Training on Biomechanics and Virtual Reality tools in the field of Stroke Rehabilitation

Learning guide

INDEX

1. INTRODUCTION

Welcome to the "**Training on Biomechanics and Virtual Reality Tools in the field of Post-Stroke Rehabilitation" - Pilot Course,** which will take place from **March 7, 2022** to **April 20, 2022.**

Before beginning the training, we recommend reading carefully the following **Learning guide.** This guide is intended to be a useful tool for the student because it collects all the information required to have a global vision of the course and the context in which the teaching-learning process will be developed.

Taking the course includes:

- Initial streaming session: an introduction to the use of the virtual platform and how the course works in general.

- Final streaming session: the course will end with the revision of the final exam and the resolution of doubts.

Keep in mind that **studying online** does not only involve downloading or printing materials to study offline, but taking advantage of all the possibilities provided by the Information and Communication Technologies (ICT).

It is essential that trainees know that they have greater freedom and responsibility in their training, which involves organizing their learning pace, doing the planned activities and using the different tools available to communicate with the teaching team and engage with other participating classmates.

2. OBJECTIVES

BRAIN4TRAIN arises to generate a learning offer addressed to healthcare professionals involved in the use of new technologies to improve functioning of people suffering from neurological disorders, especially stroke or cerebrovascular accident (CVA), to complement the learning outcomes of current formal high educational programs with a training in these new technologies for assessment and treatment.

The aim of the course is to give learners the needed knowledge about:

- general and specific aspects of stroke accidents and rehabilitation procedures;

- innovative technologies and devices available for stroke rehabilitation;
- technical and clinical aspects of using Virtual Reality and biomechanics systems in stroke rehabilitation;
- examples of supporting motor and cognitive rehabilitation based on Virtual Reality and biomechanical systems.

3. COURSE CONTENTS

MODULE 1: INTRODUCTION TO STROKE REHABILITATION

Session 1: Stroke: Clinical features, impairment and functional evaluation from a holistic point of view

DESCRIPTION

This session contains specialized information about the physiopathology and epidemiology of stroke, including types and subtypes of stroke classification and clinical features, as well as prognosis according to the former. Additionally, this session includes information about how to assess patients who have suffered a stroke, including scales, classic test and most widespread methods to perform a comprehensive evaluation of impairment.

LEARNING OBJECTIVES

- To know the etiopathogenic classification of stroke and the differences according to mechanism (ischemic vs. hemorrhagic).
- To know the epidemiology of stroke.
- To know the different subtypes according to the origin and location of the stroke.
- To know differences in clinical features and impairments caused by each of the stroke subtypes.
- To know evaluation methods and scales used for the assessment of any sort of impairment in patients with stroke.

Session 2: Stroke and rehabilitation. State of the art and scientific evidences. Clinical practice guidelines

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DESCRIPTION

In this session, the student will find useful information describing the main therapeutic approaches in rehabilitation of stroke, always according to scientific literature. This include the description of different rehabilitation treatments for cognitive, motor and sensitive functional impairments and their neurophysiological fundamentals in each case.

LEARNING OBJECTIVES

- To know which are the main aims and phases in the rehabilitation process of stroke according to clinical features, type of stroke and prognosis.
- To know the different approaches on the rehabilitation process of stroke according to type of impairment: cognitive, motor and sensitive functional impairments.
- To know recommendation and level of evidence existing for each approach or method.
- To know neurophysiological fundamentals of rehabilitation treatment.
- To know main official clinical guidelines that address rehabilitation in stroke.

Session 3: Introduction to new technologies in Physical and rehabilitation Medicine (PRM). Neurophysiological basis and state of the art

DESCRIPTION

This Session will give an overview of several technological solutions that can be used as a support to traditional rehabilitation, focusing on the available devices and showing the different categories developed for helping the physical therapists to improve the recovery from motor impairments due to stroke, including locomotion and upper-limbs function restoration, exploiting strategies underlying robotic-based training and virtual reality features.

LEARNING OBJECTIVES

- To know the different kinds of technologies available in the rehabilitation field in general and, in particular, those regarding motor recovery after stroke.
- To know which are the main technological tools that can be specifically applied to improve function of either upper-limbs or lower-limbs.
- To know that technological support can be provided through robotic mechanisms, exoskeletons or wearable devices, integrated with virtual reality or rehabilitation gaming features.
- To know the neuro-physiological basis of the strategies underlying the mechanisms employed by such technologies.

- To know the categories of the state-of-the-art tools that can be used in rehabilitation, of post stroke people in particular, according to their impairment and rehabilitation programs.

MODULE 2: BIOMECHANICS IN STROKE REHABILITATION

Session 1: Introduction to biomechanics. Clinical basis & usefulness in the rehabilitation field

DESCRIPTION

Throughout this session, the student will find information about functional functional assessment in the rehabilitation field, regarding what it consists on and how it can be performed. Includes topics like the differences between classical methodology VS biomechanical instrumented analysis. Additionally, an introduction about main biomechanical parameters and which tools can be used to measure them is done.

LEARNING OBJECTIVES

- To know about basics concepts in biomechanics related to kinematic and kinetic parameters.
- To know how to interpret basic kinetic and kinematic data.
- To know main biomechanical system and tools that can be used to measure each parameter.
- To know the advantages of biomechanical assessment compared to classical functional assessment.
- To know the applicability of biomechanical functional assessment within the field of stroke rehabilitation.

Session 2: Biomechanics and functional assessment of gait in stroke

DESCRIPTION

This session presents the structure of a general gait analysis laboratory and deals with practical issues related to the use of the movement analysis technologies in stroke patients. The main kinematic and kinetic variables and the electromyography patterns are analyzed with reference to the normal population and to an example of stroke subject.

LEARNING OBJECTIVES

- To know how a biomechanical gait analysis is performed
- To know which measurements are taken or processed to obtain both kinematic and kinetic variables.

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- To know the meaning of these variables and their patterns as a function of the gait phases during normal walking
- To know the main factors influencing these patterns (age, gender, velocity) and how to consider such influence on the analysis of pathological walking.
- To know the main pathological factors leading to abnormal walking patterns which are most frequently observed in post-stroke individuals.

Session 3: Biomechanics and functional assessment of balance in stroke

DESCRIPTION

During the present session, the student will find information related to normal balance and how it is impaired in stroke. It includes an insight on physiologic basis of normal and of pathological Balance, as well as the tools that can be used to measure it, highlighting topics related to posturography and the parameters it provides.

LEARNING OBJECTIVES

- To know about fundamentals and physiological basis of normal balance
- To know about physiopathology of balance impairment in stroke
- To know which tools can be used to perform an instrumented balance assessment and which parameters they provide
- To know fundamentals of posturography
- To know how to interpret basic biomechanical data coming from balance assessment
- To know about typical findings of balance in stroke
- To recognise the utility and applicability of biomechanical instrumented assessment of balance within the field of stroke rehabilitation

Session 4: Biomechanics and its role in the therapeutic decision-making

DESCRIPTION

This session shows some of the recent existing evidence on the use of biomechanical assessment methodologies in stroke, including information provided by different scientific papers and clinical guidelines.

LEARNING OBJECTIVES

- To know the applicability and usefulness of biomechanical assessment in Neurological rehabilitation.
- To familiarize with existing scientific evidence on the role of biomechanical functional assessment, with special awareness on Neurological rehabilitation and stroke.

MODULE 3: VIRTUAL REALITY IN STROKE REHABILITATION

Session 1: Introduction to Virtual Reality. Clinical basis & usefulness in the rehabilitation field

DESCRIPTION

In this session, a general information on technical aspects of VR technology is provided. The areas of utility of VR are presented focusing particularly on training, medicine and social applications. There are also described different examples of using VR in stroke rehabilitation. Here two types of general impairments of post-stroke patients are taken into account: motoric and cognitive functionality.

LEARNING OBJECTIVES

- To know the definition of Virtual Reality.
- To provide examples of Virtual Reality tools.
- To learn differentiates of Virtual Reality Tools in reference to potential scope of supporting certain impairments of post-stroke patients.
- To know the software basis for Virtual Reality.
- To know hardware components of Virtual Reality.
- To know the Virtual Reality market products (consoles) of both for entertainment uses and rehabilitation uses.
- To know the scope of functionality of Virtual Reality and its potential for stroke rehabilitation.
- To give evidence of positive feedback of using Virtual Reality tools in stroke rehabilitation.
- To know the neurophysiological fundamentals foundation of Virtual Reality.

Session 2: Virtual reality as treatment and assessment tool in stroke rehabilitation – a practical guide

DESCRIPTION

Session 2 is devoted to describe a practical guide for using particular VR devices in stroke patient's rehabilitation process. This description is provided in a path from general to specific information that gives the opportunity to explain how and in what way the treatment and assessment can be supported by VR. Finally short cases with video is embedded into contend in order to illustrate both motor and cognitive recovery.

LEARNING OBJECTIVES

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- To know the functionalities and the applicability of VR tools, including software and hardware, to monitor and assess the progress of rehabilitation process.
- To know the measurement parameters of VR tools for motoric and coordination assessment.
- To know the measurement parameters of VR tools for cognitive assessment.
- To know the quantitative and qualitative assessment methods, particularly based on VR tools.
- To know VR tools for surpervised and self-rehabilitation.
- To know the functionalities and the applicability Of VR tools, including software and hardware, to support treatment and post-stroke patients.
- To know the teaching and motivating methods of using VR tools by patients.
- To know how to select functions of VR tools to enhance motoric and coordination abilities.
- To know how to select functions of VR tools to enhance cognitive abilities.

Session 3: Using a full immersive environment of Virtual Reality in stroke rehabilitation

DESCRIPTION

This session provides theoretical elements of advanced VR systems which is full immersive environment. Apart of the application of using such advanced systems in post-stroke rehabilitation is described. Finally, it is pointed out both positive sides and limitations of using full immersive environment by stroke survivors.

LEARNING OBJECTIVES

- To know the possibilities of using different immersive systems in stroke rehabilitation.
- To provide theoretical knowledge on therapeutic applications of immersive environment.
- To know the advantages and disadvantages of using full immersive environment in rehabilitation.

MODULE 4: CASES STUDIES

Case 1: Assessing gait and balance in stroke

DESCRIPTION

Here a typical pattern of locomotion in a stroke patient is analyzed in details, and the different alterations are interpreted through a multifactorial analysis, in which the biomechanical variables are compared to the electromyography. In addition, the common task of rising from a chair is presented to show the main limitations, which

affect a stroke patient and how they can be quantified by means of movement analysis technologies.

LEARNING OBJECTIVES

- To learn methodology of assessment of gait kinematics of people after stroke on the basis of research conducted in a hospital.
- To learn methodology of the assessment of the ability to maintain the balance of people after stroke on the basis of research conducted in a hospital.
- To present an exemplary analysis of gait kinematics and the ability to maintain the balance of a person after stroke.
- To present average results of gait kinematics and the ability to maintain the balance of a group of 25 patients after stroke.

Additional contents: Upper limb function: the reach-to-grasp function

DESCRIPTION

In this case, the limitations affecting the hemiplegic subject in the upper limb are treated. The common task of reaching an object and grasping is analyzed and an example of performance by a stroke subject is provided.

LEARNING OBJECTIVES

- To obtain awareness of problems affecting the upper limb that can be extremely invalidating for a stroke patient.
- To get knowledge of the main features of a common reach-to-grasp task
- To understand the technical problems related to tracking the movement of the hand
- To know some practical solutions that can be adopted to analyze the reach-to-grasp function

Case 2: Virtual Reality used as assistant in motor and cognitive rehabilitation

DESCRIPTION

In this session, the possibilities of using spatial systems in connection with systems for motion analysis in clinical practice are presented. Methodology of analyzing results recorded using motion capture systems while playing patients in rehabilitation games was proposed. The methodology of the analysis is a proposal to support diagnostic procedures in the field of determining motor dysfunctions during exercise. The results of the analysis were divided into kinematics analysis, diagnostics using indicator methods and diagnostics using model methods. The solution of the

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rehabilitation system with the use of virtual reality presented in the chapter may serve diagnostic and therapeutic purposes in motor and cognitive rehabilitation after stroke.

LEARNING OBJECTIVES

- To provide basic knowledge about measurements of the kinematic parameters of upper limb movement and present the quantities most frequently used in such measurements.
- To show possibilities of the use of 3D projection systems in rehabilitation of cognitive function after stroke.
- To show methodology of use of indexes in diagnostic processes.
- To show methodology of use of musculoskeletal models in diagnostic processes.
- To provide basic knowledge about analyzing of kinematic data from motion capture systems.

Case 3: New horizons: Examples of use of other methodologies

DESCRIPTION

In this session, is presented a new approach to methodology for supporting measurements in rehabilitation. The use of VR in assessment of the ability to maintain the balance and balance treatment gives many of new ways to realize these scopes. One of them is the use of moving surroundings as a measurements in sensory conflict conditions. But it runs out that traditional methods of balance assessment are insufficient. Therefore, the use of analysis in frequency domain is proposed and explained as a method that complements traditional ways of results interpretation.

LEARNING OBJECTIVES

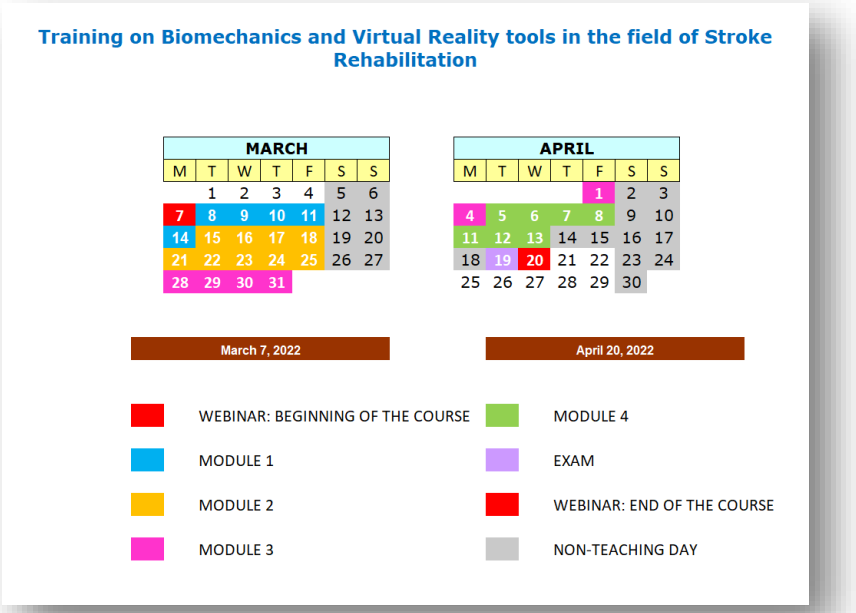
- To provide basic knowledge about measurements of the ability to maintain the balance and present the quantities most frequently used in such measurements.
- To show possibilities of the use of measurements in sensory conflict conditions and to present how VR can be used in such measurements.
- To show why other methods of results analysis are necessary in such measurements.
- To provide basic knowledge about analyses in frequency domain.
- To present how analysis in frequency domain can be used in the assessment of the ability to maintain the balance in sensory conflict conditions realized by means of VR.

- To present, on the basis of case study, how to interpret results obtained in frequency domain to assess the ability to maintain the balance.

4. TIME PLANNING

The course will take place from **March 7, 2022** to **April 20, 2022** but the contents will remain available during approximately one month after the end of the course in order to let the students see their record and find any information they need.

The course planning involves studying **1,5 hours** per day as marked on the calendar. Obviously, each student can set his or her own pace of study and decide when to connect to the platform, when to do an activity, etc. Occasionally, there may be activities (such as taking part in a forum) that take place only on specific days.



This time allocation does not mean time connected. It is possible to work with the contents without being connected, although it is necessary to be connected to do some tasks. The academic calendar planned for the course that will help students organize their study is shown below:

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The calendar is interpreted as follows:

Each color belongs to a different date/matter.

- The days on which the course starts and ends are colored brown.
- Vacation days are colored green. Study is not planned during vacation days, so they are perfect days for the student who has fallen behind to catch up with the course.
- The other colors show how many days are allocated to the study of each section (one of the four Modules).
- This calendar is also used as a reference to monitor the student's progress through the course.

5. METHODOLOGY

HOW DO I HAVE TO STUDY? HOW IS THE COURSE STRUCTURED?

This section includes the answer to this type of questions about the learning method designed for this e-learning training course.

As soon as you start, you will meet the classroom facilitator, who will welcome you to the course and, together with your tutor/expert (specialized in the area addressed by the course) will guide your learning throughout the process.

Studying on paper is different from studying in front of a computer screen, but the communication tools of the platform will make the study easier, more enjoyable and more dynamic:

- **E-mail.** It makes it possible to communicate within the platform and is very appropriate to ask question in a personalized way.
- **Forum.** As messages are public, issues of general interest can be raised.
- **Instant messaging.** It makes it possible to communicate and chat in real time with those mates who are also connected.

WHAT IS THE FOLLOW UP LIKE?

The methodology of the courses proposed by the IBV involves **monitoring the student learning progress**.

The different **tools** that will help students and teachers monitor the study are as follows:

- **News**. Panel through which facilitators remind students about important dates in the course (e.g.: the date of an exam, practice, etc.)

- **Calendar.** The course calendar shows the student how many days are allotted to the study of each module.
- **Grades.** The virtual platform allows students to see their assessments, the activities done, etc.
- **Personalized monitoring for each student.** The facilitators will carry out several follow-ups of the students' activity during the course to encourage them and consider their individual pace of study.
- **Course general forum.** The general forum is available to the students, where facilitators and tutors take part, together with the students, by managing any inquiries and concerns that may arise.

RECOMMENDATIONS TO START STUDYING

Bear in mind that studying online changes the traditional role of students in the learning process, who become protagonists by using ICTs. For this reason, **our methodology offers the student a series of recommendations** to make the most of the course.

- **Read the "TO BEGIN" section** to become familiar with the virtual learning environment. This section contains this teaching guide of the course and some frequently asked questions that can help you solve your doubts.
- **Observe the tools** available on the platform, how the different spaces are used and how to use them. (It is very important, for instance, to see the calendar and the dates marked on it).
- **Know your profile.** Your profile identifies you, we encourage you to put a photo so that we can all create a friendlier space.
- **Choose the most convenient time for your study.** Since there is no rigorous schedule, the student will have to organize a flexible one.
- **Visit the library** to view or download documents related to the course contents.
- If you have any questions, **do not feel alone, you can contact the tutors or your classmates** through the course general forum, email, instant messaging, etc.
- The course has a recommended **study calendar** which you can follow or set your own learning pace; however, remember that if you fall behind, you will not be able to take part in any of the activities scheduled (for example, a forum designed to participate with your colleagues on specific days).
- **Perform a regular monitoring of the virtual classroom**. It is necessary to respect deadlines and the course pace so as not to reduce interactivity. Each person has different learning paces, but it is also essential to enter and see

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the recommended pace of the course, since there are forums that open and close within a specific period of time.

- **Learn how to see your record.** There is a section in the course where you can see your grades at any moment.
- **Form a learning community**. This means being open to a permanent exchange of opinions, open to work as a team and considering interaction as part of this type of training, and not limited to solving specific doubts.
- **Perform autonomous research** by looking for more information on the subjects and sharing it with your mates through the forum.

The main rules for **studying online** do not differ much from the traditional ones. It is advisable to have self-motivation, enthusiasm for knowledge, organization of your study time, search for information (autonomous research is ideal to share with mates) and, above all, desire to learn.

6. RESOURCES

This section includes the resources (symbols, types of activities, etc.) of the methodology that the students will find when reading the study materials.

6.1 RESOURCES IN THE TEACHING UNITS

- **Examples.** The student will find examples that stand out in this format:

Example

This is an example of a resource that you will find when reading the teaching units of the course.

- **Explaining/ expanding on a concept:**

Concept

Through this resource we highlight some explanations, definitions of concepts that appear when reading the materials.

- **Expanding on the content.** The tables with the following format expand on the content:

Expanding on the content. Collagen fibers
"Since the creep velocity is primarily governed by the flow velocity of the interstitial fluid, this technique can be used to determine the…"

- **Highlighted tables.** In addition, some ideas stand out in a table whose format includes pencils drawn in the title:


The therapeutic objectives of any lower limb prosthesis will be: - **Functional** - **Esthetic** - **Psychological**

- **Bibliography.** You will find the general bibliography section of the course in a document available in the virtual classroom library. However, some teaching units include the bibliography that refers to that text in particular.

6.2 RESOURCES IN THE ACTIVITIES OF THE COURSE

Throughout the course, you can find various types of activities, the most used are those detailed below:

- **Activity questionnaires.** Each session offers two or three exercise with automatic checking to test the knowledge acquired by the student and to reinforce it (they are exercise of true/false, completing a sentence, multiple choice, etc.).

7. TEACHING STAFF

How will I communicate?

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Communication with the teaching team and the rest of the classmates is carried out through the forum and the Virtual Campus instant messaging.

You will receive personalized support from the course facilitator, who will guide your learning and follow your progress according to the recommended study schedule. There are also teachers who are experts in the area and will solve your questions.

If you have any doubts about the theoretical content or the activities, please contact by writing in the forum or, if it is a personal or particular topic, to the following address: campus.ibv@ibv.org

QUESTIONS THROUGH THE FORUM. Post your doubts in the forum.

This forum can be found on the main page of the course, in the header, outside the modules. The tutors will answer you through it.

The course is given by members of the BRAIN4TRAIN Consortium, which include University Doctors, General practitioners, diferent Physical and Rehabilitation Medicine Professionals (PRM-Physicians, Neurologists, Physiotherapists, Orthopedists and Rheumatologists), Pedagogues and graduates in Information Sciences, with extensive experience in teaching and in the application of biomechanical assessment methodologies.

QUESTIONS VIA EMAIL/TELEPHONE. For particular inquiries that should be individually treated, the student has an email address and a telephone number to contact throug:

- **Email address:** campus.ibv@ibv.org

8. ASSESSMENT

The assessment is conceived as a continuous process that allows us to collect and analyze information to give a value judgment and which must be applied to all the elements that make up the learning process.

The certificate of achievement will be issued when the student has passed both the theoretical and practical part of the contents of the course.

The assessment will consider:

- Completion of the course activities (40%)
- Completion of the final exam (60%)

9. CERTIFICATE

After notifying the results of the final assessment to all the students, the Certificates of Achievement of the course will be issued within approximately one month from the date of the request.

The organization responsible for the direction and coordination of the course (Instituto de Biomecánica - IBV) will send the student certificates by post. For this reason, it is very important to have the correct address of the student, who should communicate any modifications of such address.

For any questions about the certificates:

- **Customer Support:** 96 111 11 80
- **E-mail:** campus.ibv@ibv.org

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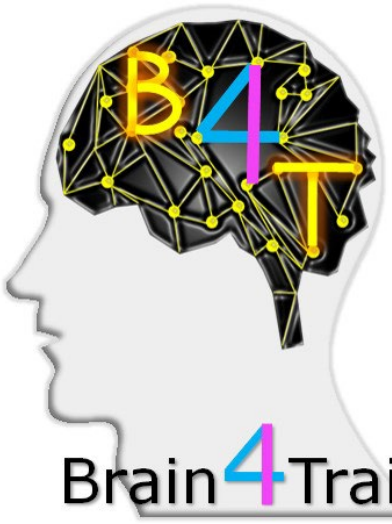

Consortium:

Politechnika Śląska

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ESPRM European Society of Physical & Rehabilitation Medicine

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