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WJMER

World Journal of Medical Education and Research

An Official Publication of the Education and Research Division of Doctors Academy

DOCTORS ACADEMY

BETTER EDUCATION. BETTER HEALTH.

ISSN 2052-1715

World Journal of Medical Education and Research:
An Official Publication of the Education and Research Division of Doctors Academy

Medical Education
DAUIN 20230205

E-Learning is an Acceptable and Effective Method to Improve Emergency Physicians' Musculoskeletal Knowledge

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WJMER, Vol 29: Issue 1, 2023

Abstract:
Background: Emergency medicine physicians are commonly tasked with the initial assessment and management of musculoskeletal presentations despite widely reported poor musculoskeletal competency. This study aimed to develop and evaluate an online E-Learning musculoskeletal medicine programme for junior emergency doctors.
Methods: A prospective observational study was conducted. A musculoskeletal E-learning programme, which was developed from the Royal College of Emergency Medicine curriculum, was launched on the online learning platform 'Edmodo©'. A convenience sample of all junior emergency medicine doctors in an Irish emergency department was taken. The Kirkpatrick model of learning evaluation was used to assess the impact of the programme. Evaluation at Kirkpatrick Level 1 (response) occurred via a learner feedback questionnaire. Participant's learning (Kirkpatrick Level 2) was assessed using pre-learning and post-learning knowledge quizzes and changes in self-reported knowledge.
Results: Nineteen of twenty-three (83%) of junior emergency doctors participated in the programme. 93% of responders agreed or strongly agreed that they were satisfied with the content received. There was an increase in knowledge scores between the pre and post-learning quizzes (overall pre-learning mean score 55.2% v overall post-learning mean score 84%, $p < 0.05$). Participants' self-reported knowledge improved post completion of the E-learning programme (9 positive pre-learning self-reported responses v 37 positive post-learning self-reported responses, $p<0.05$).
Conclusion: This study shows that a bespoke musculoskeletal medicine E-learning programme is acceptable to emergency medicine doctors and increases their knowledge acquisition.

Key Words:
E-Learning; Musculoskeletal Medicine; Sports Medicine; Emergency Medicine; Medical Education

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Introduction

Acute musculoskeletal injuries may result in loss of playing time, on-going pain and disability for athletes and patients. Furthermore, musculoskeletal injuries are a major cause of absenteeism, affecting 480,000 individuals in the UK resulting in 8.9 million lost working days in 2019/2020.[1] The emergency department (ED) is often the first point of access for the initial assessment and management of acute musculoskeletal injuries. Indeed, musculoskeletal presentations as a whole may account for up to 20% of ED presentations.[2] The increased promotion of physical activity and rising levels of sporting participation increases the importance of good musculoskeletal management into the future.[3,4]

Despite the high prevalence, evidence suggests that medical students graduate without sufficient knowledge of musculoskeletal medicine.[5-7] In Ireland, Canada and the USA, deficiencies in injury knowledge have been noted in medical students, general practice trainees and general practitioners.[6,8,9] Junior emergency medicine doctors come from various clinical backgrounds and may lack experience in managing injuries. This is supported by low levels of musculoskeletal competency being observed in American emergency physicians.[7,10] To combat this gap in knowledge there have been calls to increase musculoskeletal medicine education at an undergraduate and postgraduate level.[11]

The emergency department is a challenging learning environment where shift work, clinical demands and time limitations reduce opportunities for in-person classroom teaching. E-learning can be defined as learning where content is delivered electronically to remote learners via a computer network.[12] Advantages of E-learning include interactivity, efficacy, flexibility and the potential to allow users

engage at a convenient time and location.[13] Furthermore, E-learning allows teaching to proceed while adhering to social distancing guidelines. This has allowed some medical education to proceed during the COVID-19 pandemic and provides certainty and continuity for future pandemics where in-person teaching may not proceed.

To date there has been a paucity of evidence in the literature looking at the effectiveness of a musculoskeletal E-learning programme targeted at emergency medicine physicians. The aim of this study was to develop and evaluate a musculoskeletal medicine E-learning programme for emergency medicine doctors; specifically incorporating fractures, soft-tissue injuries and concussion.

Materials and Methods

A prospective observational study was conducted in Tallaght University Hospital, Dublin, Ireland. The department is a tertiary urban adult ED treating approximately 52,000 annual presentations. The joint research ethics committee of St James's Hospital/ Tallaght University Hospital granted the study ethical approval.

The primary objective of the study was to develop and evaluate the efficacy of a musculoskeletal medicine E-learning programme for junior emergency department doctors.

Development of the Musculoskeletal Medicine E-learning Programme

A six-module E-learning programme was developed to reflect common musculoskeletal injuries that present to the ED. The six modules covered included ankle, knee, shoulder, elbow and wrist injuries and concussion. Each module focused on the anatomy, epidemiology, diagnosis, and management of common musculoskeletal presentations (Appendix 1) and was designed to take approximately one hour to complete. The content was developed by a sports medicine clinician and adhered to the Royal College of Emergency Medicine curriculum.[14] The modules were peer reviewed independently by a consultant in emergency medicine and a senior musculoskeletal physiotherapist.

Each module, except the concussion module, was accompanied by a clinical musculoskeletal examination video demonstrated by the sports medicine clinician. Each video was based on a 'look, feel, move, associated special test' approach and lasted five to seven minutes.

Evaluation of the E-learning Programme.

The musculoskeletal injury E-learning programme was evaluated using the Kirkpatrick learning evaluation module.[15] Kirkpatrick's level I evaluates the degree to which participants find the training favourable, engaging and relevant to their clinical role. Kirkpatrick's level II assesses the participant's learning outcomes and increase in knowledge.

Evaluation at Kirkpatrick Level I (reaction) was assessed at the end of each module via a questionnaire asking learners to rate the content, length and complexity of the modules and whether they would recommend it to others. A five-point Likert scale was used to respond to statements. Specific questions targeting the musculoskeletal exam videos included if participants found they were now more confident in musculoskeletal exam and if they found the videos more helpful compared to text and pictorial demonstration.

Evaluation at Kirkpatrick Level 2 (learning) was achieved via a knowledge assessment quiz, based on the content provided, containing five to ten true/ false or multiple-choice questions. An identical quiz was taken before (pre-learning) and after (post-learning) completion of each module. Participants were not provided with answers to the pre-learning quiz but did receive feedback following the post-learning quiz. Although a 60% pass mark is common in medical education, the pass mark was set at 75% to account for the true/false style multiple-choice questions used.[16] Secondarily, participants were asked to evaluate their topic-specific knowledge before and after the modules.

Roll-out of the E-learning Programme

The E-learning programme was hosted on the free online E-learning platform Edmodo © (Edmodo, San Mateo, California USA https://edmodo.com/). The platform was chosen for its accessibility, provision of immediate feedback and was available via personal computer or as a smartphone application. A virtual classroom was created for the participants and all content was available on launch. Informed consent for inclusion in the study and use of anonymised data was obtained from participants via a check-box agreement prior to enrolment.

Participants were recruited via an email sent to all junior doctors working in the ED and announcements at shift handovers. The email contained a link to join the virtual class online. The programme ran for four weeks from November 2nd to November 29th 2020.

Promotion of the E-learning Programme

Weekly emails were sent to participants informing them of the programme. Due to restrictions in face -to-face teaching during the COVID-19 pandemic this online learning programme replaced the usual departmental teaching for the duration of the study. Participation in the E-learning programme was taken as attendance at departmental teaching. Upon

completion of the programme a certificate was issued which could be used by the doctors for continuous professional development requirements. In line with rates reported by similar studies, we aimed for 80% enrolment and a participation rate of 55% of eligible doctors.[17,18]

Data Analysis

Statistical analysis was performed using Microsoft Excel (Microsoft Professional Plus, Redmond, Washington, Seattle, USA) and IBM® SPSS® version 27 (IBM Armonk, New York, USA). An initial Kolmogorov-Smirnov test was performed which revealed a non-normally distributed data set, therefore a T-test was not performed. Any statistical change between pre-learning and post-learning knowledge quizzes was assessed using a non-parametric Wilcoxon signed-rank test. Participants' self-reported knowledge level before and after completing each E-learning programme were evaluated for significance of difference using a Chi-squared test by segregating responses into two groups: high and very high and unsure, low and very low. A p value of <0.05 was used to define statistical significance.

Results

Nineteen of twenty-three (83%) junior doctors working in the Emergency Department at the time of study joined the virtual class (Table 1). This included ten male and nine female doctors. There was a 74% completion rate with fourteen doctors (61%) completing at least one feedback form.

Evaluation at Kirkpatrick Level 1

Overall, there was very positive participant responses to the E-Learning programme (Figure 1). 93% of responses either agreed or strongly agreed that they were satisfied with the information they received and a similar 93% either agreed or strongly agreed that they would recommend the programme to others. There were similar positive reactions for the musculoskeletal examination videos (Figure 2); 87% of responses either agreed or strongly agreed that they preferred the videos to slides and 84% of responses agreed or strongly agreed that they were more now confident in musculoskeletal examination.

Evaluation at Kirkpatrick Level 2

There was an increase in the knowledge scores between the pre and post-learning quizzes (overall pre-learning mean score 55.2% v overall post-learning mean score 84%, p <0.05) (Table 2). The overall mean score surpassed the arbitrary pass mark (75%) in one module in the pre-learning knowledge quizzes compared to five modules in the post-learning quizzes (Table 2). Participants' self-reported knowledge improved post completion of the E-learning programme (9 positive pre-learning self-reported responses v 37 positive post-learning self-reported responses, p<0.05) (Table 3).

Staff Grade	**Number**
Specialist Registrar	3
Registrar	4
Senior House Officer	10
Intern	2

***Table 1*:** *Staff Grade of Participants*

	Pre-Learning Completed Tests	**Mean %**	**SD %**	**Post-Learning Completed Tests**	**Mean %**	**SD %**	***P* Value**
Ankle Injuries	9	82.2	9.2	9	93.3	5.3	<0.05*
Knee Injuries	10	54.2	13.6	9	73.3	18.2	<0.05*
Concussion	10	70.5	20.4	10	77.9	16.6	0.402
Wrist Injuries	10	73.8	10.2	10	89.3	10.4	<0.05*
Elbow Injuries	11	47.6	15.5	10	81.2	20.3	<0.01*
Shoulder Injuries	12	64	19.7	11	89.2	9.9	<0.001*
Overall	62	55.2	14.8	59	84	13.4	<0.001 *

***Table 2*:** *Mean results and standard deviation of pre- and post-learning knowledge quizzes. Star symbol (*) indicates statistical significance from Pre-learning quiz at P < 0.05.*

	Pre-Learning	**Post-Learning**
Very High	0	3
High	9	34
Total positive	9	37*
Unsure	25	17
Low	17	0
Very Low	2	0
Total negative	44	17*

Table 3: *Participants' self-reported knowledge before and after learning. Star symbol (*) indicates a statistically significant change from the Pre-learning quiz at P < 0.05.*

Discussion

The aim of this study was to develop a musculoskeletal injury E-learning programme for emergency medicine physicians who are often the first health care professionals to assess an acutely injured athlete. Kirkpatrick's learning evaluation model was selected as it is widely used and accepted in healthcare settings.[19,20] With positive participant responses and improvements in knowledge seen following completion of the programme, the study achieved its aims.

Firstly, it was recognised when designing the programme that its potential success would directly correlate to the perception of the programme being appealing and recipient orientated.[21,22] Evaluation at Kirkpatrick Level 1 revealed favourable learner responses and high user satisfaction. There was a high participation rate by the emergency medicine clinicians working in our department represented by 83% of participants reviewing content and 61% of the cohort completing module feedback and quizzes. We therefore achieved our target aim of 80% enrolment and 55% completion. This compares well with a 54% participation in junior doctors by Goh *et al.*[18] and 55% E-Learning completion rate reported in paediatric emergency medicine doctors and students reported by Chang *et al.*[17], although it was below their reported 90% enrolment.

Secondly, a successful learning programme must not only be acceptable to the user but also result in knowledge translation. Our study showed that pre-learning knowledge in musculoskeletal injuries in emergency medicine physicians were less than desirable; only one module (ankle injuries) attracted a mean passing grade. This correlates with our cohort's self-reported level of knowledge; 17% reported high or very high knowledge pre-learning. Our results validate the view that emergency physicians may not be receiving adequate education to achieve clinical competency in musculoskeletal medicine during training.[7,23,24]

Evaluation at Kirkpatrick level 2 showed significant improvements in musculoskeletal medicine knowledge and mean passing grades. These results are compatible with those observed by Wünschel *et al.* and Back *et al.* who observed significant improvements in knowledge following orthopaedic online education programmes for medical students.[25,26]

E-learning has become integral to medical education.[12,27] Similar to other studies, our data confirms that E-learning can be well-received by doctors and is an effective method of knowledge translation.[18,28] This is particularly satisfying as the study was conducted when ED face-to-face teaching had been suspended due to COVID-19 social distancing restrictions.

Our use of video demonstration was well-received by participants, who reported that the video was more useful than slides and were now more confident in musculoskeletal examination. However it is recognised that practical skills and communication are better taught face-to-face and these skills will be incorporated into a future blended learning programme in our ED.[29]

Strengths

In sports medicine, studies are still comparatively rare evaluating E-learning as a knowledge translation tool. This is the first study to assess a bespoke musculoskeletal injury E-learning programme's influence on acquisition of knowledge and acceptability to emergency medicine doctors. A further strength of the programme was the use of Kirkpatrick's level I and II training evaluation model to assess its acceptability and impact on physician's level of knowledge.[15] While other non-healthcare

settings often evaluate using only Kirkpatrick level I we evaluated up to level II. Any change in patient outcomes (Kirkpatrick level III) was beyond the scope of the study, although it is possible that improved physician knowledge can lead to improved patient care. As reported by Sinclair et al.[13] no studies reporting a change in patient outcomes following a healthcare-based E-learning programme have been published to date; future studies should attempt to establish any link between E-Learning and patient outcomes.

The programme reflected components of effective E-Learning in that it was interactive, varied, promoted participant engagement and provided feedback. We included a few key design components; namely videos of the musculoskeletal exams and designing the content to be as visual as possible with anatomical diagrams and images of radiographs. Participant feedback reflected positively on the programme, with 96% agreeing or strongly agreeing that the modules were well-structured and easy to follow.

To ensure that the content of the E-learning programme was of high quality, the material was derived from the Royal College of Emergency Medicine curriculum and reviewed by a consultant in emergency medicine and a senior musculoskeletal physiotherapist. For future iterations of our programme, we will also incorporate the American College of Sports Medicine's recently published standardized musculoskeletal and sports medicine curriculum for emergency medicine training.[23]

Limitations

Whilst, this was single centre study with a small number of participants, the study demonstrated improvements in learner knowledge. Our ED has new doctors rotating every three to six months. Following this successful study, the programme will be delivered to all new doctors, and we believe the programme could be adapted by other emergency departments and other learners such as emergency advanced nurse practitioners.

Secondly, not all doctors completed all quizzes and feedback questionnaires. This is in keeping with other online responses for physicians, which often show low levels of engagement.[30] Nevertheless, our target completion rate of 55% was surpassed. The authors of this study felt participation was enhanced using regular reminders at clinical board rounds, offering certificates of completion for continuous professional development requirements and documenting engagement with the E-learning programme on the doctors' performance reviews. Finally, a selection bias could not be excluded due to the voluntary nature of participation, and it is possible that others may not have responded to the programme as positively.

Conclusion

Emergency medicine physicians may not be receiving adequate education to achieve clinical competency in musculoskeletal injuries and sports medicine. The development of a bespoke musculoskeletal medicine E-learning programme is acceptable and can increase knowledge acquisition amongst emergency medicine doctors.

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