Train4OrthoMIS Online Course as a Manner of Improving Ergonomics in Orthopaedic Surgery

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Abstract. The paper presents the research outcomes on ergonomic needs among orthopaedic surgeons and the way of improving working conditions while performing orthopaedic surgeries. The international survey was conducted among orthopaedic surgeons in Europe, that revealed physical ailments of surgeons like neck pain, thoracic and lumbar pain, musculoskeletal stress, fatigue in the legs and feet as well as mental fatigue or headache. In turn to the most important deficiencies in ergonomics area are: awkward body postures, having to stand, the position and height of the operating table.

Taking this into account it is proposed an open and international online training course for improving ergonomics features. The new approach of this course is demonstrated by basing on ICT functionalities and combination of specific course features like: possible short duration of training; contents focus on practice and based on knowledge visualization; mobile and open access to training or knowledge verification based on students' preferences.

Keywords: Ergonomics · Working conditions improvement · Orthopaedic procedures · Procedural knowledge · International E-learning course · Train4OrthoMIS

1 Introduction

Orthopaedics is one of the essentially domains in surgery. This results from the raising orthopaedic disorders magnified specifically by civilization factors like sedentary lifestyle, extension of lifetime, growing automotive industry and associated to this automotive accidents etc. Together with the needs in orthopaedic field it is observed the

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development of methods and procedures in orthopaedic surgeries. One of the new and still improving approaches is minimal invasive surgery (MIS) or reducing the size of skin incisions. Such direction of surgical development is positive, especially for patients, because of better efficiency and effectiveness of surgery, better cosmetics effects or lower risk of infections, but it could cause certain problems for medical staff both for surgeons and scrub nurses. These problems concern ergonomic failures what can lead to fatigue or even musculoskeletal disorders of orthopaedic surgeons and scrub nurses [1–3].

Particularly, the preliminary international survey which was conducting within 2015 on 41 orthopaedic surgeon from Europe (including 1 individual from other countries than Europe) confirmed the necessity of improving ergonomics in operating room (OR) while performing orthopaedic surgeries. Simultaneously they indicate such physical problems while performing surgeries like: neck pain, thoracic and lumbar pain, stiff neck, fatigue and musculoskeletal stress, fatigue in the legs and feet and mental fatigue or headache, see Fig. 1.

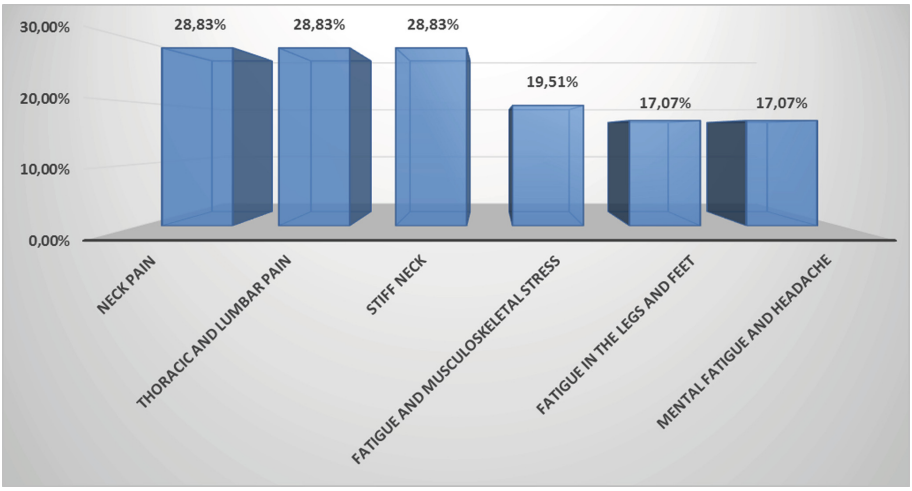

Fig. 1. The most common health problems of orthopaedics.

Regarding aspects that could affect non-ergonomic posture during surgical practice they are mainly: patient positioning, static posture surgeon, regulatory ranges and characteristics of the table and type of surgery. In turn to the most important deficiencies in ergonomics area are: awkward body postures, having to stand, the position and height of the table inadequate surgery [4].

Taking into account the challenge that is improving ergonomics in orthopaedic surgeries there was formulated the work problem as follows: how to create and implement unify ergonomics standards while performing orthopaedic surgical procedures to make them more comfortable and safe for surgeons? In order to answer this research question, the aim of the study was defined as developing the specification and content for creating the unified online training course on ergonomics directed to orthopaedic professionals regardless the country they live and work. The assumption of this online

training course is to include ICT (information and communication technology) functionalities to make the training mobile and interactive. The name of this course is Train4OrthoMIS, the acronym of the international project "Online Vocational Training course on ergonomics for orthopaedic Minimally Invasive Surgery" that has been funded with support from the European Commission.

2 Materials and Methods

2.1 Methodological Model

The aim of the study forced the development of certain methodology which is composed of four stages. Their detailed description is shown in the Fig. 2. In particular, the main issues from the marked area covering second and third stages are the subject matter of this article.

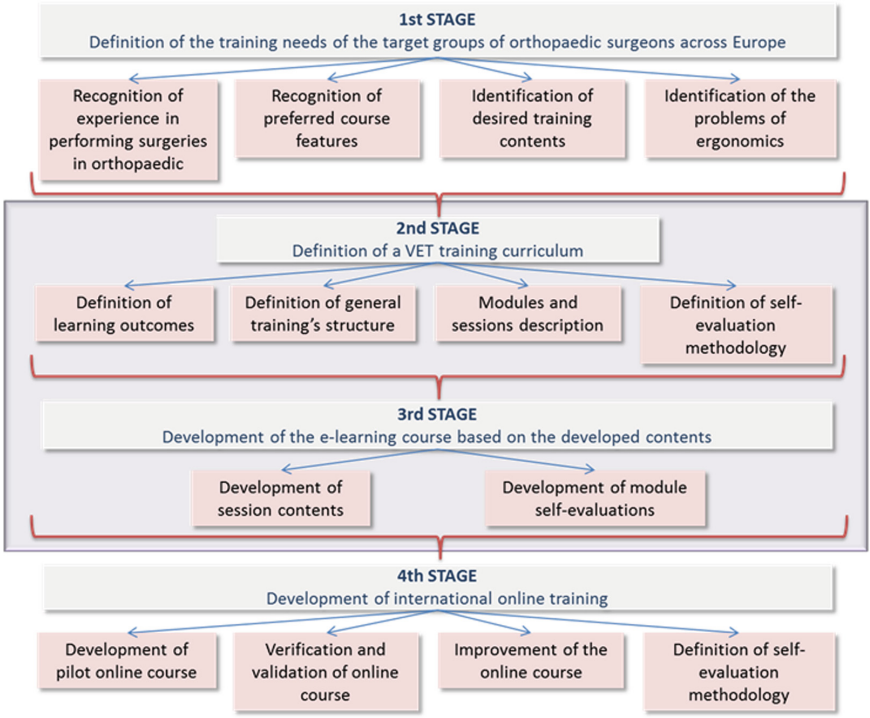

Fig. 2. Detailed description of methodology.

Specifically, these stages should be prepared in such a way that they could be useful within the work on preparation of e-learning course with the use of ICT solutions.

2.2 ICT Factors in Train4OrthoMIS Ergonomics Course

The concept of Information and Communication Technologies is greatly wide and covers all informatics and communication products and services. In particular, these technologies include processing, gathering and information transmitting technology in electronic form [5].

Considering ICT functionalities and their potentially contribution for improving the effectiveness and utility of the Train4OrthoMIS course there were recognized the essential factors determining assumptions for tasks within second and third stages in the methodology. They are following:

- *unified communications* which means the possibility of integrating different forms of real-time with non-real-time communication services, e.g. instant messaging (chat), e-mail, SMS,
- *unlimited access to e-learning contents* by stationary and mobile devices,
- *the high quality of information* which is defined by such factors as: accuracy, timeliness, completeness, relevance and coherence [6] as well as readability, understandability,
- *variable forms of e-training materials* which is associated to the size and form of the individual elements of learning objects making them reused and allowing them for combinations according to the contextual situation and the type and content of the training. In the literature, such elements are referred to as the Reusable Learning Objects (RLO) [7], E-learning Objects (ELO) or Shared Content Objects (SCO). The examples of RLOs can be video or audio, interactive games and quizzes in virtual working conditions, course modules, animations, graphics, websites, PDF files, documentation, and other elements that are designed to spread certain resources, e.g., in the form of a lesson based on the Internet [8].

Taking into account these factors there were formulated assumptions for the tasks of highlighted stages from the methodology, Table 1.

According to the formulated assumptions the learning contents meets the requirements for ICT functionalities mentioned before. Particularly all of recommended points indicated in the Table 1 will be implemented into e-Platform being simultaneously a Platform for exchanging knowledge or messages in different configurations: tutor – student, student – student and tutor – tutor, in real-time or non-real-time mode.

In the same time the assumptions are formulated to meets the students' preferences diagnosed within survey. They are specifically: possible short duration of the training; contents focus on practice and based on knowledge visualization; mobile and open access to the training; knowledge verification based on single choice tests and interactive quizzes.

Table 1. Assumptions for ICT based definition of a Train4OrthoMIS course

Task	Assumptions
2nd STAGE - definition of a VET training curriculum	
Definition of learning outcomes	There is clearly defined three groups of learning outcomes: *knowledge*, *skills*, *competences* that will designate the boundaries for ELOs, their representation forms and self-evaluation methods
Definition of general training's structure	The general training's structure definition consists of organizational and technical assumptions *Organizational assumptions*: The substantive course topics are ordered and linked together into greater objects according to diagnosed ergonomic needs and defined learning outcomes. Simultaneously they form ELOs creating modules and sessions. The number and size of ELOs is adjusted to total time for the course: 50 h *Technical assumptions*: ELOs are consisted of variable forms of knowledge representations. The selection of the ELOs' form depends on the type of knowledge, where there are assumed two types of knowledge: procedural or declarative. The procedural knowledge is a knowledge answering to the question "how" while, the declarative knowledge means its possession in the specific area, the so-called knowledge "that" [9]. The main form for declarative knowledge is text, and for procedural knowledge are video or audio, interactive games and quizzes in virtual working conditions, course modules, animations, graphics etc All of formats of ELOs are readable for standard parameters of stationary and mobile devices
Modules and sessions description	Modules description consists of substantive assumption which is compatible with the defined learning outcomes. The basic ergonomics issues are gathered in one module and is directed to both hip and spine surgeons. More specific problem areas considering certain type of surgeries are described in differed ELOs and are addressed separately for certain group of surgeons (spine and hip)
Definition of self-evaluation methodology	Definition of self-evaluation methodology consists of organizational and technical assumptions *Organizational assumptions*: self-evaluation work is present within each stage of the course. Self-evaluation test must be performed before starting the next module. There are two different types of self-evaluation tests: (a) free tests without impact on finishing course mark; (b) exam that have impact on finishing course mark Time restriction is obligatory only for the exam *Technical assumptions*: tests have variable forms for free tests and exam and are adjusted to most student preferences. All of formats of tests are readable for standard parameters of stationary and mobile devices
3rd STAGE - Development of the e-learning course based on the developed contents	
Development of session contents	Training contents are developed according to 2nd stage assumptions. Particularly declarative knowledge is formulated according to literatures, facts, interviews etc. and own knowledge repositories; declarative knowledge is formulated according to video registrations of real surgical procedures and ergonomic analysis. Within whole contents there is used unequivocal vocabulary. All material contents have electronic forms
Development of self-evaluations module	Self-evaluations module are developed according to 2nd stage assumptions. Particularly self-evaluation topics are compatible with defined learning outcomes. Within test contents there are used unequivocal vocabulary compatible with session contents

3 Results

Based the methodological structure and assumptions the implementation of ergonomics standards was performed obtaining as a result the accomplishment of all tasks described within second and third stages. First of all, the detailed description of Curriculum documentation was prepared taking into account the recommended three groups of learning outcomes: knowledge, skills and competences. This document allows future students to recognize the ergonomics aspects get to know of which they should make them able to implement ergonomic rules in their orthopaedic practice. Figure 3 presents a fragment of the documentation on the background of the assumptions for ICT (see Table 1).

Fig. 3. A fragment of curriculum for Train4OrthoMIS course including the description of learning outcomes

The description of learning outcomes is reflected in the training structure. Considering the theoretical and practical aspects of the training, the course is divided into four modules. Each module is divided into sessions which correspond to ELOs and have duration of about 2 to maximum 6 h. The Fig. 4 shows a general scheme summarizing the course structure with emphasis on the type of knowledge dominating (marked by bigger size of font in the scheme) with creation of certain ELOs. It should be highlighted that the great part of training contents is prepared based on procedural knowledge what corresponds to the surgeons' expectations.

Particularly the procedural knowledge reflects certain type of activities and resources needed to perform orthopaedic surgery of hip or spine taking into account ergonomic criteria. However, there were four phases of developing training materials:

- *First phase* was video registration of real surgeries and/or surgeon's body segment angles measurement,

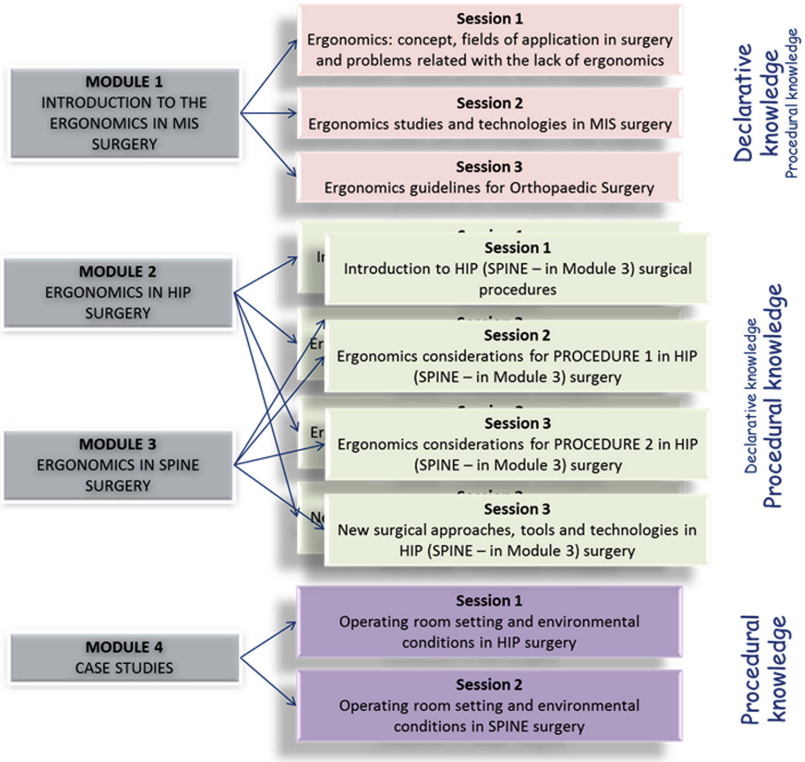

Fig. 4. General content and structure of Train4OrthoMIS course

- *Second phase* was ergonomic analysis based on video materials in such areas as: ergonomics body posture, ergonomics of surgical instruments, operating room layout, workflow and surgical team cooperation. The ergonomic tools assessment were mainly based on observational methods like OWAS, RULA, REBA, computer aided ergonomic assessment with se use of virtual environment 3DSSPP, Anthropos ErgoMAX and CAPTIV system.
- *Third phase* was developing general (for MIS in orthopaedics) and specific (for certain type of surgical procedure) recommendations.
- *Four phase* was notation of training materials with the use of visual representation like static and dynamic graphics.
- For instant, in the Fig. 5 the training materials development is presented taking into account the registration, body segment angles identification and virtual working environment creation.

All interactive ELOs are focused on the transfer of procedural knowledge what is the most important value to surgical practice. In the same time, such a way of knowledge representation is universal and intuitive for human perception making the e-training a practice tool for improving professional skills.

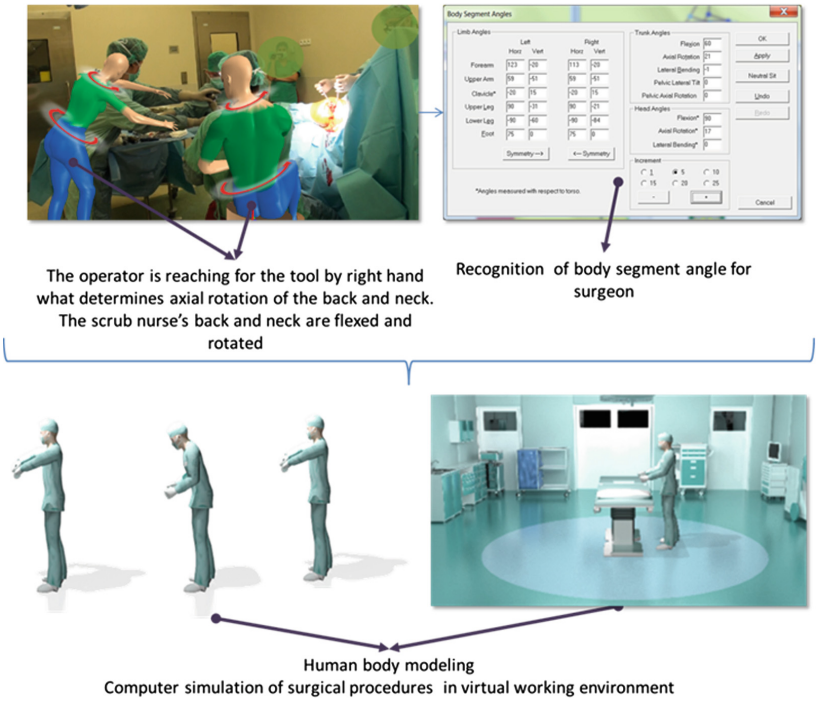

Fig. 5. The procedure of training materials development

Another way of procedural knowledge representation in learning process is the graphical based surgical workflow analysis. The basis for developing workflow is video material of surgical course. There is presented an example of using workflow representation in analysis ergonomics and effectiveness of surgical procedure. In the Fig. 6 there is presented two general sections in the graphical representation of workflow:

1. Specification of job elements, inter alia: procedure stages, tolls handling, operational activities, disruptions, deficiencies,
2. The processing of job elements showed by use of charts.

All job elements are synchronized with video materials what allows for identification of problems in range of work organization and communication within surgical team as well as their causes and consequences.

The characteristic elements describing surgical workflow and influencing ergonomics as well as effectiveness of procedure are:

- Disruptions like: improper lighting of the operative field and the need for its corrections; viability of a pump suction and flushing, which consequently can lead to replace with a new one;
- Passive action of surgeon operator results from such causes like: waiting for surgical instruments, waiting for materials etc.
- Deficiencies like: lack of materials, devices etc.

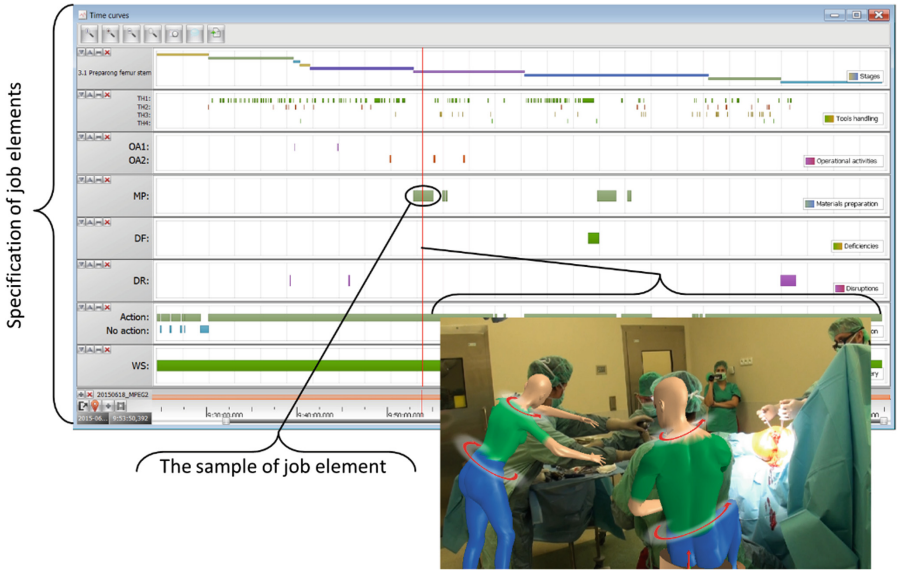

Fig. 6. Graphical representation of workflow while performing hip replacement

- Cases, where surgeon operator covers activities normally performed by an assistant,
- Cases, where surgeon operator must correct activities performed by an assistant.

The last part of e-learning course is knowledge verification of student. The ways for this process are based on electronic self-evaluation tools. The assumption was formulated that the test forms will be adjusted to the future students' preferences. For this reason, the survey was conducted on 184 respondents. The most preferred way of knowledge verification is traditional method i.e. single choice. However, more sophisticated quizzes can be a supplementary way of self-knowledge evaluation, especially within daily work on e-Platform.

4 Conclusions

Train4OrthoMIS course is the professional knowledge platform directed to orthopaedic surgeons the aim of which is to improve their practice in ergonomics area. The need of developing the course results from the occupational hazard in MIS surgery and simultaneously a lack of ergonomics contents within standard high education system. This problem is common for surgeons population regardless the country they practice.

Hence, the recognition of ergonomic problems while performing orthopaedic MIS on international level was the opportunity to complete formative e-learning content according to real surgeons' needs and implement ergonomics standards in orthopaedic surgery. ICT tools are here the accurate solution allowing the wide audience of orthopaedic practitioners an access to ergonomic knowledge. In the same time the currently results showed that certain ICT functionalities, like making declarative and practical

knowledge available and explicit by interactive graphical representations or online transferring knowledge in line student – academic tutor, can be successfully used for improving practical skills of surgeons in ergonomic area and help them to make working condition more user friendly.

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