

Current Status of Simulation-based Training Tools in Orthopedic Surgery: A Systematic Review

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OBJECTIVE: To conduct a systematic review of orthopedic training and assessment simulators with reference to their level of evidence (LoE) and level of recommendation.

DESIGN: Medline and EMBASE library databases were searched for English language articles published between 1980 and 2016, describing orthopedic simulators or validation studies of these models. All studies were assessed for LoE, and each model was subsequently awarded a level of recommendation using a modified Oxford Centre for Evidence-Based Medicine classification, adapted for education.

RESULTS: A total of 76 articles describing orthopedic simulators met the inclusion criteria, 47 of which described at least 1 validation study. The most commonly identified models ($n = 34$) and validation studies ($n = 26$) were for knee arthroscopy. Construct validation was the most frequent validation study attempted by authors. In all, 62% (47 of 76) of the simulator studies described arthroscopy simulators, which also contained validation studies with the highest LoE.

CONCLUSIONS: Orthopedic simulators are increasingly being subjected to validation studies, although the LoE of such studies generally remain low. There remains a lack of focus on nontechnical skills and on cost analyses of orthopedic simulators. (J Surg Ed ■■■■-■■■. © 2017 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: orthopedic surgery, simulation, training, systematic review

COMPETENCIES: Patient Care, Practice-Based Learning and Improvement, Interpersonal and Communication Skills

INTRODUCTION

Halstead's method of "see one, do one, teach one" has traditionally been the preferred method of surgical training.¹ Learning as an "apprentice" in the operating room (OR) was the principal method of gaining skills at any level of a surgical trainee's learning curve, until relatively recently.¹ With increased focus on patient safety, heightened patient expectations, and working time restrictions on weekly working hours, the Halsteadian method of training is now less applicable.^{2,3} The successful implementation of simulation within the military and the aviation industries has paved the way for simulation-enhanced training in surgery.^{3,4}

The benefits of simulation training in the current climate are recognized by most surgical specialties, and increasing numbers of simulators have been developed as a result.⁵ Orthopedic simulation has generally lagged behind other specialties, with fewer validated simulators available, though this trend is now changing.⁵

Surgical simulators may be divided into several categories, including synthetic bench, animal and human cadaver models, and computer-assisted "virtual reality" (VR) simulators. Before these can be used for training and assessment, they must initially undergo a multiparametric assessment of validity.^{6,7} The aim of this study is to identify all of the orthopedic simulators described in the literature and review their validity.

METHODS

Search Methods

The EMBASE and MEDLINE databases were searched for articles that described orthopedic training models or simulators between 1980 and March 2016. The search strategy

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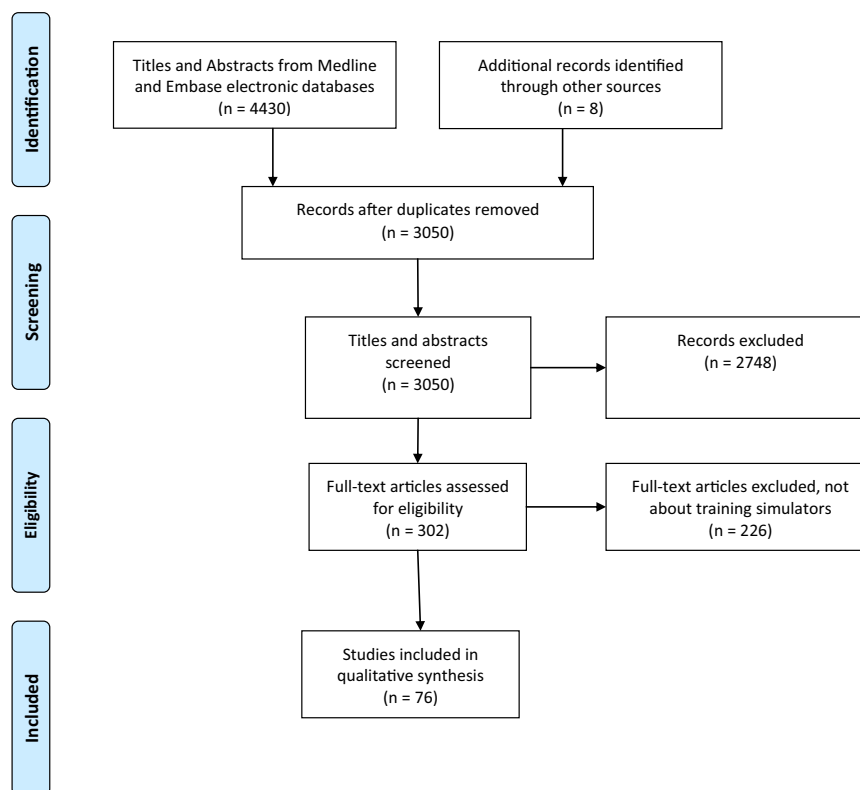


FIGURE 1. Systematic review algorithm, employing the PRISMA guidelines in the EMBASE and MEDLINE databases.

employed the following terms: “orthopaedic” or “orthopedic” or “arthros*” and “simulat*.” Duplicates were removed and titles and abstracts were screened for relevance, using the PRISMA guidelines⁸ (Fig. 1).

Selection Criteria

Articles describing an orthopedic training simulator or validating an existing training model/simulator were included. Articles were excluded if they were not in the English language or if they were not complete by their author’s description. Models and simulators were classified into the following categories: bench, VR, cadaver, animal model, and augmented reality. These categories have, in places, been expanded to include details about the type of bench model, such as a Sawbones product, or the use of an additional system such as motion analysis.

Data Extraction

After the initial articles were screened using their titles and abstracts, the remaining articles were examined in their entirety. Articles were included if they described an orthopedic simulator used for training. If the reference list of an article contained a study that was not found in the search result but appeared relevant to this article, the said study was subjected to the same selection criteria.

Data Analysis

The outcomes for the validation studies were selected and reported. Definitions of validity were based on the definitions of van Nortwick et al.⁹ (Fig. 2). Some studies did not explicitly state the type of validation study undertaken; in these cases, they were classified according to the definitions below. Face and content validity inquire the realism and

Face Validity	– Degree to which the simulator resembles clinical scenarios, i.e. realism
Content Validity	– Whether the domain or criteria attempting to be measured is actually being measured by the assessment tool or simulator
Construct Validity	– Capability of the simulator to distinguish between different levels of expertise
Transfer Validity	– A gauge of whether the simulator has the effect it proposes to have, ie will the simulator improve performance whilst operating through a consequence of learning

FIGURE 2. Validation definitions.⁹

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