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Oncology E-Learning for Undergraduate. A Prospective Randomized Controlled Trial

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Abstract
The e-learning education is a promising method, but there are few prospective randomized publications in oncology. The purpose of this study was to assess the level of retention of information in oncology from undergraduate students of physiotherapy. A prospective, controlled, randomized, crossover study, 72 undergraduate students of physiotherapy, from the second to fourth years, were randomized to perform a course of physiotherapy in oncology (PHO) using traditional classroom or e-learning. Students were offered the same content of the subject. The teacher in the traditional classroom model and the e-learning students used the *Articulate*® software. The course tackled the main issues related to PHO, and it was divided into six modules, 18 lessons, evaluated by 126 questions. A diagnosis evaluation was performed previous to the course and after every module. The sample consisted of 67 students, allocated in groups A ($n=35$) and B ($n=32$), and the distribution was homogeneous between the groups. Evaluating the correct answers, we observed a limited score in the pre-test (average grade 44.6 %), which has significant ($p<0.001$) improvement in post-test evaluation (average grade 73.9 %). The correct pre-test ($p=0.556$) and post-test ($p=0.729$) evaluation and the retention of information ($p=0.408$) were not different between the two groups. The course in PHO allowed significant acquisition of knowledge to undergraduate students, but the level of information retention was statistically similar between the traditional classroom form and the e-learning, a fact that encourages the use of e-learning in oncology.

Clinical Trial Registration number
REBECU1111-1142-1963

Keywords Oncology · Physical therapy specialty · Education · Teaching and methods · Education, distance · Education, higher

Introduction

The worldwide incidence of cancer continues to grow. In 2008, there were an estimated 12.7 million cases of cancer and 7.6 million deaths due to this disease [1]. The increase in the number of cancer cases [1] demands an increase in the number of professionals with expertise in oncology who are able to perform curative, palliative, or supportive procedures. Likewise, there is an increase of the survivals and the sequel resulting from treatment [2].

Thus, it is necessary to improve and spread the knowledge of oncology among undergraduate students and general health professionals, as knowledge is usually limited [3, 4]. By performing activities specific for undergraduate students, we will foster a greater acceptance of oncology [5], increased knowledge [5–7], an appreciation of oncology as an area of

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expertise [3, 7, 8], and improved understanding of the multidisciplinary nature of oncology [6]. Oncologists tend to better study the issue and to appreciate the curricular offerings [3, 4, 6, 8], while professionals without full knowledge of this area tend not to appreciate the curricular offerings. E-learning allows a way to complement the curriculum [5], supporting or supplementing classroom education.

There is a shortage of prospective, randomized, and controlled studies on the topic, especially with regard to distance education. This fact is aggravated by the use of highly variable methodologies between studies and the absence of widely accepted parameters to evaluate the capabilities of e-learning [9], a circumstance that can lead to discordant or biased findings. Distance education is associated with positive [9–14], equal [11, 15–21], or negative [22] outcomes. There are a limited number of studies in the literature that address distance education in oncology [5, 23]; the number is even lower when we consider randomized controlled studies during undergraduate education [9]. In this sense, the realization of a randomized, controlled crossover study with similar content between the groups, evaluating the level of knowledge about oncology in undergraduate students, pre- and post-intervention, will allow the evaluation of potential questions raised by previous studies.

Material and Methods

Design

A prospective, controlled, randomized, and crossover study without blinding was conducted. It was registered in the Brazilian Clinical Trials Registry (http://www.ensaiosclinicos.gov.br) and in the International Clinical Trials Registry Platform (http://www.who.int/ictrp/en/) under number U1111-1142-1963.

Setting

This study sought to compare the use of e-learning with classroom learning for undergraduate students of physiotherapy. The evaluation model used was a University Extension course named "Fundamentals of Oncological Physiotherapy."

The physiotherapy course has 4 years in duration. The inclusion criteria were students duly enrolled in the second, third, and fourth years of the Physiotherapy program, older than 18 years, with a weighted average grade ≥ 5.0 in previous academic years, and who agreed to participate in the study and signed the informed consent form. Hearing and/or visually impaired students were excluded.

The course was publicized 2 months prior to its start date, and 72 vacancies (24 *per* school year) were offered. The vacancies were considered based on the proportion 1:1 between the groups and year of graduation, the sample size, and the physical limitations of informatics classroom.

Prior to the course, a lecture (title: "Importance of Clinical Trials and Physiotherapy in the Epidemiological Context of Cancer") was given to all enrolled in the course to emphasize the importance of clinical studies and to increase adherence to them. At the end of the lecture, the informed consent form was read and delivered to all of the participants. Doubts were clarified, and the consent of the students was obtained. During enrollment, each student completed a sociodemographic questionnaire.

Sample Analysis and Randomization

The number of vacancies available for the course was 72, and a minimum sample size of 66 students was considered. Beta = 0.1 and alpha = 0.05 were used, with significant differences of 2.5 points (scale ranging from 0 to 20 points) and a final sample size of 33 subjects for each group.

Students were randomized into two classes (class A or B) to attend lectures in which the same content was presented simultaneously, differing only in the teaching modality; one class attended a classroom lecture, while the other attended an e-lecture.

Parallel to classroom for traditional education, the other students were grouped in an informatics classroom. In this room, each student used a single computer to listen the same didactic content. The difference between groups was the sequence of the teaching modality (classroom or e-learning). We chose to alternate between teaching modalities at the end of each lecture, with crossover between groups. Prior to beginning the course, the students were unaware of both the groups in which they were placed and the sequence of the teaching modality. This blinding occurred only during the first day, during the delivery of the material.

Randomization was performed by CZO. It occurred by school year and by weighted average grade in recent years. Randomization occurred by average grades and not by names; thus, the researchers were unaware of the identities of the students during the randomization. In each stratum, students who would compose classes A and B were randomly selected. Thus, it was ensured that each class would consist of 12 students from each year with similar average grades. The 72 students enrolled were divided into 12 strata, considering the school year and the course grades; a stratified randomization was performed by school year and course grade. The software R for Windows® (www.r-porject.org) was used for the randomization. The randomization details are shown in Fig. 1 (CONSORT).

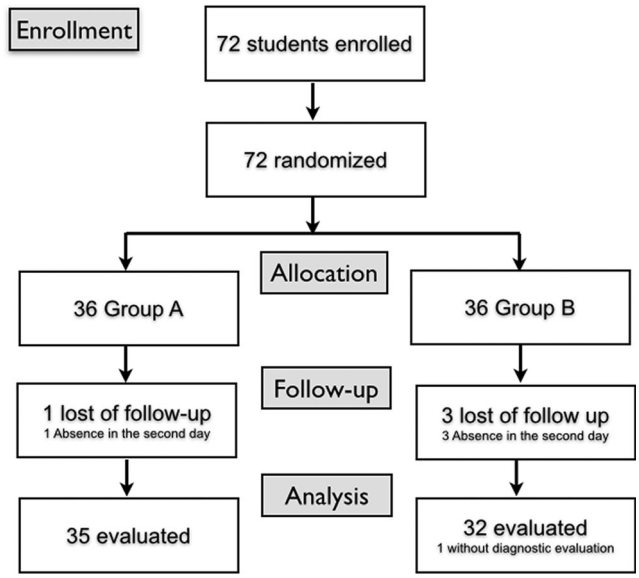

Fig. 1 CONSORT. Diagram showing the flow of participating students

Oncological Physiotherapy Course

For construction of the course, the epidemiology of the local Department of Physiotherapy, associated with the main topics to be addressed in cancer patients, was evaluated. Physicians and physiotherapists of a Tertiary Oncological Hospital were then asked to teach the course. The teaching staff was mainly composed by nine PhDs and four masters, which eight was physicians.

Each teacher initially received instructions regarding the lecture format, the layout of the PowerPoint® software and the presentation time (20′ to 25′). The lectures and evaluations underwent a methodological review and were assessed by the course organizers (RACV, AHL). The teachers, physicians, or physiotherapists aligned their lecture contents to establish a logical reasoning sequence. For the e-learning, the Articulate® software program was used. A single professional oversaw the recording of the content to keep similarity in terms of teacher and content.

The course was divided into 2 days (April 2014, days 06 and 13) and six modules (three modules/day), where each module corresponded to distinct content divided into three lectures, constituting a total of 18 subjects. The topics of the modules are described in Table 1.

The same content was simultaneously given to classes A and B. For example, class A had a traditional classroom, and at the content end, the students had 5 min for discussion with the teacher. At the same time, the class B had the same e-learning classroom (storage material), using an individual computer and 5 min was given to study with the computer. The students could study the slides content, as there was no professor for discussion; the secretariat just controlled the same time (5 min). There was a sequential change related to the classroom form of presentation. So, in the first module, class A had a sequence of traditional/e-learning/traditional classroom and the class B had an e-learning/traditional/e-learning sequence (Fig. 2). After each module (three lectures), the students had a minimum of 30 min to change to the other classroom.

Course Evaluation

For each topic, seven relevant educational objectives specifically pertaining to oncology were established that should be achieved by the students after the presentation. Thus, the teachers created seven questions per module that comprised the diagnostic and final or summative assessment and were instructed as to the format of the responses to these questions [24]. To measure knowledge, questions with few words were used to minimize the students' reading time and to increase the test's reliability [25]. For each question, only three types of answers were considered: true, false, or do not know. The test contained 126 questions, which were presented at two different time points, i.e., 22 days prior to the beginning of the course, which was called a diagnostic evaluation where the students rated the 126 questions, and after the end of each module, i.e., at the end each topic (three lectures), students went through an objective assessment by answering 21 questions, known as a summative evaluation.

The grades of the diagnostic assessment (pre-test) and the summative assessment (post-test) corresponded to the correct answers to the questions. To assess the level of information retention (short-term recall of knowledge), the questions were compared one by one, and four situations were considered in the evaluations regarding the diagnostic and summative assessments [24]: (1) correct–correct: the student already knew, (2) incorrect–incorrect: the student neither knew nor retained the information, (3) correct–incorrect: random hit, and (4) incorrect–correct: students retained the information. When the student selected the answer "do not know," it was considered an error for assessing the level of retention of information.

Therefore, each student was given a diagnostic and a summative grade, and it was possible to evaluate the grades according to the teaching modality, i.e., classroom or e-learning. These data were initially evaluated from the numerical point of view and were subsequently evaluated in the form of frequencies. Figure 2 shows the distribution of the groups according to module and teaching modality.

In addition, in the summative evaluation of the last module, a subjective assessment related to the level of satisfaction with the different teaching methodologies and course content was performed. The students were given a free space to gather information about the course, evaluation format, and suggestions and criticisms.

Table 1 Percentages of answers: correct answers, incorrect answers, and "do not know" of the full diagnostic evaluation and by modules, stratified between classes A and B

Variable	Category	Group	Mean	SD	Median	Minimum	Maximum	*p*
Diagnostic Evaluation	% Correct	A	45.73	17.85	40.48	15.08	78.57	0.556
		B	43.27	16.00	44.04	11.11	71.43	
	% Incorrect	A	12.24	5.73	12.69	2.38	25.40	0.394
		B	10.93	6.72	9.52	2.38	27.78	
	% Do not know	A	42.01	21.24	42.06	1.59	82.54	0.460
		B	45.78	20.08	44.84	17.46	85.71	
% Correct by module	Module 1	A	44.08	12.72	42.86	19.00	71.00	0.992
		B	44.05	13.36	47.62	10.00	67.00	
	Module 2	A	55.65	20.87	57.14	14.00	95.00	0.591
		B	52.98	19.45	57.14	10.00	86.00	
	Module 3	A	53.74	17.87	52.38	24.00	90.00	0.332
		B	49.40	18.45	52.38	14.00	90.00	
	Module 4	A	33.61	20.23	28.57	5.00	76.00	0.594
		B	30.95	20.31	28.57	0.00	67.00	
	Module 5	A	45.17	25.65	47.62	5.00	95.00	0.843
		B	44.05	19.76	45.24	0.00	81.00	
	Module 6	A	42.04	19.78	42.86	5.00	86.00	0.456
		B	38.24	21.68	33.33	0.00	81.00	

Module 1: Foundations of Oncology, Module 2: Pain and Palliative Care, Module 3: Breast Cancer, Module 4: Bone and Soft Tissue Tumors, Module 5: Neurological Tumors, Module 6: Urogynecological Cancer

SD standard deviation

Statistical Analysis

Initially, descriptive statistics (means, medians, and standard deviations) were calculated for quantitative variables and frequencies, and percentages were calculated for qualitative variables. Each student received a grade in the diagnostic evaluation.

To evaluate the present of absence of association between classes A and B, the chi-squared test (or Fisher's exact test) was used in the case of categorical variables, and the Student's *t* test (for independent samples) was used for quantitative variables.

For comparative analysis of the teaching modalities, the grades of the summative evaluation and of retention of information were grouped according to the classroom learning and e-learning modules. For comparison of grades between the classroom learning and e-learning modalities (in both the summative and the retention of information evaluations), Student's *t* test for paired samples was used.

Significance levels of 5 % were considered. SPSS version 21.0 software was used.

Results

Of the initial 72 students, four were lost due to lack of participation on the second day of the course and one due to non-completion of the evaluation (Fig. 1). Thus, a total of 67 students participated in the study and were divided into classes A (48 %) and B (52 %); there were 23, 22, and 22 students from

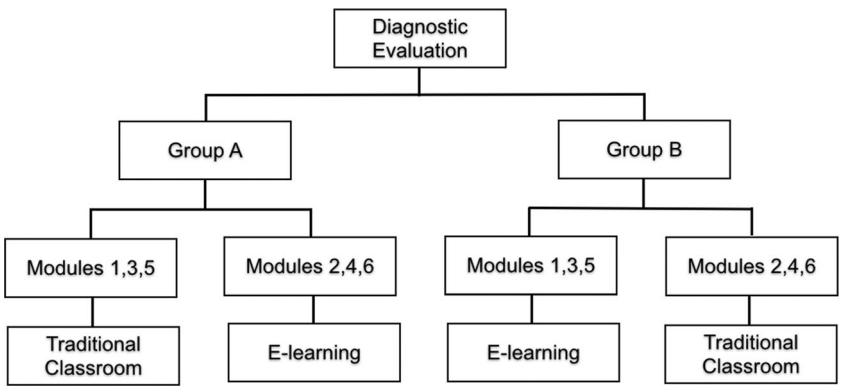

Fig. 2 Grouping of grades of the final and diagnostic evaluations

the second, third, and fourth years, respectively. The majority of the students attended the night period (67.2 %), where females (80.6 %) without paid work (79.1 %) had an average school grade of 7.43 (SD 0.94) and an average age of 20.9 years (SD 2.27). Classes A and B were similar regarding school year ($p = 0.955$), gender (female 82.9 vs. 78.1 %, $p = 0.625$), paid work (absent in 80.0 × 78.1 %, $p = 0.850$), average age (21.27 × 20.66 years, $p = 0.274$), and average school grade (7.39 SD 0.96 × 7.47 SD 0.91 points, $p = 0.721$).

In the diagnostic evaluation, it was observed that the minimum knowledge about oncology was low (44.56 SD 16.91), and most students were unaware of the issues related to bone and soft tissue tumors. The students showed a greater knowledge in issues related to pain and palliative care, a fact that was similar between the two classes (Table 1). No difference between the classes (Table 2) was observed when comparing the respective students according to the teaching modality to which they were subjected.

The course was within the predicted program and time schedule, with full teacher participation and with similar content for the classroom and e-learning lectures. The time for questions after each lecture was also equivalent between groups. In the final whole-group evaluation, there was a general increase in the number of correct answers (73.92, $p < 0.001$), independent of the associations of initial and final correct answers and errors and teaching modality (Table 2, Fig. 3a). However, that result was influenced by the content of the modules, as the students had higher initial and final grades in module 1-3-5. From the results, it is also observed that the average percentages of answers considered random (correct answer in the diagnostic evaluation and incorrect answer in the final evaluation) were minimal when compared to the rest of the answers: 4.99 (SD 3.85) for classroom learning and 4.76 (SD 3.74) for e-learning. Likewise, information retention was high, regardless of the teaching modality (Table 2, Fig. 3b).

Approximately 52 % of students reported that the topic added greatly to his or her knowledge. The grades were 9.30 (SD 0.83) for the classroom course and 7.87 (SD 1.23) for the e-learning course, and 57 % ($n = 38$) of students considered e-learning superior or similar to the conventional classroom methodology. When asked if an extension course could be delivered remotely, 27 % said yes, and 15 % stated that the teaching modality did not influence learning. However, 21 % said that a lack of communication with the teacher led to learning difficulties.

Table 2 Percentage of responses in the diagnostic and final evaluations according to group and teaching modality

Variable	Group/questions	Group/mode of education	Mean	SD	Median	Minimum	Maximum	*p*
Diagnostic evaluation	Group A	A Traditional[a]	46.94	16.72	47.62	19.05	80.95	0.019
		A E-learning[b]	43.63	19.28	39.68	9.52	82.54	
	Group B	B E-learning[a]	45.54	14.53	44.44	15.87	71.43	0.029
		B Traditional[b]	41.67	17.84	40.48	6.35	76.19	
	All	A	45.73	17.85	40.48	15.08	78.57	0.556
		B	43.27	16.00	44.04	11.11	71.43	
Final evaluation	Group A	A Traditional[a]	68.34	11.92	66.67	36.51	87.30	<0.001
		A E-learning[b]	76.42	9.55	76.19	57.14	93.65	
	Group B	B Traditional[b]	80.31	7.42	79.37	65.08	92.06	<0.001
		B E-learning[a]	70.93	8.73	70.63	53.97	87.30	
	All	Traditional	74.06	11.63	76.19	36.51	92.06	0.858
		E-learning	73.02	9.51	73.06	53.97	93.65	
	Correct/correct	Traditional	38.97	17.05	38.09	6.35	73.02	0.308
		E-learning	40.13	16.33	39.68	9.52	76.19	
	Incorrect/incorrect	Traditional	20.94	10.48	20.63	1.59	53.97	0.670
		E-learning	21.44	8.76	22.22	6.35	42.86	
	Correct/incorrect	Traditional	4.99	3.85	4.76	0.00	15.87	0.675
		E-learning	4.76	3.74	4.76	0.00	15.87	
	Information retention	Traditional	35.08	14.57	31.74	11.11	73.02	0.408
		E-learning	33.66	12.21	33.33	7.94	61.90	

SD standard deviation, *Information retention* incorrect answer in the diagnostic evaluation and correct answer in the final evaluation, *Final grade* = (-correct answer in the diagnostic and final evaluations) + (incorrect answer in diagnostic evaluation and correct answer in the final evaluation)

[a] Modules 1, 3, 5 = Foundations of oncology; breast cancer; neurological tumors

[b] Module 2, 4, 6 = Pain and palliative care; bone and soft tissue tumors; urogynecological cancer

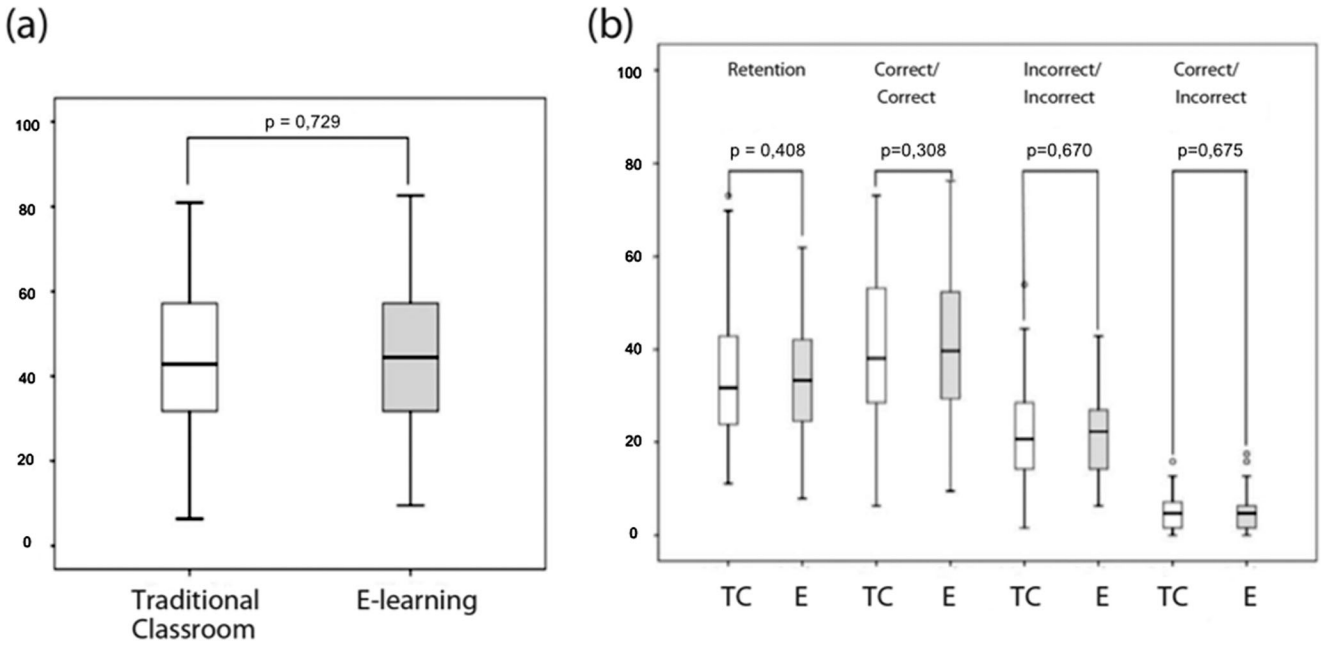

Fig. 3 Percentage distributions of responses from the initial and final evaluations according to teaching modality, i.e., traditional classroom (TC) or e-learning (E). **a** Overall and **b** type of response

Discussion

The traditional teaching and learning process (i.e., the classroom) is commonly centered on the role of the teacher as knowledge transmitter, making the student just a passive reproducer of information. Considering the educational realities and the changes and advances in educational technologies, it is necessary to train students with critical, creative, and innovative thinking [26].

In pursuit of comparability between the classroom and e-learning methodologies, there is a lack of standardization in the workload of the course/lecture [12, 16, 18, 19, 27, 28]. In the current study, the workloads used in the classroom and e-lectures were identical, as were the syllabi, the teaching staff, the classrooms, and the technological apparatus applied to all e-lectures, favoring the standardization and reliability of these teaching methodologies, facilitating comparisons of the level of knowledge acquisition among the students after the course, and reducing possible biases.

This study was randomized, with random allocation, due to the limitations of well-controlled studies on the topic, thus avoiding possible research biases [29]. School year and weighted average grade of the previous school years were used, and the students were homogeneously distributed into classes A and B, with the intention of standardizing the subjects (students), preventing any attraction for and initial choice of a teaching modality [17]. The homogeneity of classes A and B regarding the sociodemographic characteristics and the level of knowledge of oncological physiotherapy ($p = 0.556$) obtained in the study contributed effectively to measuring the level of retention of information after the course. It is noteworthy that for studies in which diagnostic evaluations were performed [9, 11-18, 20, 21, 23, 28, 30], there was no description of the results regarding the level of prior knowledge about the topic. This parameter is intended to contribute to the validity of the course offered and the reliability of the measurements of the level of knowledge after the intervention.

E-Learning

Comparisons between e-learning and traditional classroom teaching have been evaluated in several studies [10, 14–16, 19, 22, 28, 31–33]. E-learning improves the practical training of students, increasing their responsibility in the learning process compared to the traditional method and possibly raising the level of student satisfaction [34]. Moreover, e-learning decreases costs [32] because the same program can be broadcasted to a larger number of people, reducing the demand for a classroom tutor and offering more flexibility [33].

E-learning has been used with undergraduate students [33, 35, 36], individuals with undergraduate degrees/residents and graduate students [16], and is effective in facilitating student-teacher communication. Its use in oncology is limited [37].

The Articulate® software was selected because it is a self-executable program that enables the import of lectures previously prepared in PowerPoint and the inclusion of audio allowing greater teacher independence [38]. Many studies [19–21, 28, 39] using identical content on different types of teaching modalities supported the methodology applied in this study.

When we evaluated the performance measurements of undergraduate physiotherapy students after the university

extension course on oncological physiotherapy, similar results were obtained for the two teaching modalities with respect to the retention of information. The level of information retention between different school years is frequently not evaluated in e-learning studies [9, 10, 14, 17, 20, 27, 31].

However, findings for satisfaction regarding the participation in an e-learning course are contradictory [17]. Although only 27 % of students responded that the course could be conducted at a distance, 41.8 % of students considered e-learning inferior, but in the summative evaluation, the information retention levels were similar, a fact that demonstrates the subjectivity of personal impressions and a tendency to not accept the active form of education, justifying well-designed randomized studies, a fact that can avoid the bias of selection.

With regard to publications that describe the superiority of e-learning education, we can observe possible biases in these studies, like problems in the randomization [9], limitations in the adherence [11], or different contents between the groups [10, 12, 14] absence of intervention in the control group [13, 40]. The above studies had the possibility of biases that can positively influence e-learning studies, either by differences of content or format or by not evaluating the knowledge prior to randomization. In this study, students were randomly assigned by year of schooling, and although the timeline of the module was not pre-selected, we observed that a module (1-3-5) was related to higher grades in the summative and diagnostic assessments, a fact independent of the teaching modality. However, due to the crossover between the groups, this fact did not influence the overall results (Table 2). In a randomized, prospective study, Wandorff et al. (2009) [22] reported negative results for e-learning, but they had a high loss of subjects.

There are several publications showing that e-learning has similar results in comparison with classroom teaching, but the literature also reports conflicting conclusions, with e-learning exhibiting better, worse, or similar results [11, 15–21, 23, 30]. In this study, we sought to control most of the variables, thus reducing possible biases, observing that the e-learning method was as effective as classroom education in terms of knowledge retention. Thus, the present study gives satisfactory scientific evidence of the effectiveness of e-learning in oncology for undergraduate students of physiotherapy, a fact that opens the way for other undergraduate courses in the field of oncology, other undergraduate health-related areas, or oncology residents.

This study leads to important clinical implications. Articulate® or recorded lesson may be stored and presented as an e-learning course, supported by other software, as Moodle® for example, which is able to control student access and create evaluation scores. Other possibility is the use of it as Supplementary Material from classroom, improving the classroom discussion.

Conclusion

E-learning modalities are a complementary way to improve oncology knowledge to undergraduate students. The use substitution of conventional classroom to e-learning modality leads to same results of retention of information, a fact that promotes e-learning methodology. It is necessary for more studies to evaluate the requirement of specific oncology course during graduation of Physiotherapy.

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Compliance with Ethical Standards

Conflict of Interest None

Ethical Approval This research project, number 616/2012, was approved by the Ethics Committee in Research of the Barretos Cancer Hospital on 27 November 2012. It was conducted according to the Declaration of Helsinki. It was registered at Brazilian Registry of Clinical trials (REBEC, 04/21/2013), number U1111-1142-1963.

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