Dutch version** |
|---|---|---|
| **Experimental e-learning** | https://nomadeproject.eu/4xt38e745y5n6ad/ | https://nomadeproject.eu/nl/mtg2hep824m8dwe/ |
| **Traditional e-learning** | https://nomadeproject.eu/5k8m8mymx3x4rkf/ | https://nomadeproject.eu/nl/2zhexg5ypyy3vru/ |

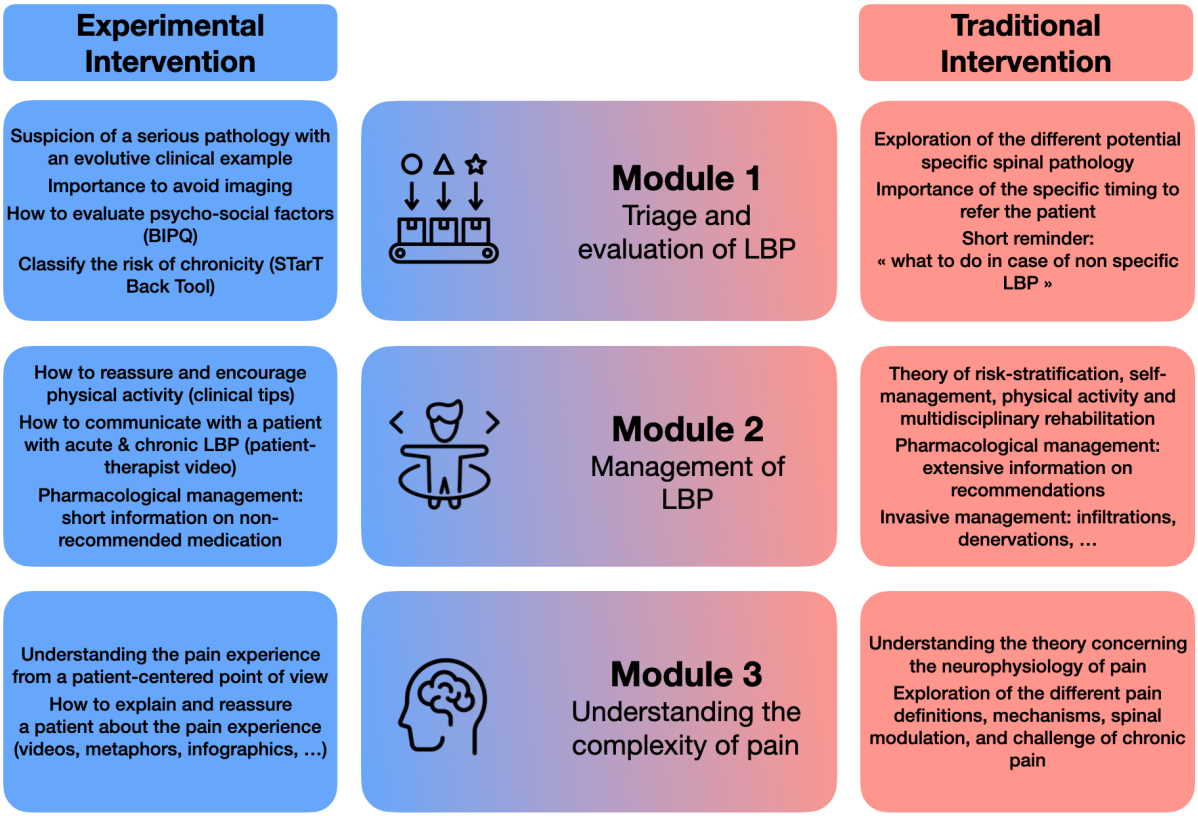


***Fig. 1****: Different emphasis of the same theme in the experimental and traditional e-learning intervention.*

## *Experimental e-learning intervention*

The experimental e-learning intervention was designed to be interactive with the inclusion of menus, videos, simulated clinical situations, metaphors, voice-overs, and quiz (see Fig. 2). Participants were able to evolve towards a controllable e-learning (play, pause, or going back in specific chapters if necessary). The purpose of the e-learning was to be as pragmatic as possible to help physiotherapists to integrate guidelines in their daily practice. During the e-learning the following topics were developed in more detail: the importance of screening psychosocial factors, the reassurance of the patient and the understanding the pain experience from a clinical point of view (e.g., stories and metaphors) [41–45]. The e-learning was designed using PowerPoint and transformed in an interactive e-learning using the H5P plugin.

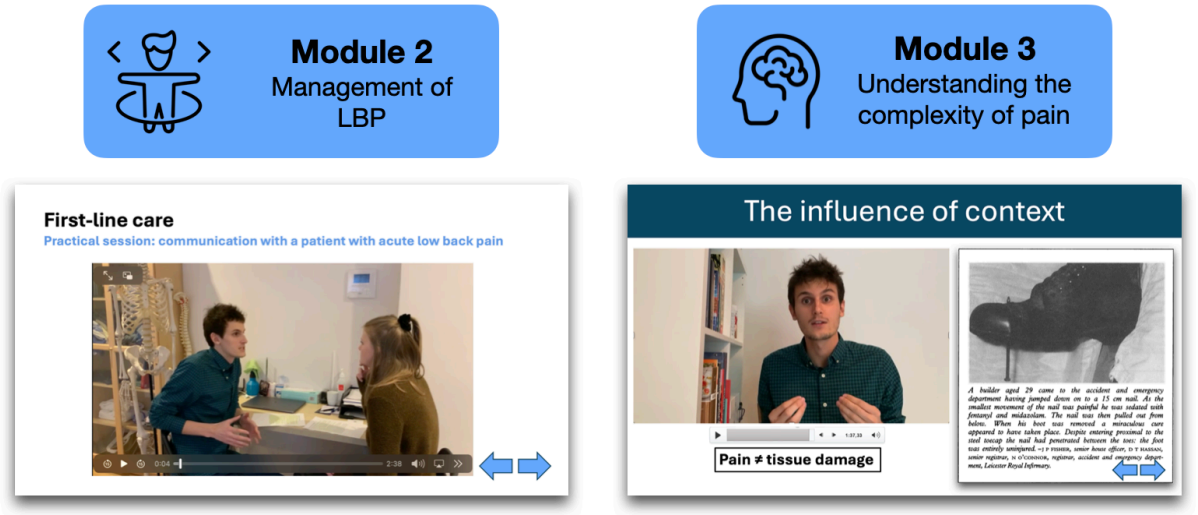


***Fig. 2****: Illustration of the experimental e-learning, designed as an interactive environment (videos, simulated clinical situations, metaphors, controllable interface) (module 2 & 3). The content was translated in English from the original version in French.*

### *Traditional e-learning*

The traditional e-learning intervention was designed to be a classical online lecture without interaction or clinical examples (see Fig. 3). Participants were not able to control the e-learning, they were only able to watch a recorded video. The traditional intervention could be considered as a control intervention. The focus of the e-learning was set on the following content of the guidelines: the importance of a first screening to exclude a specific underlying cause of LBP, the stepwise approach to implement physical activity, pharmacological treatment and the theoretical approach to understand the pain experience, including the neurophysiology of pain [3,4]. The e-learning was designed using a PowerPoint presentation with voices exported as a video.

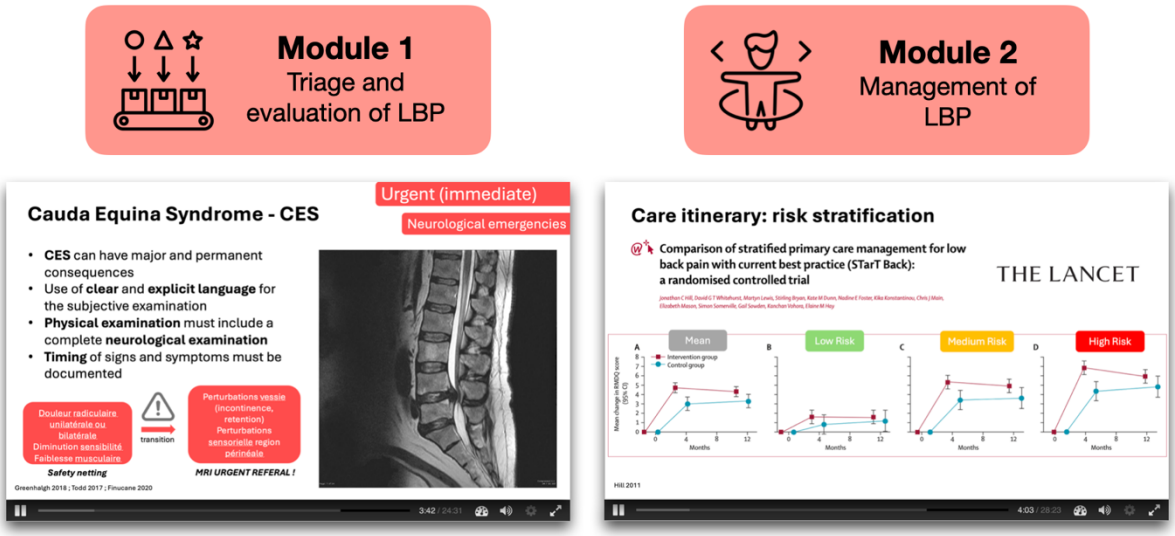


***Fig. 3****: Illustration of the traditional e-learning, designed as a classical online lecture without interactivity (module 1&2). The content was translated in English from the original version (French).*

## Outcomes

Five questionnaires were used: A self-developed socio-demographic questionnaire (see Appendix 1), the Health Care Providers' Pain and Impairment Relationship Scale (HC-PAIRS) [46,47], the Back Pain Attitudes Questionnaire (Back-PAQ) [48,49], the revised Neurophysiology of Pain Questionnaire (NPQ) [50,51] and a clinical vignette (about a patient with non-specific LBP [52]). All questionnaires were available in the language of the participant (French and Dutch) (see Appendix 2). The Back-PAQ and the NPQ were translated in Dutch using a back-and-forth translation process with four translators (two French-speaking and two Dutch-speaking) [53]. The HC-PAIRS and the clinical vignette translated in a previous study with the same process were used for the French-speaking participants [16]. Two additional questions were asked, one about the confidence in their own knowledge of guidelines for the management of LBP and the second about their application of guidelines in clinical practice (Yes or No answer).

### *Socio-demographic questionnaire*

This self-developed questionnaire included several questions related to personal factors (age, gender, region, clinical occupation, and settings) of participants.

### *Health Care Providers' Pain and Impairment Relationship Scale (HC-PAIRS)*

The HC-PAIRS assesses attitudes and beliefs concerning physical impairments for patients with chronic LBP [54]. It consists of 13 statements that must be rated on a seven-point Likert scale, ranging from ‘totally disagree’ to ‘totally agree’. The total score ranges from 13 to 91. A high score on the HC-PAIRS reflects a belief with a strong relationship between pain and impairment [46]. Good psychometric properties of this questionnaire have been established in physiotherapists [54,55].

### *Back Pain and Attitudes Questionnaire (Back-PAQ)*

The Back-PAQ questionnaire (10 items version) [48] assesses attitudes and underlying beliefs about back pain on a 5-point Likert scale. The scoring of the answers ranges from −2 to +2. Items 6-7-8 have reversed score. The total score ranges from -20 to 20. A negative score reflects beliefs that are unhelpful and vice-versa. All items were written in the second person to personalize the questionnaire. The purpose of this personalization is that responders present their own beliefs rather than projecting their beliefs onto people with LBP or presenting their beliefs about people with LBP [48].

### *Neurophysiology of Pain Questionnaire (NPQ)*

The Neurophysiology of pain questionnaire (NPQ**)** assesses how an individual conceptualizes biological mechanisms underpinning pain [50]. The NPQ includes 19 questions with three answer options (true; undecided; false). The scoring is 1 for a correct answer and 0 if the participant was wrong or undecided. Higher scores reflect better knowledge of the pain neurophysiology. This questionnaire was included to evaluate PTs' knowledge of the neurophysiology of pain [51,56] as pain education could improve kinesiophobia and pain catastrophizing in patients with chronic LBP [57].

### *Clinical vignette*

A vignette describing a patient with non-specific LBP (i.e. third vignette developed by Rainville) was used [52]. Participants were asked to give their opinion on the appropriate level of activity HCP should recommend to the patient, with choices graded from 1 (no limitations on activity) to 5 (limit all physical activity) and assess the patient's ability to work, from 1 (full-time) to 5 (remain out of work). If the score of the participant was between 1 and 2 it was considered guideline-consistent [16]. If the score was between 3 and 5 it was considered guideline-inconsistent [16].

## Sample size

An a priori calculation of F tests (ANCOVA) was made using G*Power [58] to compute the sample size necessary for this randomized controlled trial. The primary outcomes were the knowledge, attitudes and beliefs of the participants measured with HC-PAIRS, Back-PAQ, and NPQ. The hypothesis was "there is a greater improvement in knowledge, attitudes and clinical decision making in the experimental group compared to the traditional group". A reasonable moderate detectable effect size f was chosen (0.25). A statistical significance (α err. prob) of 0.05 and a power (1-β err. prob) of 95% was predefined. On that basis a sample size of 210 participants was required. The average response rate in online surveys tend to be lower than in-person surveys [59]. It was reasonable to assume a dropout rate between baseline and post-intervention assessment. Therefore, we aimed to recruit a larger number of participants to avoid a sample size smaller than required.

## Randomization

The online platform automatically randomized participants with a 1/1 allocation in each intervention after the baseline assessment. Participants received an access to the attributed e-learning.

## Blinding

This study was double-blinded. Participants did not know they were following either the experimental or traditional e-learning intervention. Researchers assessed anonymous dataset files and were not involved in the randomization process.

## Statistical methods

Data were downloaded from the online platform (Qualtrics) and sorted using Microsoft Excel (16.57). IBM Statistics 28 and R core team 22 were used to perform statistical analyses. Only participants with complete data (i.e. all questionnaires completed) were included in the statistical analyses. Student t-test was used to measure the effect of the e-learning intervention in each group. ANCOVA test was used to control the effect of baseline scores and measure the effect of the intervention type on the scores difference between groups post-intervention. The effect size was calculated using partial eta squared ($\eta^2_p$). Interpretation (magnitude) of effect size was small ($\eta^2_p$ = 0.01), medium ($\eta^2_p$ = 0.06), or large ($\eta^2_p$ = 0.14) [60,61]. Fisher's exact t-tests were used to compare the results of the vignette at baseline and post-intervention between the two groups. The minimal clinically important difference (MCID) for the questionnaires was 6 for Back-PAQ, 4.2 or 4.6% for HC-PAIRS and 0.9 or 7.3% for NPQ in previous studies [50,62,63].

# Results

In total 819 physiotherapists were assessed for eligibility to participate to the study. The technical evaluation showed that 9% of the participants contacted the researchers concerning difficulties with the account/access to the e-learning, 3% for technical problems within the interventions (e.g. sound) and 10% with questions concerning the accreditation process after the interventions. Each complaint was successfully managed. Of the 737 included physiotherapists who completed the baseline assessment and were randomly assigned to either intervention, 419 (57%) completed the post-intervention assessment and were included in the analysis (see Fig. 4). No significant differences in baseline scores were found between participants who dropped-out and participants included in the analysis in each group, except for the NPQ in the experimental group with slightly lower scores for the drop-out group (mean difference = 0.77; $p$ = .003), but not clinically relevant (MCID: 0.9) [50,62].

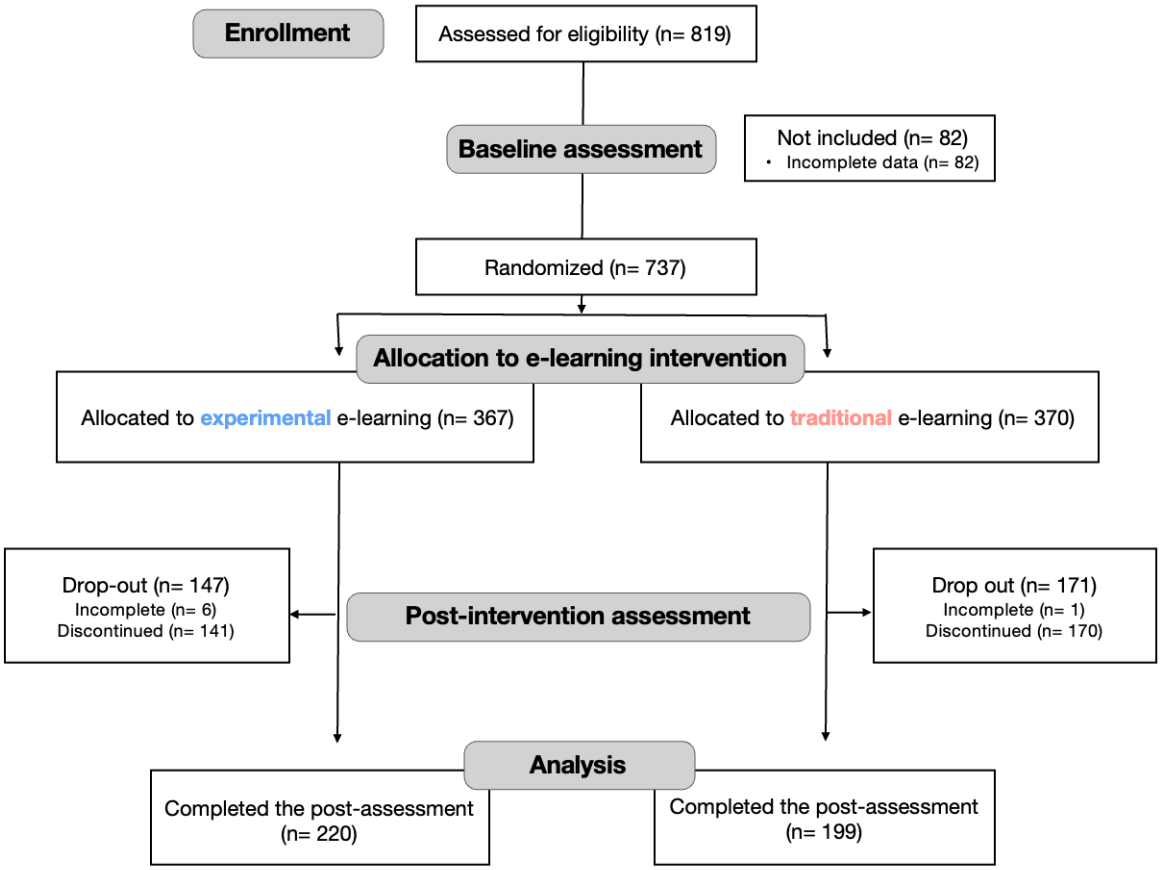


***Fig. 4:*** *CONSORT flow diagram of the study.*

The baseline characteristics of all participants are detailed in Table 1.

| | | **Experimental e-learning** | | **Traditional e-learning** | |
|---|---|---|---|---|---|
| | | **n (%) or Median [Q1, Q3]** | | **n (%) or Median [Q1, Q3]** | |
| **Number of participants** | Total | 220 | 100% | 199 | 100% |
| | Belgium (French-speaking) | 57 | 26% | 50 | 25% |
| | Belgium (Dutch-speaking) | 140 | 64% | 129 | 65% |

| | | | | | |
|---|---|---|---|---|---|
| | France | 23 | 10% | 20 | 10% |
| **Age (year)** | | 31 | [26-44] | 31 | [26-45] |
| **Gender (Male or Female)** | Female | 131 | 60% | 125 | 63% |
| | Male | 89 | 40% | 74 | 37% |
| **Years of practice** | | 6 | [2-22] | 7 | [2-22] |
| **Clinical occupation** | 100% | 173 | 79% | 157 | 79% |
| | 75% | 29 | 13% | 27 | 14% |
| | 50% | 13 | 6% | 11 | 6% |
| | 25% | 5 | 2% | 4 | 2% |
| **Work setting (multiple answers allowed)** | Self-employed | 71 | 32% | 56 | 28% |
| | Self-employed (in a group with same profession) | 96 | 44% | 97 | 49% |
| | Multidisciplinary | 33 | 15% | 39 | 20% |
| | Medical house | 17 | 8% | 11 | 6% |
| | Hospital | 53 | 24% | 42 | 21% |
| | Disability sector | 11 | 5% | 5 | 3% |
| **LBP patients per month** | 1-5 | 67 | 30% | 53 | 27% |
| | 5-10 | 23 | 10% | 11 | 6% |
| | 10-15 | 38 | 17% | 46 | 23% |
| | 15-20 | 80 | 36% | 75 | 38% |
| | 20+ | 12 | 5% | 14 | 7% |
| **Self-reported knowledge of the guidelines** | Yes | 85 | 39% | 65 | 33% |
| | Uncertain | 128 | 58% | 122 | 61% |
| | No | 7 | 3% | 12 | 6% |
| **Self-reported application of guidelines in practice** | Yes | 63 | 29% | 63 | 32% |
| | Sometimes | 142 | 65% | 117 | 59% |
| | No | 15 | 7% | 19 | 10% |

**Table 1:** socio-demographic results for the experimental and traditional group.

Fig. 5 includes results of baseline and post-intervention assessments. Mean scores of HC-PAIRS, Back-PAQ and NPQ were similar between the experimental and traditional group at baseline and significantly improved post-intervention in both groups ($p < .001$). A larger effect was observed in the experimental group post-intervention for HC-PAIRS and Back-PAQ but not for NPQ.

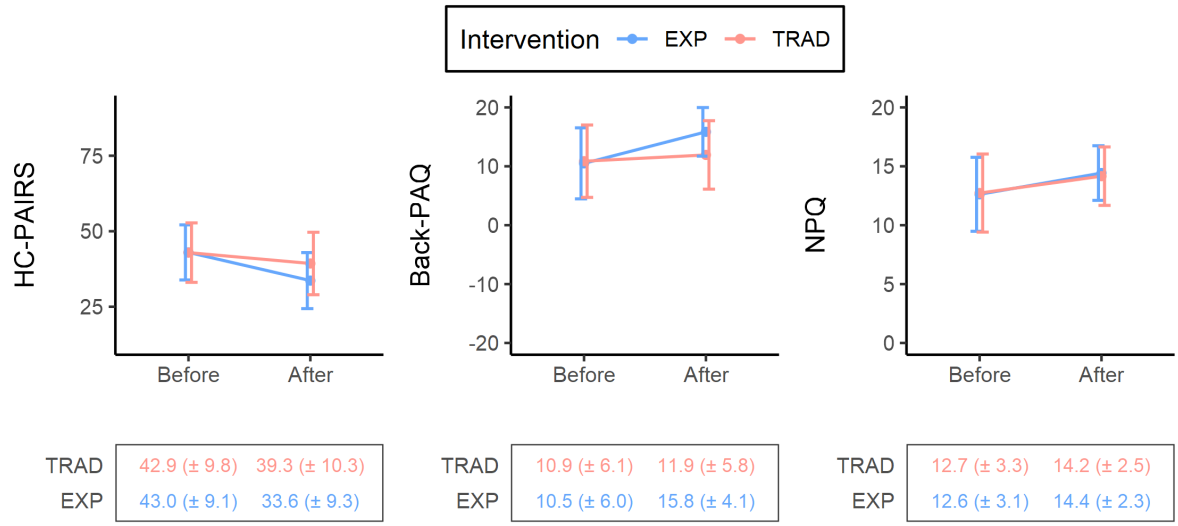


***Fig. 5*:** Mean scores and standard deviation of HC-PAIRS, Back-PAQ and NPQ at baseline and post-intervention assessment in the experimental (EXP) and traditional (TRAD) group.

When controlling for baseline scores, there was a significant effect of the intervention type (EXP vs TRAD) on the HC-PAIRS (large effect) and Back-PAQ (medium effect) scores, but this was not the case for the NPQ. These results confirm the visual interpretation of Fig. 5.

| **ANCOVA** | **Variable** | **Effect** | **F** | **p-value** | **Partial eta-squared ($\eta^2_p$)** | **Magnitude** |
|---|---|---|---|---|---|---|
| | HC-PAIRS | Baseline score | 366 | $p < .001$ | .468 | Large |
| | | Intervention type | 133 | $p < .001$ | .243 | Large |
| | Back-PAQ | Baseline score | 347 | $p < .001$ | .455 | Large |
| | | Intervention type | 65 | $p < .001$ | .135 | Medium |
| | NPQ | Baseline score | 430.1 | $p < .001$ | .508 | Large |
| | | Intervention type | 3.84 | $p = .05$ | .009 | Small |

**Table 2:** ANCOVA results of HC-PAIRS, Back-PAQ and NPQ. F = between-groups variance divided by within-groups variance.

Results of the vignette are presented in Table 3. At baseline assessment, the large majority of both groups gave guideline-inconsistent recommendations regarding work, whereas the percentage of guideline-consistent recommendations concerning work largely increased post-intervention in the experimental group ($p < .001$).

| **Fisher's exact t-test** | | **Baseline** | | | **Post-intervention** | | |
|---|---|---|---|---|---|---|---|
| | **Group** | **Guideline-inconsistent (%)** | **Guideline-consistent (%)** | **Two-sided p-value** | **Guideline-inconsistent (%)** | **Guideline-consistent (%)** | **Two-sided p-value** |
| **Activity** | EXP | 26.4 | 73.6 | $p = 0.57$ | 21.8 | 78.2 | $p = 0.09$ |
| | TRAD | 23.6 | 76.4 | | 29.1 | 70.9 | |
| **Work** | EXP | 61.8 | 38.2 | $p = .02$ | 35.9 | 64.1 | $p < .001$ |
| | TRAD | 72.9 | 27.1 | | 61.3 | 38.7 | |

**Table 3:** Vignette's score concerning recommendations about activity and work before and after the intervention.

# Discussion

This randomized controlled study compared physiotherapists' knowledge, attitudes, and clinical decision making following completion of either an experimental e-learning (interactive and using clinical examples) or a traditional e-learning (classical lecture without interaction) intervention. Both e-learning impacted positively the physiotherapists in this study, but meaningful changes (based on MCID) were reached only after the experimental intervention. Beliefs and attitudes about pain and impairment improved significantly more in physiotherapists following the experimental e-learning intervention compared to physiotherapists that received the traditional intervention. However, pain neurophysiology knowledge was not impacted differently by either intervention despite the fact that both groups received pain education content. The experimental e-learning intervention led to a larger increase of guideline-consistent recommendations concerning return to work compared to the traditional intervention.

## *Comparison of the findings with other studies*

Only few studies evaluated the efficiency of e-learning interventions on the knowledge, attitudes and beliefs of graduated physiotherapists concerning LBP management [64,65]. Our results are similar to other studies that demonstrated that emphasizing a bio-psycho-social approach in e-learning interventions for the management of LBP was effective to reduce negative beliefs of HCPs [35–37,66]. Our results concerning pain neurophysiology knowledge differ from a study which found that a focused pain education module increased pain knowledge (measured by the NPQ) but also strengthened beliefs that pain justifies impairment (HC-PAIRS) of medical students [67].
Return to work recommendations were largely influenced by the experimental e-learning intervention compared to the traditional intervention. This is an important finding, return to work is a challenging topic in the management of LBP and efficient return to work strategies are difficult to implement because of multiple variables (e.g., etiology of illness or psychosocial factors) [18,68,69]. Given the time they spend with patients, physiotherapists have an important role and could positively influence return to work processes [70]. Our results are promising but future studies should also measure practitioners activity and work recommendations in real-life consults [71].

Baseline scores of this randomized controlled trial were discussed in a previous paper and were considered concerning [72]. This study found that a high proportion of physiotherapists (63%) were unfamiliar with guidelines and that was associated with inadequate knowledge, attitudes and beliefs concerning LBP management highlighting the need to develop interventions to enhance them [72]. The minimal clinically difference important difference (MCID) was 6 for Back-PAQ, 4.2 or 4.6% for HC-PAIRS and 0.9 or 7.3% for NPQ in previous studies [50,62,63]. Hence, the results of the experimental group post-intervention could be considered as clinically relevant for HC-PAIRS and NPQ. The mean difference for the Back-PAQ is lower (5.3) than the 6-point change needed to be considered clinically relevant. Despite the efficiency of the experimental e-learning there is room for improvement.

## *Improved performance of the experimental e-learning intervention*

Until now, it is unknown what is the optimal content of education from the guidelines as well as what ways of education delivery are likely to reinforce positively knowledge, attitudes and clinical decision making of HCPs. Hence, both interventions were based on the main content of the guidelines and presented the same themes, but some messages and content were emphasized differently in each intervention (see Fig. 1). Moreover, the way of delivering the education was different. This approach was chosen to explore how these different messages may affect the HCPs and impact their knowledge, attitudes and clinical decision making. The experimental intervention emphasized the importance of promoting self-management, reassurance of the patient and the screening of psychosocial factors in non-specific LBP. Concrete examples were given to show how to reassure and evaluate people with LBP (with increased risk of chronicity due to the presence of psychosocial factors) in a patient-centered way including metaphors, infographics, and tools usable by practitioners [45,73–75]. The traditional intervention emphasized the importance to exclude a specific underlying cause of LBP with detailed information on the different specific pathologies and potential red flags. The importance of stratified care comprising the

stepwise approach to favor physical activity was explained, but no clinical examples were given. Finally, the recommendations for the pharmacological treatment and invasive treatment in case of failure of conservative management were extensively explained.

One of the core differences between the two intervention was that the experimental intervention concretely shows **how to** apply important recommendations. For example, two videos of a clinician-patient communication were shown to illustrate **how to** reassure and promote self-management in a patient in an acute or chronic LBP situation. In the traditional intervention it was mentioned but without giving concrete clinical examples (similarly to the guidelines). Moreover, other key differences surely played an important role in the results. The experimental e-learning allowed the participants to control their learning (play, pause, rewind) and interact (navigation in menus and Q&R). It was not the case for the traditional intervention. Thus, these differences in the content emphasized and how it was presented could have influenced the results and the overall clinical superiority of the experimental intervention.

The third module of the two e-learning interventions ("*Understanding the complexity of pain*") was developed to positively impact pain knowledge of HCPs. The purpose of this module was to give clinicians either contextualized information, metaphors and stories covering the understanding of the pain experience (experimental intervention) or a more theoretical approach to understand the pain experience (traditional intervention). No significant effect was found concerning the intervention type in post-intervention assessment scores of the NPQ. Both intervention types may have been informative, but the results showed that one intervention was not superior to the other. It could be hypothesized that the NPQ is designed to assess theoretical concept about the neurophysiology of pain and not to capture a change in knowledge concerning the complexity of a patient-centered reassurance about her/his pain experience (experimental module). It is also possible that this third module focusing on the understanding of the pain experience could have positively impacted attitudes and beliefs (HC-PAIRS, Back-PAQ and activity/work recommendations) of physiotherapists as seen in previous studies [76,77].

The recommendations concerning the return to work were significantly more guideline-consistent in the experimental group post-intervention. This could be explained by the content of the experimental e-learning intervention, in which the importance of return to work was explicitly stressed. Moreover, the third experimental module ("*Understanding the complexity of pain*") could have positively impacted work recommendations. A better understanding about the importance of context in the pain experience could have reassured HCPs and favor positive recommendations concerning return to work.

Future qualitative studies should evaluate which elements of the interventions led to a change in knowledge, attitudes and clinical decision making. This could allow to develop new e-learning interventions that are even more efficient to positively impact HCPs. Moreover, future studies should evaluate the impact of the different types of e-learning by considering the socio-demographic characteristics of participants (such as age), as this could lead to a personalized and more efficient approach of delivering guidelines content.

The current study might also help to understand why presenting a written form of the guidelines might not be useful to help clinicians to adapt their management strategies. Other studies reported that the interactive aspect of an e-learning intervention is associated with significant improvement in knowledge, attitudes and clinical decision making of HCPs [33,78,79]. The experimental e-learning intervention was designed in a similar way, to be interactive (e.g., menus, voice-overs, and quiz), controllable (e.g., the ability to advance, go back or rewind in the content) and to include videos of concrete clinical situations to understand how to apply guideline recommendations (e.g., what to communicate to reassure a patient about the benign aspect of LBP). The traditional intervention could be compared to a written version of the guidelines because only text and images on static slides were presented to participants. The didactical approach of the experimental intervention could have contributed to the better results in that group.

### *Limitations and strengths*

This study had some limitations. Firstly, there was a dropout percentage of 57% between baseline and post-intervention assessment. This dropout was expected because of the online setting, but the sample size met the calculated requirements. The online design of the study (i.e., without direct contact with the experts), the time necessary to complete the post-intervention assessment or the individual learning needs of participants could explain this quite high dropout. An e-mail reminder to follow the e-learning and complete the study was sent one week after baseline assessment, but it is plausible that it was not enough, and that some physiotherapists forgot or did not take the time to complete the study. It is also possible that the e-learning intervention that was assigned to them did not meet their learning needs. Secondly, this study compared two interventions but did not include a genuine control group (with participants receiving only the written version of the guidelines). Thirdly, because of multiple influencing factors (design of the e-learning & different emphasis of the main content), it is not possible to be more specific in the exploration of factors that have contributed to the better results in the experimental group. A study using a qualitative research is needed to explore participants experience and learning needs. It is also important to acknowledge that these e-learning interventions were designed for physiotherapists in developed countries such as Belgium and France where access to an internet-connect device is routine. The results cannot be generalized to physiotherapists from countries where internet access is still a challenge. Another limitation is that the vignette from Rainville was originally developed to evaluate physicians' recommendations and not physiotherapists.

Finally, the follow-up of this study was short, and future studies should evaluate if changes in clinical behavior of physiotherapists occurred after the intervention. To enhance the efficacy of the interventions and favor behavioral changes, additional strategies could be used (in-person reminders and practical sessions). Future e-learning interventions could offer the possibility to tailor the method of education based on the learning needs of physiotherapists and strengthen their impact on clinical practice.

The large sample size should certainly be considered as a strength. The results of this study are promising, given the difficulty to change beliefs of physiotherapists, especially recommendations about return to work [36]. Moreover, this study showed that education initiatives can be effective at meeting the educational needs of various physiotherapists and changing their knowledge, attitudes and clinical decision making about management of LBP. The method of delivery but also the content presented could play an important role in that positive change and potential change in behavior in practice. Integrating easy-access and costless tools such as interactive e-learning in continued education could help to largely disseminate up-to-date information from research to clinical practice, enhance knowledge, attitudes and beliefs of physiotherapists regarding recommendations for the management of LBP and participate to better treatments in guideline-consistent care.

## Conclusion

This study showed that an experimental e-learning intervention designed to be interactive and to give concrete examples on how to practically integrate content of the guidelines, such as adapted communication to reassure the patient, promote self-management and the importance of screening psycho-social factors led to significantly better improvement in attitudes, beliefs and clinical decision making concerning return to work in physiotherapists than a traditional online lecture. Future studies should analyze physiotherapists' perception about the e-learning interventions to explore the effect of these interventions and investigate their impact on the clinical behavior of physiotherapists.

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## Data availability statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

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