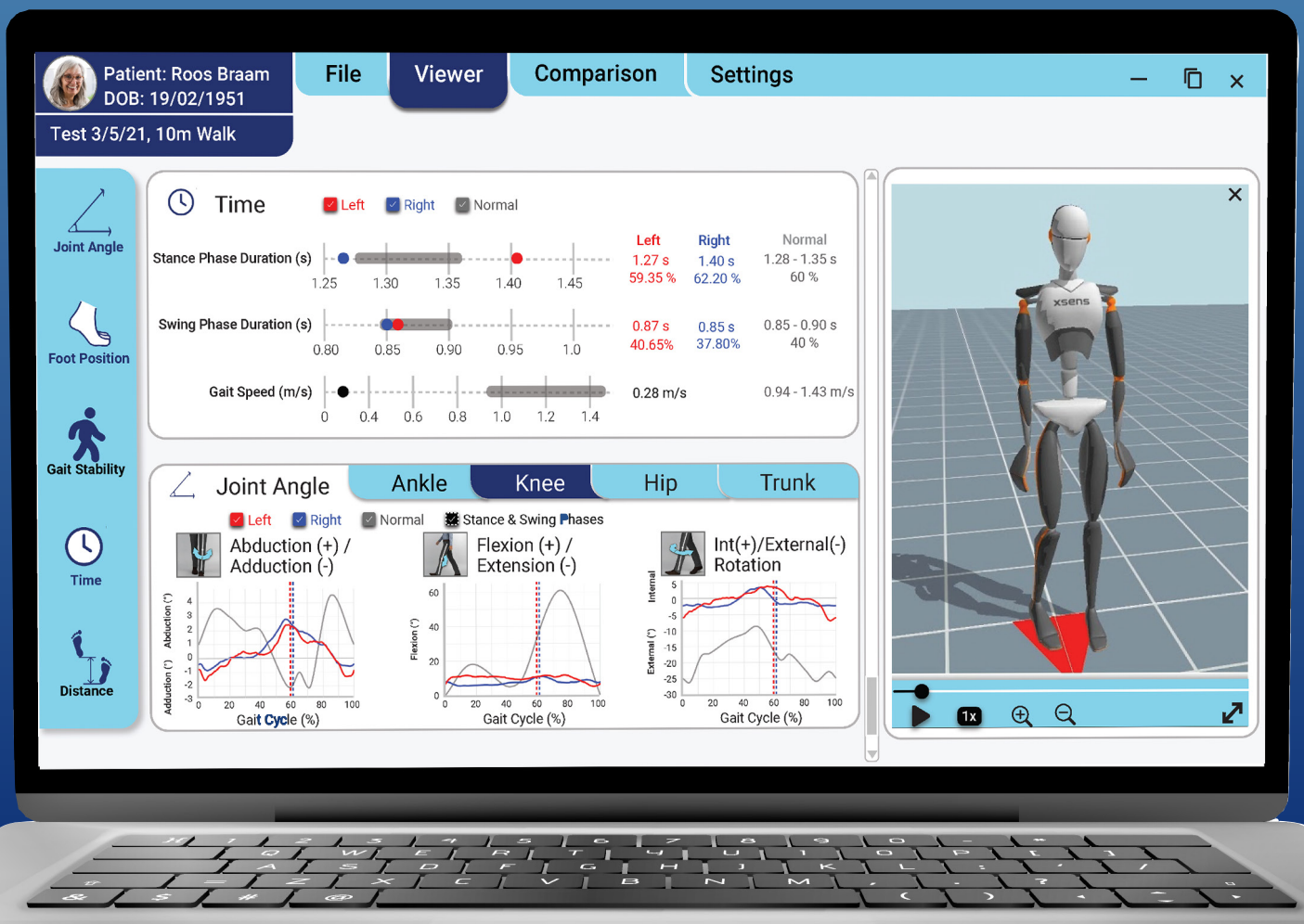
Appendix

Design of Interface for Gait Assessment in Spinal Cord Injury

Master Thesis

Rebekah Kempske



Appendix

Design of Interface for Gait Assessment in Spinal Cord Injury

Rebekah Kempske

Industrial Design Engineering
MSc Integrated Product Design
Delft University of Technology
July, 2021

Student

Rebekah Kempske

Delft University of Technology

Industrial Design Engineering

MSc Integrated Product Design

Supervisory Team

Dr. ir. Armagan Albayrak | Chair

Prof. dr. ir. Richard Goossens | Chair

MSc. BSc. Hilbrand Bodewes | Mentor

Company

Erasmus MC

Dr. Herwin Horemans | Mentor

Dr. Daniel Lemus Perez | Mentor

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Appendix A. Graduation Project Brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Kempske
initials: RB given name: Rebekah Blair
student number: 5044693
street & no.:
zipcode & city:
country:
phone:
email: r.b.kempske@student.tudelft.nl

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD ( ) DfI ( ) SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: ( ) Medisign
( ) Tech. in Sustainable Design
( ) Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: dept. / section: HCD/AED
** mentor: Hilbrand Bodewes dept. / section: HCD
2nd mentor: Daniel Lemus
organisation: Erasmus MC
city: Rotterdam country: Netherlands

comments (optional): Graduation Support forwarded the confirmation of the HCD department that Hilbrand Bodewes can be my mentor, to the Board of Examiners (dd 28-1-2021).

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair _____ date 15 - 01 - 2021 signature _____

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: n.v.t. EC

Of which, taking the conditional requirements into account, can be part of the exam programme n.v.t. EC

List of electives obtained before the third semester without approval of the BoE

( ) YES all 1st year master courses passed

(X) NO missing 1st year master courses are:

ID4010 Design Theory and Methodology (3ec)
ID470 Advanced Concept Design (21ec)

name C. van der Bunt date 22 - 02 - 2021 signature CB

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: (V) APPROVED ( ) NOT APPROVED

Procedure: (V) APPROVED ( ) NOT APPROVED

- remark: - the missing courses have been finished in the meantime

comments

name Monique von Morgen date 2/3/2021 - signature _____

Design of Interface for Gait Assessment in Spinal Cord Injury — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 08 - 02 - 2021 — 25 - 06 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Spinal cord injury (SCI) occurs from compulsion, incision, or contusion of the spine. Common causes of SCI include traffic accidents, falls, and sports injuries. Patients with SCI suffer severe disability and complications. In doing so, multidisciplinary rehabilitation is critical to a patient's quality of life, of which physical therapy for walking plays a significant role (Nas et al., 2015).

A part of this physical therapy is gait training. To evaluate a patient's walking ability, gait analysis is used. Through sensors attached to the patient and computer software, advanced biomechanical assessment on the patient's walking metrics can be obtained and a 3D schematic of the patient is created. Metrics measured by such systems include, but are not limited to, joint angles, step length, stride length, speed, and balance (Muro-De-La-Herran, 2014). Gait analysis allows for a greater understanding of a patient's walking pattern. It also provides more detailed and exact information than can be obtained by just observing a patient. Using this information, clinicians can choose suitable treatment and exercises tailored to each patient (Patrick, 2003).

Engineers at the Department of Rehabilitation Medicine of Erasmus MC have developed modular robotic devices that can be used during SCI rehabilitation. Through a series of gyroscopic actuators and sensors, the devices provide information on the patient's movement for gait analysis and allow clinicians to control the rotation of different parts of the body, depending on where the device is placed.

With the development of these assistive devices, there is still a disconnect between the assistive devices and the clinicians and therapists being able to operate them. Since gait analysis requires advanced technical knowledge to interpret the data, it is currently not easily accessible by clinicians (Vallery & Ribbers, 2019). This project will focus on developing a user interface that allows clinicians and therapists to monitor and assess the patient's gait performance in an intuitive and accessible way. This project is in collaboration with the Department of Rehabilitation Medicine at Erasmus MC as part of "Clinicians Controlling Rehabilitation Technology."

Muro-De-La-Herran, A., Garcia-Zapirain, B., & Mendez-Zorrilla, A. (2014). Gait analysis methods: An overview of wearable and non-wearable systems, highlighting clinical applications. Sensors, 14(2), 3362-3394.

Nas, K., Yazmalar, L., Şah, V., Aydın, A., & Öneş, K. (2015). Rehabilitation of spinal cord injuries. World journal of orthopedics, 6(1), 8.

Patrick, J. H. (2003). The Case for gait analysis as part of the management of incomplete spinal cord injury. Spinal Cord, 41(9), 479-482.

Vallery, H., & Ribbers, G. (2019). Clinicians Controlling Rehabilitation Technology.

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introduction (continued): space for images

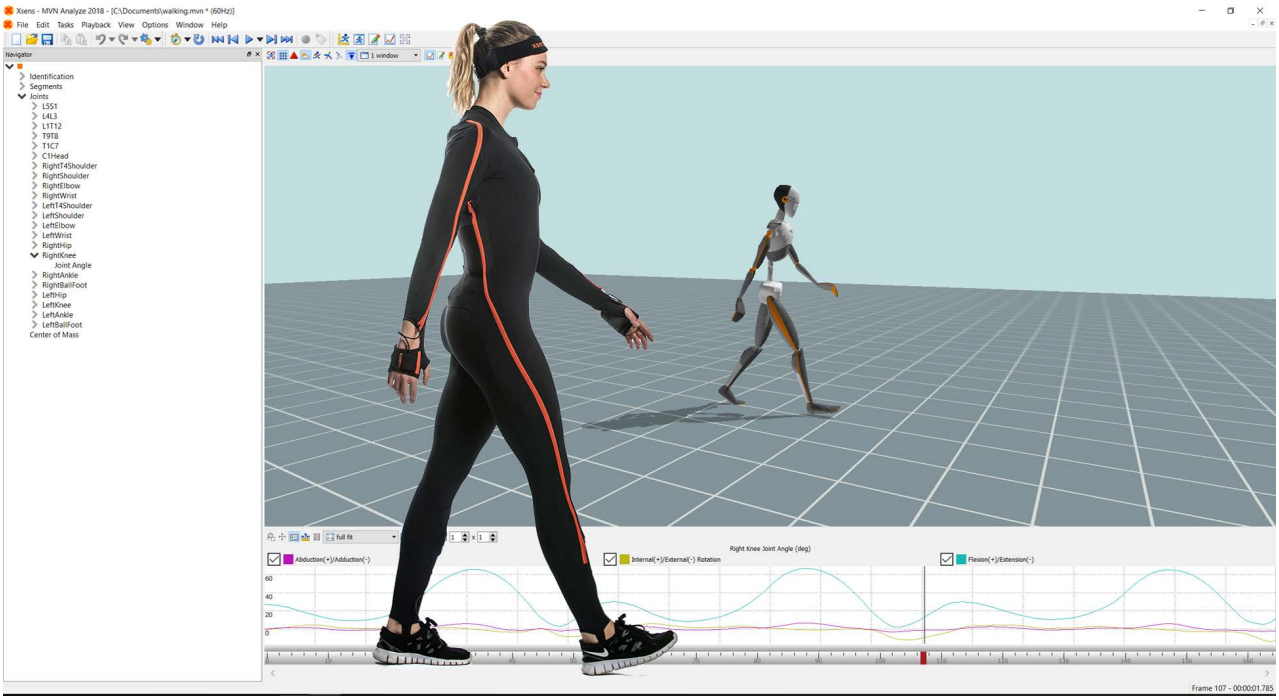


image / figure 1: Gate Analysis with Xsens Software

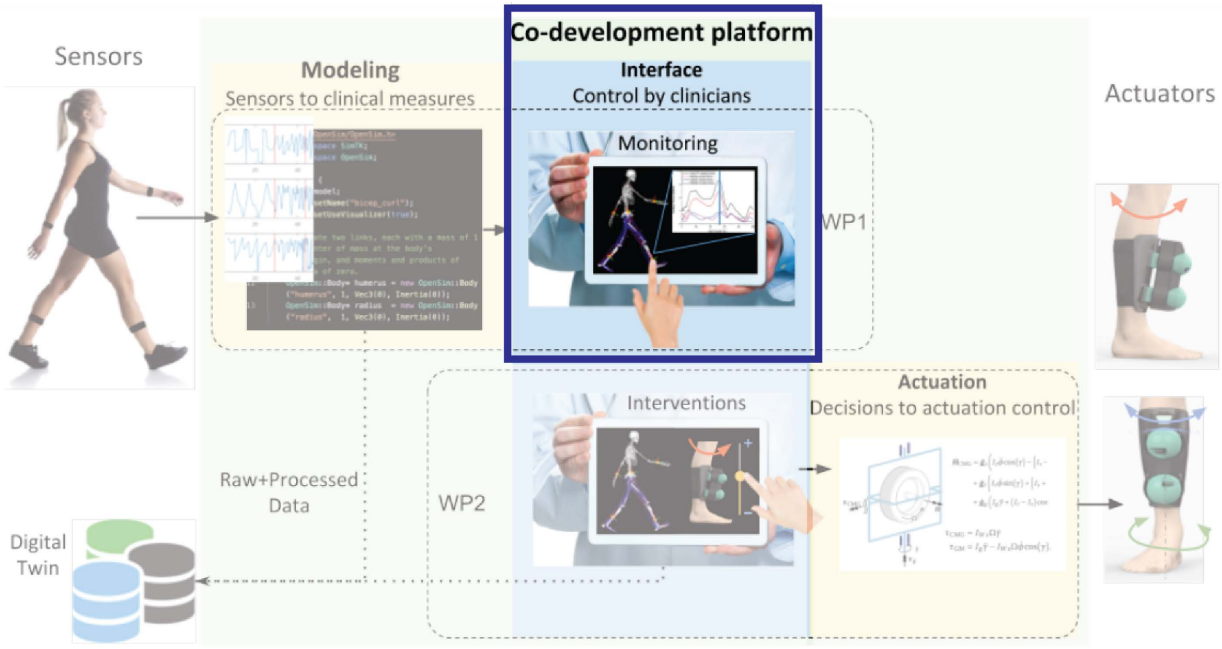


image / figure 2: Focus of Project

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The assistive devices developed by Erasmus MC have the technical capabilities to aid in the walking rehabilitation of SCI patients. However, the data provided by the devices on gait analysis is too complex and time-consuming for clinicians to interpret. The gate analysis data also contains extra information not relevant for clinicians (Vallery & Ribbers, 2019).

The challenge to be tackled in this project is to bridge the gap between the capabilities of the assistive devices and their operation by clinicians. To do so, what metrics in the gate analysis are relevant to clinicians will be determined. A digital interface will then be developed to allow clinicians and therapists to view the patient's gait performance. The user interface will encourage clinicians to use the devices through being intuitive to use and requiring limited technical knowledge for operation. By clinicians being able to view and interpret the gait analysis data quickly, the interface will improve and speed up clinical decision making. Clinicians will also be able to use the data to recommend future treatments.

Vallery, H., & Ribbers, G. (2019). Clinicians Controlling Rehabilitation Technology.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

The relevant metrics to include in the interface for gate analysis will be selected by conducting interviews with clinicians and therapists. An experiential prototype of the user interface will be developed that visualizes the patient's gait performance.

At the end of the project, a product,with a focus on interaction and experience design will be delivered. In doing so, visualizations of the digital interface will be completed, which will then be given to Erasmus MC to develop into an operational app. These visualizations will include how the clinicians see and interact with the patient's gait performance data. In addition, how data is presented in a way that can be quickly used in clinical decisions.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 8 - 2 - 2021 25 - 6 - 2021 end date

Month	February			March				April					May				June			
Calender Week	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Project Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Kick-Off																				
Research																				
Background research on devices & gait analysis																				
Interview techniques																				
Prepare interview materials																				
Interviews clinicians & therapists																				
Analysis																				
Analyze interview data																				
Chose metrics																				
Conceptualize																				
Brainstorm on user interface visualization																				
Design and build user interface																				
Midterm																				
Test																				
Prepare testing materials																				
Test with clinicians and therapists																				
Conceptualize																				
Analyze participant feedback																				
Brainstorm user interface visualization																				
Design and build user interface																				
Test																				
Prepare testing materials																				
Test with clinicians and therapists																				
Green Light																				
Graduation																				
Report																				
Presentation																				

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

My motivation for starting this project is I am interested in medisign and impact-driven design. I am passionate about designing products with a purpose and that make a lasting impact on people's lives and this project will allow me to do just that.

Through this project, I would like to further improve the competencies that I have developed through Advanced Concept Design and Advanced Embodiment Design on aesthetics, ergonomics, and technology. I would like to improve on my project management skills and on managing a team as well.

I want to broaden my competencies by learning more about human-centered design and developing user interfaces. With this, I want to gain knowledge on tools and methodologies for successful co-creation. I also want to become more well-versed in applying the Double Diamond Design Method in my design process.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Appendix B. Selection of Gait Analysis System

	Direct information	Assessable parameters	Validity checked	Implementable (SDK)
APDM	+	+	+	+/-
Noraxon	-	+/-	+	-
STT	-	+/-	+/-	-
GaitUp	+	+	+/-	+/-
RehaGait	+	+	+	-
Riablo	+	+/-	+	-
Xsens	+	+	+	+
G-walk	-	+/-	+/-	-
BioSensics	+	+	-	-
McRoberts	-	+/-	+/-	-

Appendix C. Xsens MTw Awinda Specifications

Specifications Awinda™ station

Operating temperature range	
Ambient	-25°C - 80°C
Specified Performance	0°C - 65°C
Specifications for non-condensing environment. Avoid wet and humid conditions	
Power Supply	EU/US/UK power adapters provided
Communication	
Awinda Station	PC Interface: USB
Physical Properties	
Dimensions (without antenna)	148 x 104 x 31.9 mm (5.8 x 4.1 x 1.3 in)
Weight	200g (7 oz.)
Synchronization with third party devices	
4 BNC connectors	- 2 for sync in - 2 for sync out
TTL pulses	0-3.3V levels
Software configurable	
Wireless update rates	
1 MTw	120 Hz

Communication

Range	Awinda station	Awinda dongle
Open space	Up to 50 m (165 ft.)	Up to 20 m (65 ft.)
Office space	Up to 20 m (65 ft.)	Up to 10 m (33 ft.)

Wireless protocol	Xsens patented Awinda protocol	
Receiver	Awinda Station / Awinda Dongle	

Tracker components

	Angular velocity	Acceleration	Magnetic field
Dimensions	3 axes	3 axes	3 axes
Full scale	± 2000 deg/s	± 160 m/s	± 1.9 Gauss

Orientation		**Dynamic Accuracy (Roll/Pitch)**	0.75 deg RMS
Static Accuracy (Roll/Pitch)	0.5 deg RMS	**Dynamic Accuracy (Heading)**	1.5 deg RMS
Static Accuracy (Heading)	1 deg RMS		

Tracker Components		**Dimensions**	3 axes
Full scale	± 2000 deg/s | ± 160 m/s2 | ± 1.9 Gauss		

Tracker placement	Velcro straps	**Internal sampling rate**	1000 Hz
Latency	30 ms	**Buffer time (retransmissions)**	10 s
Battery life (continuous use)	6 Hours	**Dimensions Tracker**	47 x 30 x 13 mm
Weight	16 g	**Operating temperature range**	0°C – 50°C

Wireless update rates		**1 - 5 MTw**	120 Hz
10 MTw	80 Hz	**6 - 9 MTw**	120 Hz
20 MTw (maximum)	60 Hz		

Appendix D. Segments & Joints MVN Analyze Can Measure

Segments

1. Pelvis
2. L5
3. L3
4. T12
5. Sternum (T8)
6. Neck
7. Head
8. Shoulder (Right, Left)
9. Upper Arm (Right, Left)
10. Forearm (Right, Left)
11. Hand (Right, Left)
12. Upper leg (Right, Left)
13. Lower Leg (Right, Left)
14. Foot (Right, Left)
15. Toe (Right, Left)

* L5 , L3 , T12 , neck , and toes do not have a sensor attached and their movement is estimated by combining the information of connected segments and the biomechanical model

Joints:

1. L5-S1
2. L4-L3
3. L1-T12
4. T9-T8
5. T1-C7
6. C1-Head
7. T4-Shoulder (Right, Left)
8. Shoulder (Right, Left)
9. Elbow (Right, Left)
10. Wrist (Right, Left)
11. Hip (Right, Left)
12. Knee (Right, Left)
13. Ankle (Right, Left)
14. Ball of Foot (Right, Left)

Appendix E. Principles of User Interface Design

Principles for User Interface Design

In developing user interfaces, there are developed principles that can be used as a guide when designing user interfaces.

Jakob Nielsen's Usability Heuristics

1. Through feedback, communicate with the user about the status of the system.

2. The system should use the same language, terminology, and concepts as the user experiences in the real world.

3. Give the user control and freedom by presenting a clear way to exit out of an unwanted action and supporting undo and redo.

4. Be consistent and follow established conventions.

5. Prevent the user from making errors by having a confirmation option before committing to an action, supporting undo, and not requiring users to memorize extensive information to operate the system.

6. Minimize the amount of information that users have to remember. This can be done by making objects, actions, and options visible and providing help when operating the system.

7. Incorporate accelerators and allow for customisation such that expert users can speed up how they use the system.

8. Keep the content and visual design as minimalistic as possible, only include essential information and elements.

9. Format error messages such that they are easy to recognize and tell the user precisely what went wrong in terminology that they will understand.

10. Documentation created to help instruct users how to use the interface should list concrete steps that the user has to carry out and should not be extensive. If possible, provide such documentation when it is required as the user is using the system. (Nielsen, 2005; Nielsen, 2020).

Tuft Grand Principles

1. Enforce visual comparisons through thickness, color, weight, and size.

2. Show causality

3. Show multiple variables.

4. Integrate text, graphics, and data in one display rather than placing all information in a legend.

5. Ensure the content has quality, relevance, and integrity

6. When showing changes over time, display the changes adjacent in space, not staked in time.

7. Do not de-quantify quantifiable data (Cooper et al., 2014)

Gestalt Principles

1. Similarity: Similar elements are grouped together. This can be done by color, shape, or size.

2. Continuation: An intersection between two or more elements is perceived as a single uninterrupted object.

3. Closure: Even though the elements do not touch each other, there is a visual connection or continuity between the elements.

4. Proximity: Elements close together are perceived to be more related than elements spaced farther apart

5. Figure / Ground: Objects are perceived as either being in the foreground or background.

6. Symmetry: An object is seen as symmetrical shapes that form around a center ("6 Gestalt Principles", n.d.).

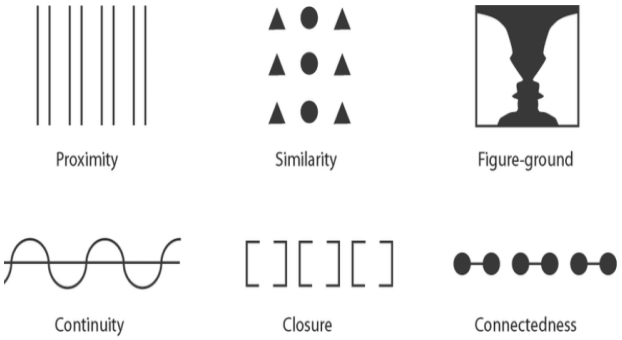


Figure FIXME. Gestalt Principles (Burkhard, 2005)

User Interface Design Parameters

Element, arrangement, and behavior are key factors in interface design. Within these elements, there are parameters that should be taken into account (Figure FIXME) (van Kuijk, 2021).

Element	Arrangement	Behavior
Size	Position	Show
Shape	Order	Highlight
Material	Grouping	Timing
Color	Spacing	Transitions
Contrast	Containers	Movement
Text	Dividers	
Icons	Mapping	
Texture		
Haptic		
Auditory		

Figure FIXME. Interface Design Parameters

Usability

- Use conventions when possible. These include, but not limited to:
    - The primary navigation is located across the top of the screen or down the left side
    - Icons, such as the search icon or the play button for a video (Krug, 2014)
- Implement affordances. These include, but not limited to:
    - It should be obvious to the user what is clickable. This can be done by shape (buttons, tabs), location (in a menu bar), and formatting (color and underlining) (Krug, 2014)
    - Use shading and highlights to give buttons affordance (Figure FIXME) (Cooper et al., 2014)

Figure FIXME. Using shading and highlights on buttons

Layout

- Layouts containing an odd number of elements tend to stand out more (Barry, 2021).
- Create effective visual hierarchies
    - The most important elements should be larger, bolder, in a distinctive color, set off by more space, or near the top of the page
    - Items that are related logically should also be related visually. This can be done by grouping items, having them all in the same visual style, or placing them in one defined area.
    - Nest items to show what they are a part of.
- Take into account the order or the tasks and how the user scans the screen (Krug, 2014).
- If using multiple headings, ensure there is a distinction between them and that the heading is closer to the section it pertains to than the section it follows (Figure FIXME)

Figure FIXME. Heading Examples

- Divide the screen into clearly defined areas. This allows the user to immediately decide which areas of the screen they should focus on or ignore.

- Avoid noise and clutter (Cooper et al., 2014)

- Every screen should have a name. The page name should be in correspondence with the screen's visual hierarchy and should be prominent.

- For self-evident operation of the interface, tabs should be used for navigation (Krug, 2014)

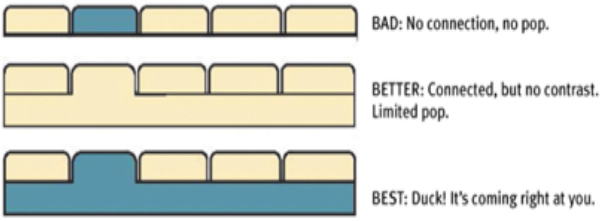


Figure FIXME. Navigation Tabs

- Designing icons:
    - Beware of metaphors and representations that have unintended means for users
    - Avoid excessive visual detail
    - Reuse icons throughout the design so that the user only needs to learn them once.
    - Should be simple and schematic. A minimal number of colors and shades are used and not too large in size.
    - Related functions should be visually related through space, color, or theme. (Cooper et al., 2014)

Appendix F. HREC Approval

Date 08-03-2021
Contact person Ir. J.B.J. Groot Kormelink, secretary HREC
Telephone +31 152783260
E-mail j.b.j.grootkormelink@tudelft.nl

Human Research Ethics Committee
TU Delft
(http://hrec.tudelft.nl/)

Visiting address
Jaffalaan 5 (building 31)
2628 BX Delft

Postal address
P.O. Box 5015 2600 GA Delft
The Netherlands

Ethics Approval Application: Focus groups clinicians controlling technology
Applicant: Lemus Perez, Daniel

Dear Daniel Lemus Perez,

It is a pleasure to inform you that your application mentioned above has been approved.

Thanks very much for your submission to the HREC which has been approved. We would advise that - according to best practice - you further clarify in your Informed Consent procedure the issues around data anonymisation (eg: of photos and audio) during analysis, as well as making the IC form itself more granlar. ie: with a check box per point rather than an umbrella consent.
Best wishes,

Good luck with your research!

Sincerely,

Dr. Ir. U. Pesch
Chair HREC
Faculty of Technology, Policy and Management

Appendix G. Questionnaire on Current Gait Assessment

Convergence Focus Group Pre-Survey

Thank you for being willing to participate in the focus group. I am developing a user interface that will visualize gait analysis data. The purpose of the focus group will be to discuss what information is to be included in the interface and how to best present it.

A critical part of developing the interface is knowing more about your current experience with assessing gait. Due to time constraints, it will not be possible to discuss this in-depth during the focus group. In doing so, it is asked if you could please fill out the following questionnaire, to the best of your ability, before the focus group. The questions can be answered in Dutch or English and do not have to be answered in complete sentences.

If you have any additional questions regarding this survey, please contact me at r.b.kempske@student.tudelft.nl or 0639136653. Any questions can also be discussed at the beginning of the focus group.

The data you submit will remain anonymous and will be used only for educational purposes.

1. Name

2. Profession

- ◯ Physician
- ◯ Physiotherapist

3. How many years of experience do you have in treating patients with a walking disability?

4. How do you currently assess gait

- ☐ Clinical Eye
- ☐ Gait Lab
- ☐ Other:

5. What populations do you work with in assessing gait?

6. Why do you assess gait?

7. In a gait assessment, what do you look for?

8. What type of decisions do you make with the information from a gait assessment?

9. In the way you currently assess gait, what do you feel is missing? What can be improved?

10. Would you be willing to be contacted for future prototype testing?

- ○ Yes
- ○ No

Appendix H. Participant Information Letter

PARTICIPANT INFORMATION LETTER

Design of Interface for Gait Assessment in Spinal Cord Injury

March 2, 2021

Dear Sir / Madam,

You have been asked to participate in a research study titled *Design of Interface for Gait Assessment in Spinal Cord Injury.* This study is being done by Rebekah Kempske from the TU Delft. In this letter, you will find information about the research. If you have any questions, please contact the persons listed at the bottom of this letter.

BACKGROUND OF THE RESEARCH

The data provided by current gait analysis systems is too complex and time-consuming for physicians and physiotherapists to interpret. The gate analysis data also contains extra information that is not relevant. This project focuses on bridging the gap between the capabilities of gait analysis and the use by physicians and physiotherapists through developing an easy-to-use user interface.

PURPOSE OF THE RESEARCH

This research study aims to determine what information is to be included in the interface and how to best present it. The data will be used for developing the design of the user interface.

BENEFITS & RISKS OF PARTICIPATING

The benefits of participating in the study are you will aid in developing a user interface that will be used to improve the walking ability of people with incomplete spinal cord injuries.

There are no risks associated with participating in this research.

WHAT DOES PARTICIPATION IN THE RESEARCH INVOLVE

Participating in the research involves filling out an online survey and partaking in an online or in-person interview.

PROCEDURES FOR WITHDRAWAL FROM THE STUDY

Your participation in this study is entirely voluntary and you can withdraw at any time. If you give your consent to this research, you have the freedom at any time to come back on this decision. You can request access to and rectification or erasure of personal data. You do not have to give an explanation for your decision. You can do this by contacting the researcher, Rebekah Kempske, via r.b.kempske@student.tudelft.nl.

CONFIDENTIALITY OF DATA

This investigation requires that the following personal data are collected: name and email address. To safeguard and maintain confidentiality of your personal information, necessary security steps will be taken. Your data will be stored in a secure storage environment at TU Delft. Data will only be accessible to the student researcher (Rebekah Kempske) and supervisors (Daniel Lemus Perez & Herwin Horemans). All data will be processed confidentially and stored using a participant number only.

Your name will be linked to a participant number. This number will be located on the document that is to be filled out during the interview. The informed consent form and document will be stored digitally in a separate and secure location. This way all your details remain confidential. Only the student researcher and supervisors can know which participant number you have.

The personal data will be retained for 1 year. After which, all personal information and audio recordings will be destroyed.

The results of this study will be published in possible future scientific publications. Your participant number and name will never be shared on publications (master thesis report, scientific publications) about the research.

CONTACT INFORMATION

If you have any complaints regarding the confidentiality of your data, you can contact the TU Delft Data Protection Officer (Erik van Leeuwen) via privacy-tud@tudelft.nl.

Thank you in advance for your possible cooperation.

Rebekah Kempske, r.b.kempske@student.tudelft.nl

Appendix I. Participant Consent Form

Design of Interface for Gait Assessment in Spinal Cord Injury

This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Student: Rebekah Kempske
Contact Information: r.b.kempske@student.tudelft.nl; 0639136653
Supervisors: Daniel Lemus Perez & Herwin Horemans

Informed consent participant

I participate in this research voluntarily.

I acknowledge that I received sufficient information and explanation about the research and that all my questions have been answered satisfactorily. I was given sufficient time to consent my participation. I can ask questions for further clarification at any moment during the research.

I am aware that this research consists of the following activities:

1. Interview
2. Questionnaire

I am aware that data will be collected during the research, such as notes, photos, video and/or audio recordings. I give permission for collecting this data and for making photos, audio and/or video recordings during the research. Data will be processed and analysed anonymously (without your name or other identifiable information). The data will only be accessible to the research team and their TU Delft supervisors.

The audio recordings will be used to support analysis of the collected data.

I give permission to store the data for a maximum of 1 year after completion of this research and using it for educational and research purposes.

I acknowledge that no financial compensation will be provided for my participation in this research.

With my signature I acknowledge that I have read the provided information about the research and understand the nature of my participation. I understand that I am free to withdraw and stop participation in the research at any given time. I understand that I am not obliged to answer questions which I prefer not to answer and I can indicate this to the research team.

The researchers take the COVID-19 measures into account. I confirm to respect the COVID-19 measures taken and will follow instruction about these provided by the researchers.

I will receive a copy of this consent form.

_____	_____
Last name	First name
_____	_____
Date (dd/mm/yyyy)	Signature

Appendix J. Work Flow Interview Questions

Physiotherapist

Do you deal with more traumatic or non-traumatic SCI?

Do you deal with more outpatient or inpatient rehabilitation?

What do you do the first time you see the patient? Do you conduct any specific tests?

How much time passes between the patient seeing the physician for the first time and seeing you for the first time?

How many times a week does the patient go the physical therapy?

How long is a therapy session?

Throughout the rehab process what are your emotions (frustration, happiness, etc.)? What is the patient emotions?

Does the patient see anyone else beside you and the physician for walking rehabilitation?

How long are your meetings with the physicians?

How long does incomplete SCI stay in rehab?

Do non-traumatic injuries go to rehab or is outpatient?

How long does it take to get an orthosesis?

Difference between outpatient and inpatient?

When a gait lab is conducted do you look at the data?

How long do you wait until trying gait lab or orthesis?

Physician

What do you do the first time you see the patient? Do you conduct any specific tests?

Do you conduct the surgery or just refer them to a specialist?

How long do you analyze the gait lab data for before you make a decision?

Are surgical interventions common?

What is the time between the leave the hospital and see you for the first time. Time between seeing you and the physiotherapist?

Timeline from when patient enters hospital to when they are completely done with physical therapy

After the patient leaves Rijndam, do you see them again for follow up appointments? If so, how often?

Gait Lab Specialist

What is process for a laboratory gait analysis?

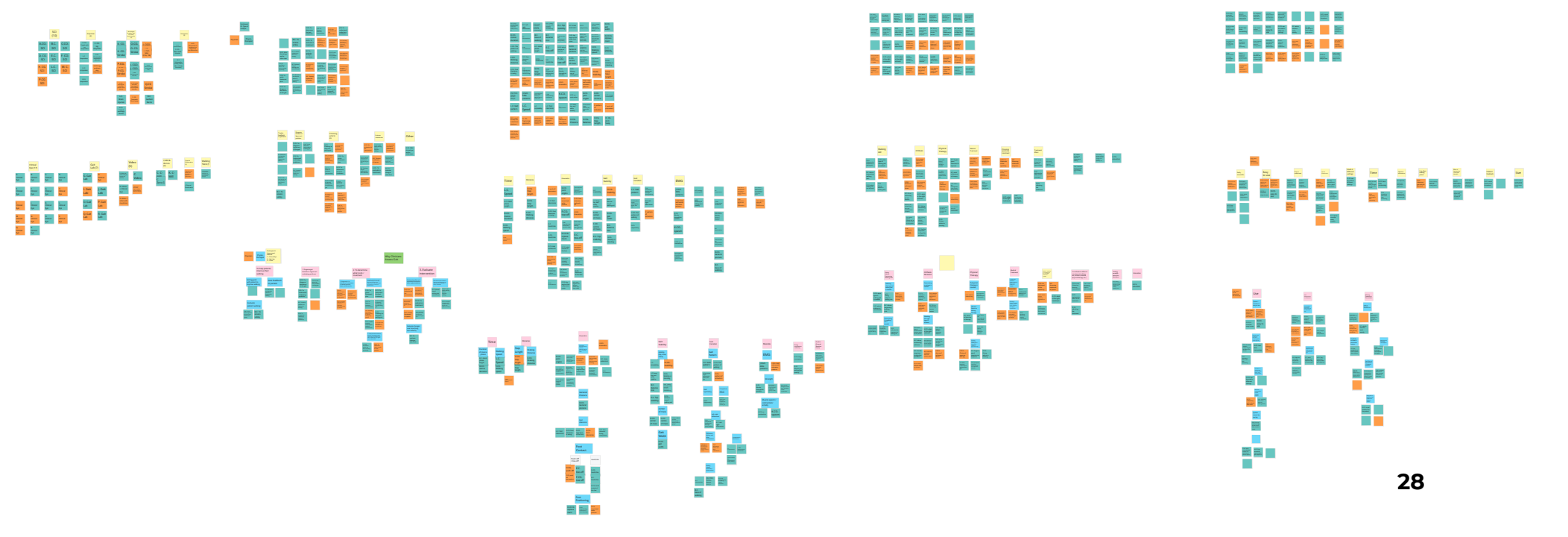
How long does a test take? How long to analyze the data?

What happens to the data after you are done? Who looks at the data?

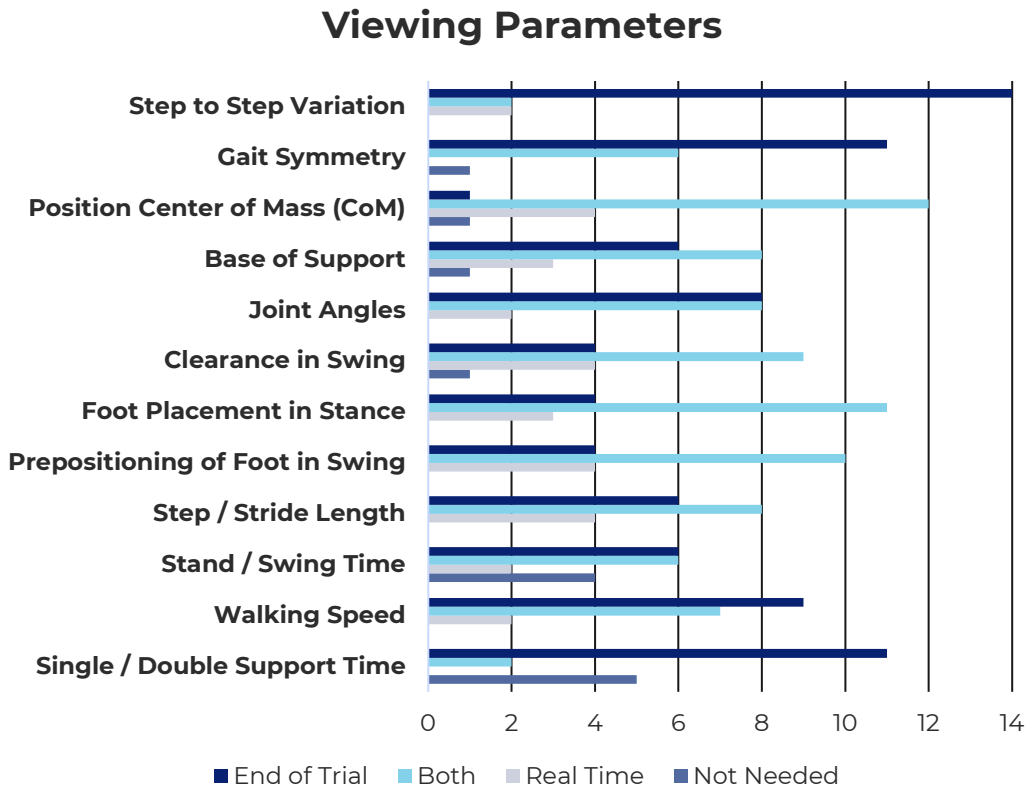
What type of workers conduct the gait lab?

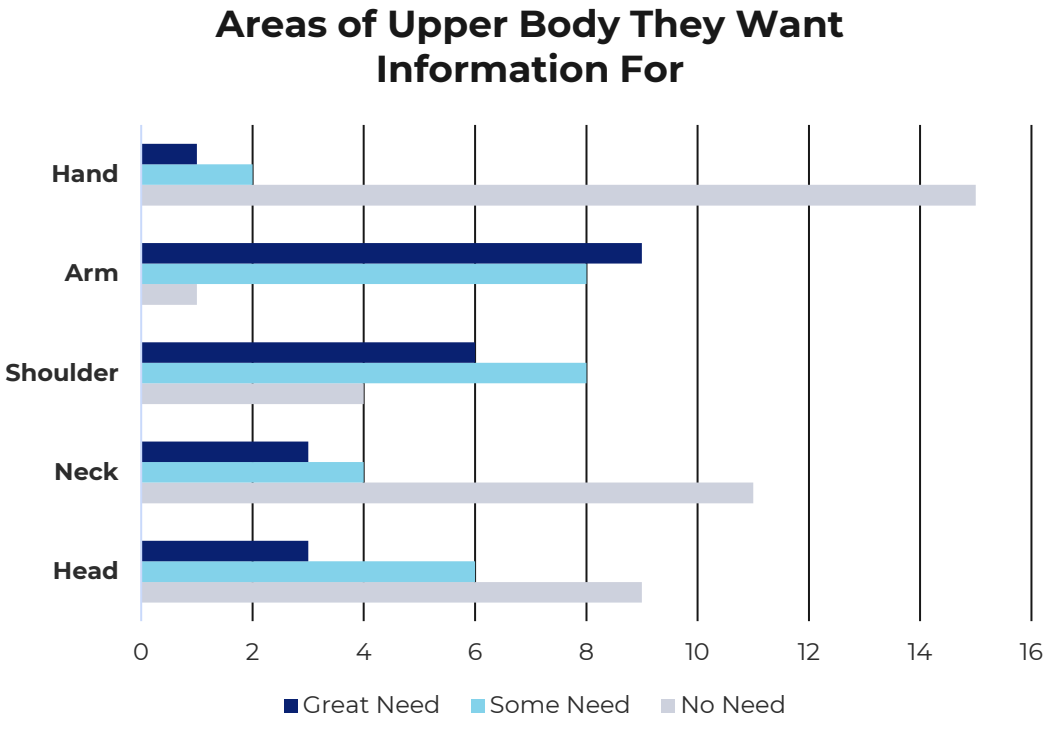
What happens with the patient after monthly meeting?

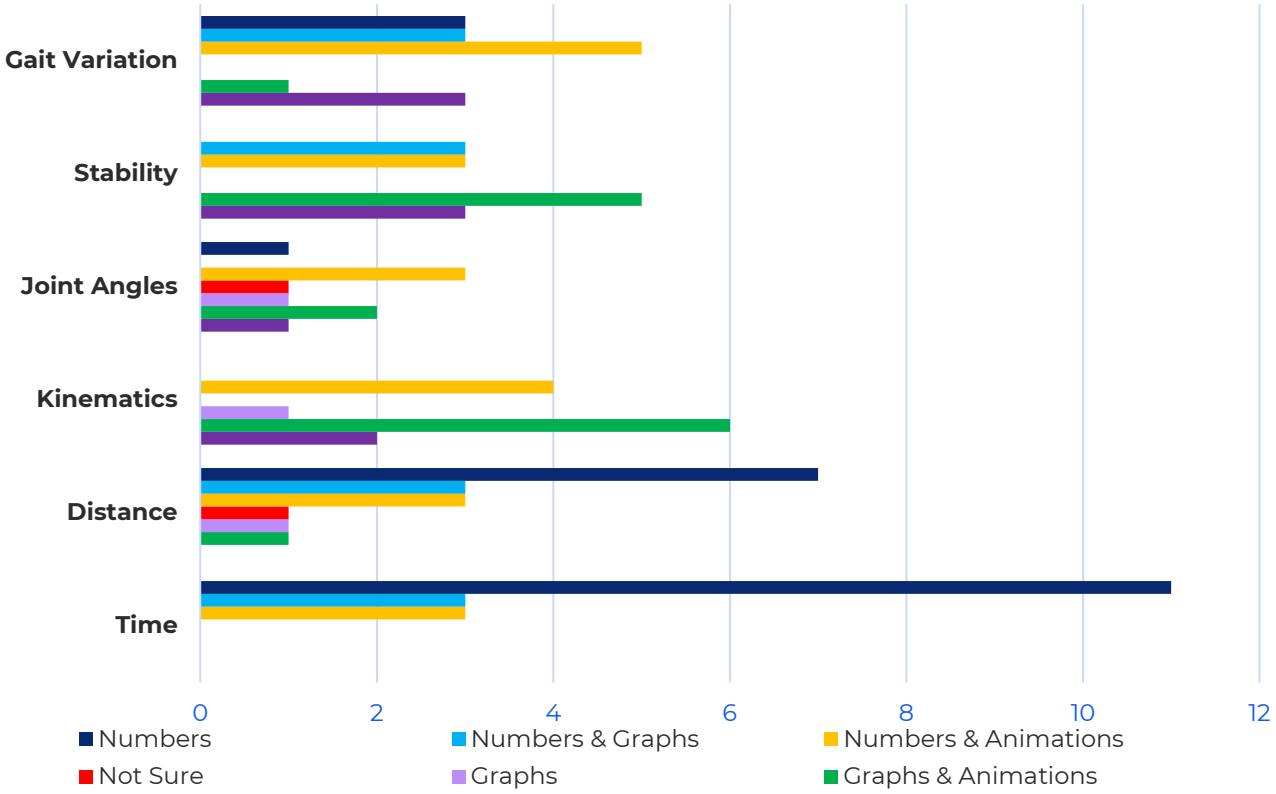
Appendix L. Questionnaire Affinity Diagrams

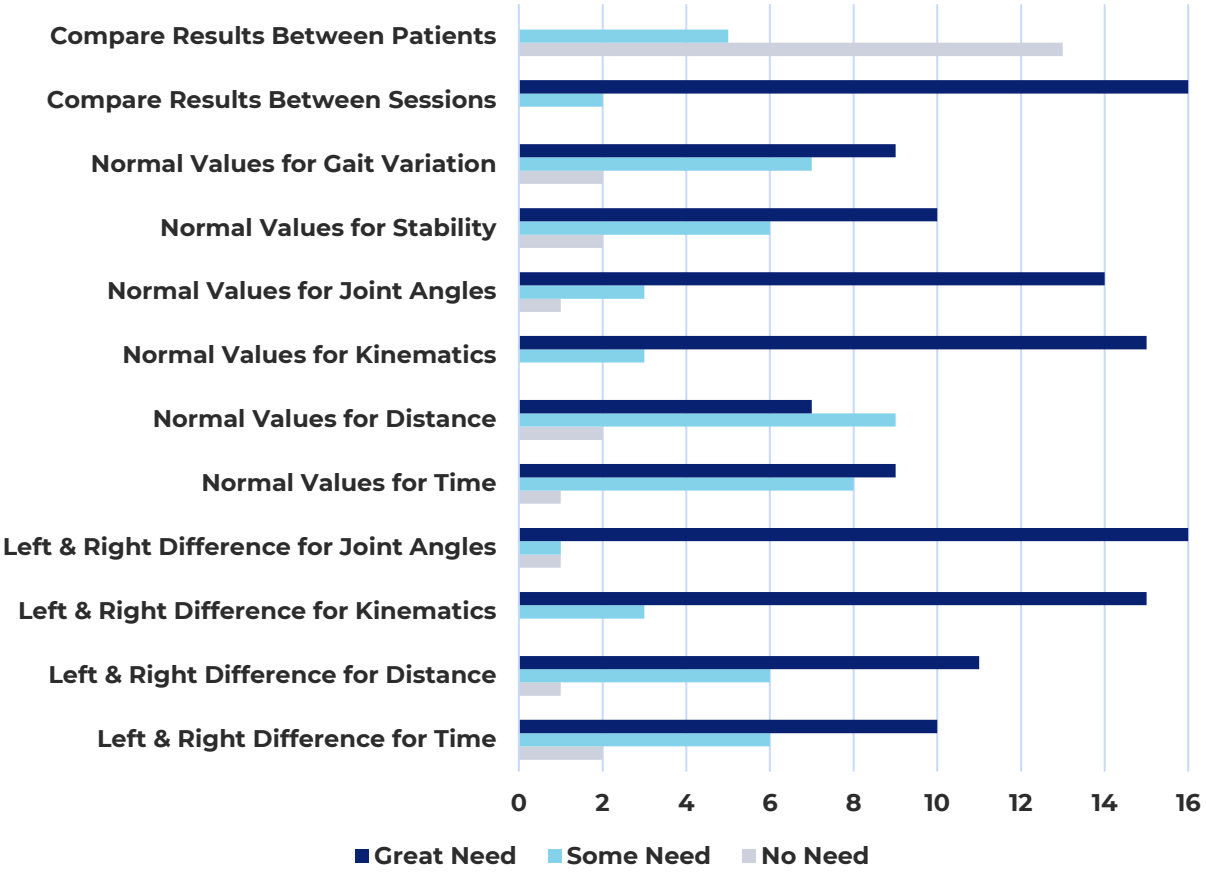


Appendix M. Focus Group Results



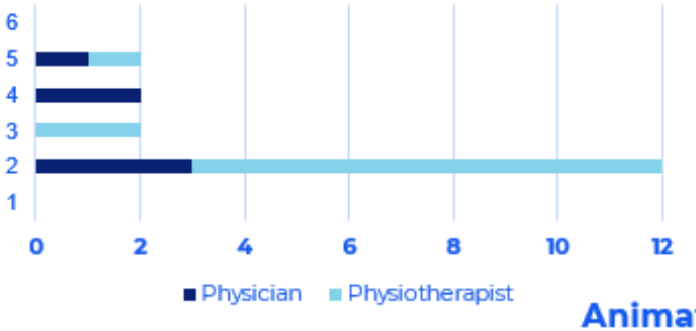



Gait Variation
Stability
Joint Angles
Kinematics
Distance
Time
0
2
4
6
8
10
12
Numbers
Numbers & Graphs
Numbers & Animations
Not Sure
Graphs
Graphs & Animations

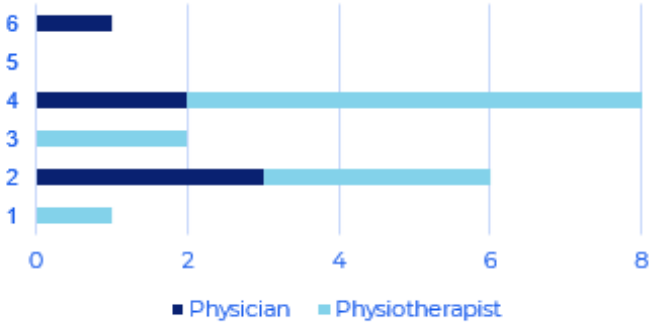

Compare Results Between Patients
Compare Results Between Sessions
Normal Values for Gait Variation
Normal Values for Stability
Normal Values for Joint Angles
Normal Values for Kinematics
Normal Values for Distance
Normal Values for Time
Left & Right Difference for Joint Angles
Left & Right Difference for Kinematics
Left & Right Difference for Distance
Left & Right Difference for Time
0
2
4
6
8
10
12
14
16
Great Need
Some Need
No Need

Feelings

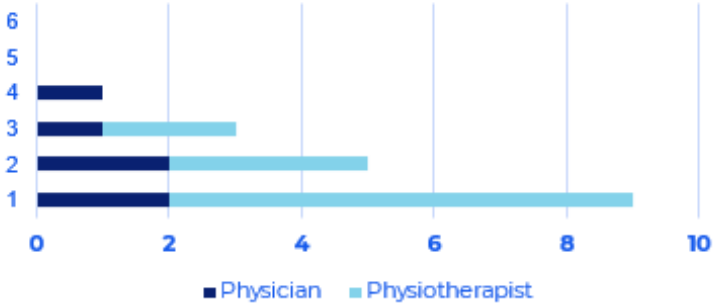
Numbers

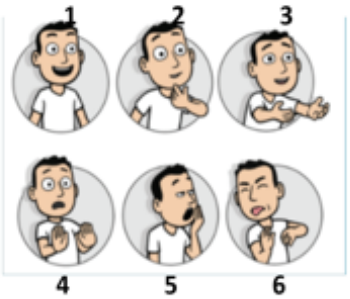


Graphs



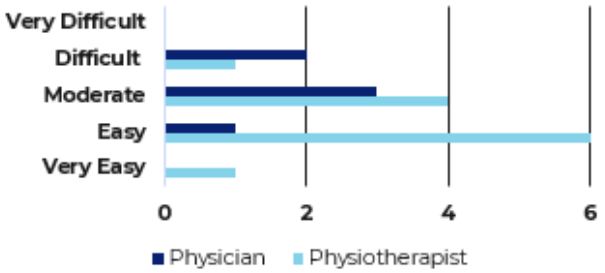
Animations



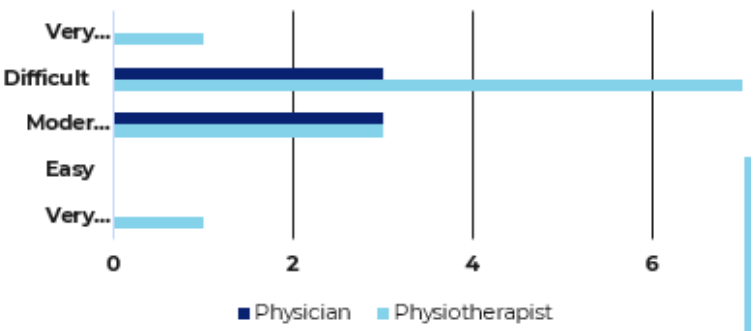


Existing Visualizations

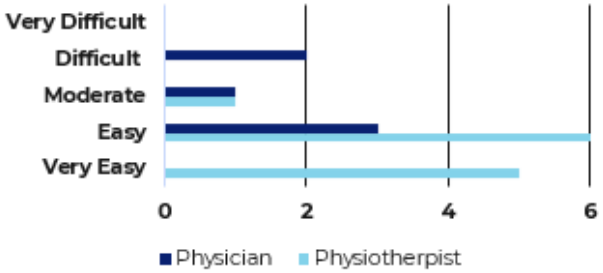
Numbers

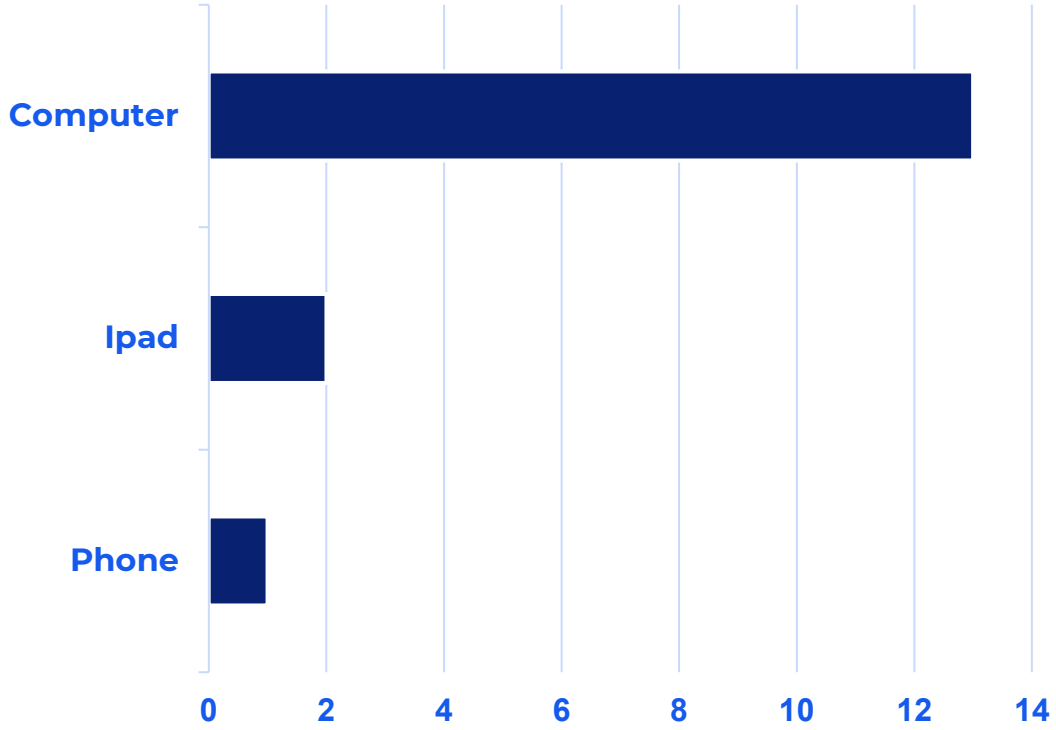


Graphs

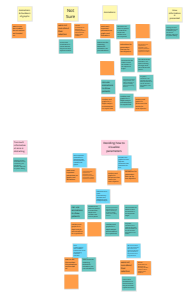


Animations




Computer
Ipad
Phone
0
2
4
6
8
10
12
14

Appendix N. Focus Group Affinity Diagrams



Appendix O. Gait Rehabilitation Experience Journey

Experience Journey
Incomplete Spinal Cord Injury Gait Rehabilitation

Patient can take care of themselves and are independent right after leaving the hospital (7% for traumatic SCI), people who go to therapy many years after injury, people who

		Transferred to Rehabilitation Center	Observation Period	Team Meeting	Physiotherapy				Update/Progress Meetings				Select Interventions							Gait Lab			Discharge	Outpatient Therapy	Follow Up Consultati
													Orthesis			Walking Aids	Medical Interventions		Physical Therapy						
					Physiotherapy Session	Walking Group	Exercise Sessions	Fitness Group	Team Meeting	Daily Meeting	Informal Meetings	Extra Meeting on Special Topics	Test Orthesis & Walking Aids	Discussion	Selection		Use botox or medicine to treat spasticity	Surgery		Test	Develop Test Report	Analyze Results			
		After 17 days spent in hospital	2 weeks	15 minutes per Patient	30 Minutes, 4 Times per Week	30 minutes, 4 Times per Week	30 minutes, 2 Times a Day	30 minutes, 3 times a week	15 minutes per patient, every 4 weeks	Short		As needed						Prescribed to neuro or orthopedic surgeon		45 minutes - 1 hr	1.5 hr to analyze tests, 2 weeks to send them			2 months	1 Time per Ye
	Patient	Transported from the hospital to a rehabilitation center			Participates in exercises	Practice standing and walking skills	Does exercise program given by physiotherapist using equipment.	Does exercise program given by physiotherapist to practice basic skills	Every 8 weeks patient and family member attend				Test orthesis in physiotherapy							Walk around for test			Go home or to a care home	Participates in therapy. Some patients still need help walking and others just need to improve their walking	Go to physician to evaluate thei progress and to address any additional issue they have.
	Physiotherapist		Evaluate the patient and conduct diagnostic tests to determine their current capabilities and what their goals are. Evaluate patient with Clinical Eye to determine what to focus on and what exercises to use Start training basic skills and sitting and standing.	Meet to discuss goals for the patient and their functional prognosis	In the beginning start with basic functions and then progress in walking as time goes on. Use G-Mill and Zero-G to aid in walking. For physiotherapy you mention the use of C Mill and Zero G. Other means are used much more often. E.g. parallel bars, special walkers etc. Important to mention that more sufisticated treatment tools like zero-g are used much less than classical aids. Evaluate patient with Clinical Eye to determine what to focus on and what exercises to use	There is one physiotherapists to 4 patients. Practice standing and walking skills.			Discuss patient's progress, updates to goals, and when other more technical aspects, such as when the patient is getting discharged	Discuss if there are any special issues with the patient.	In between sessions, physiotherapists discuss with each other their patients.	Discuss if there are any special issues with the patient.	Test different orthesis and walking aids	Propose a orthesis or walking aid. Discuss if need to wait before prescribing orthesis.	Wait additional time and see no changes							Interpret results and decide on the next steps	Decide where patient is discharged. Whole team decision Depending on their progress and what they need to work on, the patient may continue rehab at the same center or go to another center closer to home If patient still needs help walking then they will do outpatient at Rijndam/the same rehabilitation center. If patient is walking and just needs to improve it then they can go to another center for physiotherapy.	If patient does outpatient at the same center then continues to treat them.	
	Rehabilitation Physician		Conduct initial assessments of the patient.	Meet to discuss goals for the patient and their functional prognosis Responsible for entire Rehabilitation ream and develop the rehabilitation plan					Discuss patient's progress and updates to goals.	Discuss if there are any special issues with the patient.		Discuss if there are any special issues with the patient.		Discuss if need to wait before prescribing orthesis.	Meet to select an orthesis. Prescribe orthesis			Refer patient to nuero or orthopedic surgeon		Conservative Intervention is not working so request gait lab			Decide where patient is discharged	If patient does outpatient at the same center then continues to treat them.	Sees patient to evaluate their progress and if any additional interventions or treatment is ne
	Physiotherapy Technician						One Technician to 2 to 3 patients. Help patients use equipment	Watch patients so they do not get hurt. Assist patients as needed			Discuss patient's progress during exercise sessions														
	Additional Rehabilitation Staff (Occupational Therapist, Social Worker, Psychiatrist)		Conduct initial assessments of the patient.	Meet to discuss goals for the patient and their functional prognosis					Discuss patient's progress and updates to goals.														Decide where patient is discharged	If patient does outpatient at the same center then continues to treat them.	
	Patient's Family								Every 8 weeks patient and family member attend																
	Neuro or Orthopedic Surgeon																	Performs surgery							
	Orthopedics Specialist														Consult on what is the best type of orthesis to use										
	Gait Lab Operator (Specialist)																			Conducts Gait Lab test with cameras, force plate, and EMG sensors	Analyze test results. May not have time to do so right after test, has a 2 week window.				
	Rehabilitation Nurses						Supervise patient walking and practice transfers in and out of bed.																		
	Paint Points & Improvements				Clinical Eye is not very objective Cannot obtain detailed kinematic measurements with Clinical Eye Not able to provide visual feedback to patient Difficult to see small changes/effect after interventions or between sessions / compare between interventions and sessions Cannot measure energy consumption				Currently physician makes the final decision. Want it to be more of a group decision.				Since the orthesis have to go through insurance, the physiotherapist and physician need to ensure that the patient will not have any additional changes before finalizing orthesis. Difficult because they do not want to prescribe an orthesis too early and risk it not working later on but they need an orthesis to practice walking Patient uses borrowed or off the shelf orthesis or uses walking aids until decision can be finalized. Orthesis take a while to make and are usually not done before the patient is discharged.					Gait Lab is not used often due to it is time consuming and is it not possible or difficult to access Gait Lab Equipment. Difficult to view and interpret data Interface is difficult to operate Cannot be conducted outside of the lab setting or during a physical therapy session Delay of up to 2 weeks between when test is conducted and physician receives the report.			

Appendix P. Stakeholder Analysis

Stakeholder Analysis Matrix

Stakeholder Name	**Who are They**	**Interest** *How much interest do they have in the project? (Low, Medium, High)*	**Influence** *How much influence do they have over the project? (Low, Medium, High)*	**What is important to the stakeholder? What do they want?**	**How could the stakeholder contribute to the project?**	**How could the stakeholder block the project?**	**Strategy for engaging the stakeholder**	**What is their benefit?**	**Sources (assumption, interviews, etc.)**
Physiotherapist	Improve patient's gait through physiotherapy. Will be conducting the gait assessment and viewing the data	High	High	For the whole system (interface + Xsens) to provide benefits and added value over the existing gait assessment methods (clinical eye and laboratory gait analysis).	At the beginning of the project by participating in a focus group and filling out a survey to obtain information on their current experience with gait assessment and what they would like to be included in the interface. In later stages by giving feedback on proposed designs and participating in prototype testing.	By not participating in the focus groups, survey, design feedback, or prototype testing. By not wanting to change their ways and adapt the new system.	By making it as easy as possible to participate in activities (focus group, survey, testing, etc.). Providing updates throughout the project. Having a meeting at the end to present results.	From their input and participation, a user interface can be designed that allows them to obtain more accurate and objective information than the clinical eye, in way that is more accessible and less time consuming than gait lab.	Questionnaire & Focus Group
Rehabilitation Physician	Develop patient's treatment plan and prescribe interventions to aid in gait improvement.	High	High	For the whole system (interface + Xsens) to provide benefits and added value over the existing gait assessment methods (clinical eye and gait lab).	At the beginning of the project by participating in a focus group and filling out a survey to obtain information on their current experience with gait assessment and what	By not participating in the focus groups, survey, design feedback, or prototype testing.	By making it as easy as possible to participate in activities (focus group, survey, testing, etc.). Providing updates throughout the project.	From their input and participation, a user interface can be designed that allows them to obtain more accurate and objective information than	Focus Group with Clinicians

	Will be interpreting the results from the gait assessment conducted by the physiotherapist				they would like to be included in the interface. In later stages by giving feedback on proposed designs and participating in prototype testing.	By not wanting to change their ways and adapt the new system.	Having a meeting at the end to present results.	the clinical eye, in way that is more accessible and less time consuming than gait lab.	
Patient	Have an incomplete spinal cord injury and are participating in gait rehabilitation. Physiotherapists will be using system (Xsens + interface) on them to collect data on their gait.	Medium	Medium	To be able to understand the feedback from the physical therapists to improve their walking. That the best intervention/treatment is selected by the clinicians. To be able to see if and how much they are progressing.	Participating in focus groups or surveys to give feedback on the proposed designs. Participating in prototype testing.	By not participating in the activities (survey, focus group, etc.). By not wanting the clinicians to use the system /interface.	Reach out initially to explain project and why their input is helpful. By making it as easy as possible to participate in activities (focus group, survey, testing, etc.). Providing updates throughout the project. Having a meeting at the end to present results.	Through being able to visualize their gait, they can better see where and how they can improve and where they have improved. Interface will allow clinicians to have additional information to ensure they recommend the right intervention for them.	Questionnaire & Focus Group with Clinicians Literature Research
Rehabilitation Team (Occupational Therapist, Social Worker, Psychiatrist)	Provide medical, functional, and psychological rehabiliation to improve patient's functioning.	Medium	Low	For the patient receives the best treatment that is suited to them to help them improve in their functioning.	Potentially participating in focus groups or surveys to give feedback on proposed design	If they do not participate in the focus group or surveys it will not significantly impact the project	Will engage indirectly through physicians and physiotherapists	In the team meetings, physiotherapists and physicians can better explain the patient's progress through the user interface visualizations	Questionnaire & Focus Group Literature Research

Rehabilitation Nurse	Take care of the patient while they are at the rehabilitation center. Aid in walking and practicing transferring in and out of bed	Medium	Low	For the patient receives the best treatment that is suited to them to help them improve in their functioning.	Potentially participating in focus groups or surveys to give feedback on proposed design	If they do not participate in the focus group or surveys it will not significantly impact the project	Will engage indirectly through physicians and physiotherapists	In the team meetings, physiotherapists and physicians can better explain the patient's progress through the user interface visualizations. Through visualizations can gain a better understanding of what needs be worked on walking and standing practicing	Questionnaire & Focus Group Literature Research
Physiotherapist Technician	Help patients use equipment during Exercise Sessions. Assist patients as needed in Fitness Group Potential operator of system	Medium	Medium	To assist physiotherapists in improving patient's walking ability	Participating in focus groups or surveys to give feedback on the proposed designs. Participating in prototype testing.	If they do not participate in the focus group or surveys it will not significantly impact the project	Reach out initially to explain project and why their input is helpful. By making it as easy as possible to participate in activities (focus group, survey, testing, etc.). Providing updates throughout the project. Having a meeting at the end to present results.	Through visualizations can gain a better understanding of what needs be worked in Exercise Sessions and Fitness Group	Questionnaire and Focus Group
Sports Therapist	With patients practice standing and walking in the pool and	Medium	Medium	To assist physiotherapists in improving patient's walking ability	Participating in focus groups or surveys to give feedback on the proposed designs.	If they do not participate in the focus group or surveys it will	Reach out initially to explain project and why their input is helpful. By making it as easy as possible to participate in	Through visualizations can gain a better understanding of what needs be	Questionnaire and Focus Group

	through sports, such as table tennis				Participating in prototype testing.	not significantly impact the project	activities (focus group, survey, testing, etc.). Providing updates throughout the project. Having a meeting at the end to present results.	worked in sessions	
Patient's Family	Family member of patient	Medium	Low	That the patient receives the best care possible	Potentially participating in focus groups or surveys to give feedback on proposed design	If they do not participate in the focus group or surveys it will not significantly impact the project	Will engage indirectly through physicians and physiotherapists	Through user interface visualizations can understand patient's progress and why interventions are needed.	Questionnaire & Focus Group
Neuro or Orthopaedic Surgeon	Perform surgery on patient	Low	Low	That after the surgery the patient's gait improves	Potentially participating in focus groups or surveys to give feedback on proposed design	If they do not participate in the focus group or surveys it will not significantly impact the project	Will engage indirectly through physicians and physiotherapists	Obtain additional information on patient's gait that can be used to select surgical treatment and guide surgery	Questionnaire & Focus Group
Orthosis Expert	Help decide what orthesis to prescribe for the patient	Medium	Low	Orthesis is designed to optimize patient's walking	Potentially participating in focus groups or surveys to give feedback on proposed design	If they do not participate in the focus group or surveys it will not significantly impact the project	Will engage indirectly through physicians and physiotherapists	System can be used in testing orthesis to select the best one	Questionnaire & Focus Group

Convergence Project Team	Physiotherapists and researchers	High	Medium	To create an easy-to-use interface that allows clinicians to have access to objective gait analysis data without needing engineering skills.	Providing me with contacts with physicians and physiotherapists for the initial survey and focus group. Giving feedback on work and proposed designs. Guiding me in what is feasible with current technology.	Deciding to discontinue the project. Not giving me contact information for clinicians.	Weekly meetings Monthly meetings with Convergence Project Team and TU Delft Supervisory Team	Contribute towards reaching the goals set out in Convergence Project proposal	Convergence Project Proposal Meetings with Convergence Project Team
Erasmus University Medical Center (MC)	The organization for which the interface is for. The ones funding the project	Low	Medium (provide funding but not much input)	To provide clinicians with the resources and tools to provide first-rate care to patients.	By providing funding for the project.	By deciding to cut the funding for the project	Will engage convergence project team but not directly Erasmus MC	The interface will provide clinicians with information that can better inform clinical decisions and the treatment of patients.	https://www.erasmusmc.nl/en/research/mission-and-strategy

Appendix Q. Program of Requirements

REQUIREMENTS

Vision

1. Easy to Use

1.1. The user interface can be operated independently with minimal instruction.

1.2. Physicians and physiotherapists can select and change the gait parameters and the testing result visualizations they would like to view with minimal effort.

2. Selecting Interventions

2.1. Physicians and physiotherapists can use the user interface to compare and select walking aids and orthoses.

2.2. The user interface can be used to evaluate the effect of treatments and interventions.

2.3. The user interface can be used to find small differences in gait.

3. Objective

3.1. The user interface provides more objective information than is currently obtained with the clinical eye.

3.2. The upper body features in the avatar are visible.

4. Time Efficient Manner

4.1. After reviewing the testing results in the user interface for 5 minutes, physicians and physiotherapists can obtain an overview of the results.

4.2. Physicians and physiotherapists can comprehensively interpret and analyze the results within 15 minutes.

4.3. Complete test results can be viewed within 5 minutes after the test is conducted.

5. Intuitive

5.1. The testing results are easier to view and interpret than in laboratory gait analysis.

5.2. Physicians and physiotherapists with minimal pre-existing knowledge on gait analysis can understand and interpret the results.

5.3. The user interface provides enough information to allow the physicians and physiotherapists to make an informed analysis, but not so much that it overloads them with information.

User Interface Design

6. Ergonomics

6.1. To allow the visually impaired and color-blind to operate the interface, font sizing and contrast between text should abide by the Web Content Accessibility Guidelines (WCAG) (Barry, 2021).

6.2. The capital font size should be a minimal of 1/200th of the reading distance (Dul & Weerdmeester, 2008).

6.3. The space between the line should be at least 1/30th the length of the line. (Dul & Weerdmeester, 2008).

6.4. The noise level of any sounds should be below 80 decibels (Dul & Weerdmeester, 2008).

6.5. The screen's brightness should not be three times larger or smaller than the brightness of the user's close surroundings. (Dul & Weerdmeester, 2008).

7. Usability

7.1. The operation of each screen in the user interface is self-evident.

7.2. Affordances are implemented throughout the user interface. (Krug, 2014).

7.3. Be consistent and follow established conventions (Jack Nielsen's Usability Heuristics)

7.4. Minimize the number of steps needed to complete a function. (Jack Nielsen's Usability Heuristics)

7.5. Affordances are implemented throughout the user interface. (Krug, 2014).

7.6. Design for intermediate users (Cooper et al., 2014)

7.7. Allow for customisation such that expert users can speed up how they use the system (Jack Nielsen's Usability Heuristics)

7.8. If a convention is not used, then the convention should be replaced with a clear concept that the user can understand with minimal explanation or with a change that has enough added value the user will not mind a slight learning curve (Krug, 2014).

8. Layout

8.1. Cohesiveness and flow is kept throughout the user interface (Dai, 2018)

8.2. The user interface contains an effective visual hierarchy (Krug, 2014).

8.3. The user interface layout should follow a logical flow (Copper et al., 2014).

8.4. Indicate to users where they are in respect to the whole interface (Krug, 2014).

8.5. The user only needs to focus on one primary function per page ("What is User," n.d.).

8.6. Format the interface to support scanning (Cooper et al., 2014).

8.7. Divide the screen into clearly defined areas (Cooper et al., 2014)

9. Formatting & Aesthetics of Visualizations

9.1. The user interface and test results visualizations are aesthetically appealing and do not have a purely technical aesthetic.

9.2. The content and visual design are kept minimalistic as possible, and only essential information and elements are included (Jack Nielsen's Usability Heuristics).

9.3. Integrate text, graphics, and data in one display rather than placing all information in a legend (Tuft Grand Principles)

9.4. When showing changes over time, display the changes adjacent in space, not staked in time. (Tuft Grand Principles)

9.5. When designing icons, avoid excessive visual detail and reuse icons throughout the design so that the user only needs to learn them once (Cooper et al., 2014)

10. Feasibility

10.1. The testing results visualizations can be developed using data from Xsens MVN Analyze

10.2. The testing results visualizations can be developed using existing software.

11. Use Context

11.1. The user interface can be operated on a computer.

11.2. The Xsens system and user interface can be used with patients who are walking with braces/crutches and those who have a more improved level of walking.

11.3. The Xsens system and user interface can be used outside of a lab in different environments

11.4. Within 10 to 30 minutes, the entire system (Xsens and user interface) can set up, used, and produce results (focus group)

11.5. For calibration, the Xsens MTw Awinda system can be operated by physiotherapists and physicians without extensive effort and in a timely manner.

WISHES

12. The user interface can be used to provide feedback to patients to improve their waking.

13. The user interface can be used to determine the underlying problems in gait.

14. The user interface can be used to evaluate a patient's progress.

15. The user interface can be used to choose physical therapy focus.

16. Can provide visual feedback to patients.

17. The Xsens system and user interface can be used with patients who are walking parallel bars or a walker.

18. The user interface provides patients with an overview of their test results in a way they can understand.

19. The user interface can be operated on all physician and physiotherapist computers.

20. The testing results are accessible to all physiotherapists, physicians, and members of the rehabilitation team (occupational therapist, social worker, psychiatrist, nurses).

Appendix R. Parameter & Visualizations Scope

PARAMETERS

In the focus group sessions, participants were asked to evaluate six different categories of parameters.

In defining the scope of the design directions, what parameters and visualizations to focus on in ideation were also established. In the focus group sessions, it was expressed that stand/swing time and single/double support time are similar, and only one set needed to be included in the interface. As stand/swing time was rated more needed over single/double support time, it was selected to include in the interface.

Within the category of gait variation, for the parameters of gait symmetry and step-to-step variation, a visualization would need to be developed for each parameter. This would be an additional 22 visualizations. Due to the large number of visualizations needed to develop and the low level of need by participants in the focus group sessions, it was decided not to ideate on gait symmetry and step to step variation and instead focus on the remainder of the parameters.

VISUALIZATIONS

Through the focus group sessions, how the physiotherapists and physicians want the parameters to be visualized was determined (Table 2). It was also selected if they wanted to view the parameters in real time or at the end of the trial. Even though the content presented in real time and end of trial visualizations will be similar for each parameter, how they are displayed will differ. In real time, the data is continually updated, while at the end of trial, the data for the entire test has been processed and will be presented

In the focus group sessions, it was expressed that while conducting the test most clinicians' focus will be on the patient and not on the interface. In doing so, they would evaluate the end of trial visualizations more often than in real time. Consequently, it was decided to focus on the end of trial visualizations and develop the real time visualizations in later design iterations

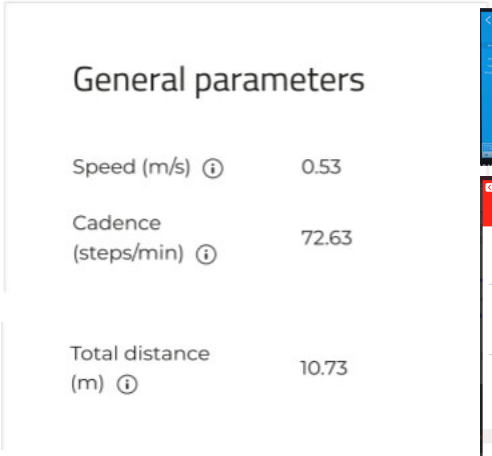
The aesthetics of the avatar was also not within the scope of the ideation. What the avatar should be able to do was focused on, but not how the avatar looks. The avatar will be later developed by Convergence Team using existing software. As this requires extensive programming and data processing, which would take a lot of time to learn and develop, it was decided that the ideation time would be better spent on the visualizations.

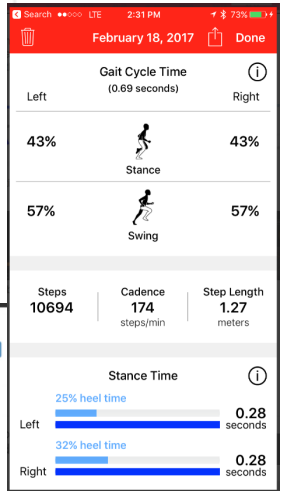
Visualizations for the upper body were also not developed. In the focus group sessions, participants were satisfied with just seeing the avatar for the upper body segments and did not think they needed to view any detailed parameter information. In doing so, information regarding upper body segments will only be displayed through the avatar

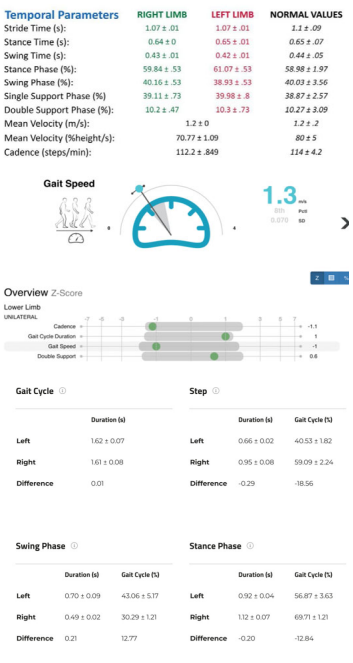
Visualizations to compare results between sessions, display the normal values, and show the left and right differences were included in the ideation scope as most participants in the focus group session said they were in great need. Comparing results between patients was of no need and thus was not included. As the visualizations displaying the data for each parameter and those displaying the normal values for each parameter are similar in content, one visualization was developed for both.

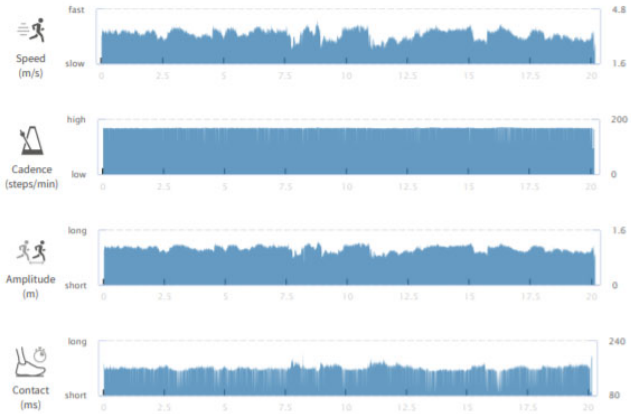
Appendix S. Visualization Collages

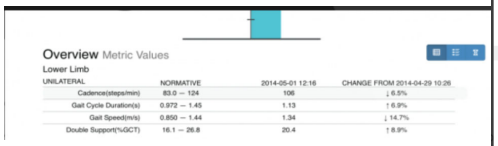
Time

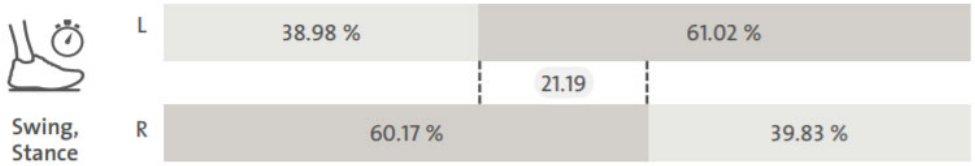






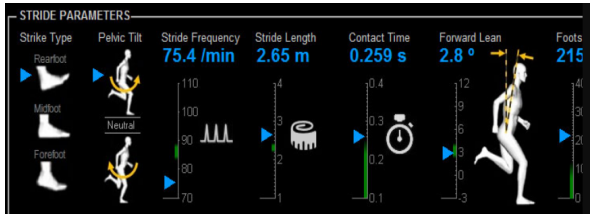




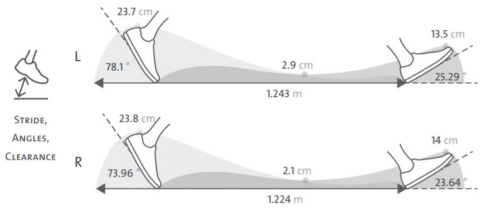


Temporal												
Parameter	Stance		Swing		Loading		Foot-Flat		Pushing		Double Support	
Unit	% Cycle		% Cycle		% Stance		% Stance		% Stance		% Cycle	
Side	L	R	L	R	L	R	L	R	L	R	L	R
Mean	61.02	60.17	38.98	39.83	12.85	12.85	51.06	52.04	36.09	35.11	21.19	21.19
Median	61.07	60.16	38.93	39.84	12.87	13	51.29	51.75	35.9	35.21	21.28	21.28
Std	1.07	1.12	1.07	1.12	1.13	1.29	2.48	2.57	2.57	2.19	1.45	1.45
Iqr	0.98	1.05	0.98	1.05	1.11	1.35	1.71	1.75	1.31	1.48	1.54	1.54
Min	53.66	54.59	35.9	34.3	7.94	7.52	29.75	33.33	27.27	23.01	11.35	11.35
Max	64.1	65.7	46.34	45.41	16.96	15.6	60.91	65.49	61.98	57.89	29.68	29.68
Ratio	1.01	0.99	0.98	1.02	1	1	0.98	1.02	1.03	0.97		
Cv	1.75	1.87	2.74	2.82	8.78	10.03	4.85	4.93	7.11	6.23	6.86	6.86

Distance



	Step Length (cm)	Step Width (cm)	Stride Length (cm)
Left	53.89 ± 3.48	21.36 ± 5.21	87.08 ± 4.84
Right	33.65 ± 2.84	20.51 ± 5.46	88.63 ± 4.86
Difference	20.24 (37.56 %)	0.85 (3.97 %)	-1.55 (-1.78 %)

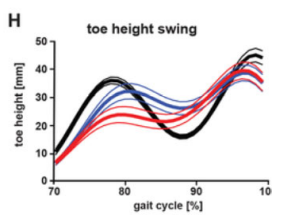


Spatial Parameters	RIGHT LIMB	LEFT LIMB	NORMAL VALUES
Stride Length (m):	1.27 ± .01	1.27 ± .01	1.36 ± .11
Stride Length (%height):	75.72 ± .88	75.32 ± .72	80 ± 10
Step Length (m):	0.66 ± .01	0.62 ± .02	0.62 ± .05
Step Width (m):	0.04 ± .01		0.08 ± .05

Spatial	Peak Ang. Velocity		Swing Speed		Strike Angle		Lift-Off Angle		Swing Width		3D Path Length	
Parameter												
Unit	Degree/S		M/S		Degree		Degree		M		% Stride Length	
Side	L	R	L	R	L	R	L	R	L	R	L	R
Mean	456.9	446.8	4.12	4.08	25.29	23.64	-78.1	-73.96	0.05	-0.02	105.95	104.91
Median	452.3	448.6	4.13	4.11	25.47	23.98	-78.23	-74.62	0.04	-0.03	105.15	104.46
Std	34.8	20.6	0.16	0.25	1.67	1.96	2.2	3.52	0.05	0.04	4.41	2.5
Iqr	42.6	22.3	0.18	0.16	1.75	1.72	1.88	2.34	0.02	0.02	1.58	0.65
Min	337.7	349.5	3.15	2.28	13.7	12.27	-84.3	-78.69	-0.13	-0.35	102.97	103.08
Max	686.9	504.3	4.55	4.48	31.19	28.12	-56.29	-50.12	0.39	0.16	143.41	133.32
Ratio	1	1	1.01	0.99	1.07	0.93	1.06	0.95	-1.94	-0.52	1.01	0.99
Cv	7.6	4.6			6.61	8.29	-2.82	-4.76			4.16	2.38

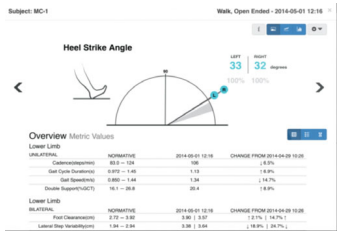
General	Cycle Duration		Cadence		Stride Length		Stride Velocity		Turning Angle	
Parameter										
Unit	S		Steps/Min		M		M/S		Degree	
Side	L	R	L	R	L	R	L	R	L	R
Mean	0.95	0.95	126.93	126.94	1.24	1.22	1.34	1.31	-4.3	-3
Median	0.94	0.94	126.98	126.98	1.25	1.24	1.34	1.32	-0.2	1.2
Std	0.02	0.02	2.97	3.07	0.07	0.11	0.07	0.11	21.5	22
Iqr	0.02	0.03	2.69	3.38	0.07	0.05	0.09	0.07	3.4	2.9
Min	0.87	0.89	115.94	109.59	0.9	0.57	0.97	0.65	-133.6	-123.4
Max	1.03	1.09	137.93	134.83	1.38	1.36	1.53	1.49	104	124.2
Ratio	1	1	1	1	1.01	0.98	1.02	0.98	1.5	0.7
Cv	2.38	2.48	2.34	2.42	5.23	8.7	5.08	8.69		

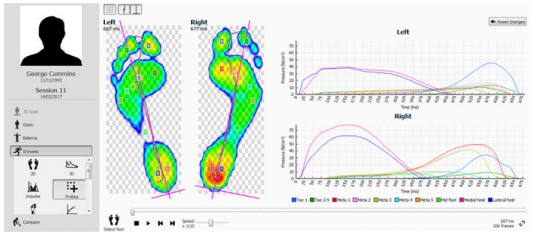
Kinematics

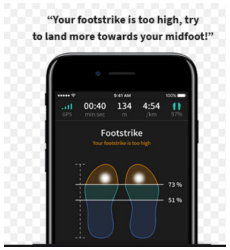


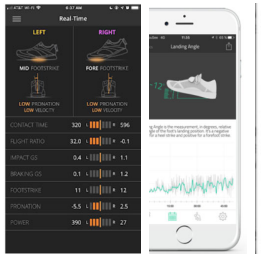
Foot Strike

	Heel		Toe	
	n	%	n	%
Left	6	42.86	2	14.29
Right	6	42.86	0	0.00
Total	12	85.71	2	14.29





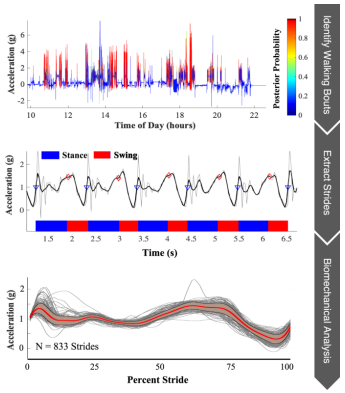


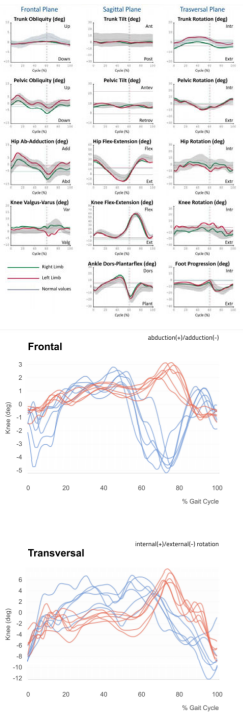


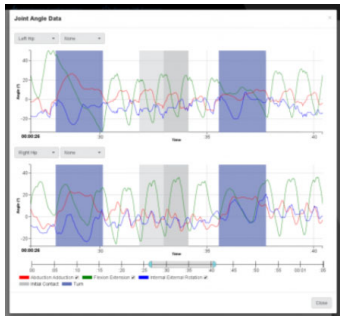
Lower Limb

BILATERAL	NORMATIVE	2014-05-01 12:16	CHANGE FROM 2014-04-29 10:26
Foot Clearance(cm)	2.72 — 3.92	3.90 | 3.57	↑ 2.1% | 14.7% ↑
Lateral Step Variability(cm)	1.94 — 2.94	3.38 | 3.64	↓ 18.9% | 24.7% ↓
Circumduction(cm)	2.09 — 6.53	4.17 | 3.37	↓ 23.7% | 16.7% ↓
Foot Strike Angle(°)	17.6 — 28.7	32.9 | 32.5	↑ 20.8% | 11.8% ↓
Toe Off Angle(°)	28.0 — 39.5	38.0 | 37.9	↓ 0.1% | 3.5% ↓
Stance(%GCT)	58.1 — 63.3	60.2 | 60.3	↑ 2.4% | 0.7% ↑
Step Duration(s)	0.486 — 0.730	0.559 | 0.585	↑ 5.0% | 11.5% ↑
Stride Length(m)	1.20 — 1.41	1.53 | 1.50	↓ 7.8% | 9.7% ↓
Swing(%GCT)	36.7 — 41.9	39.8 | 39.7	↓ 3.4% | 1.0% ↓
Toe Out Angle(°)	3.35 — 17.6	3.18 | 13.0	↓ 87.2% | 51.8% ↑

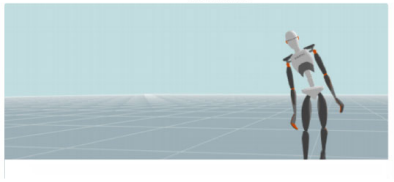
Joint Angles

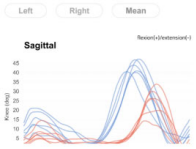






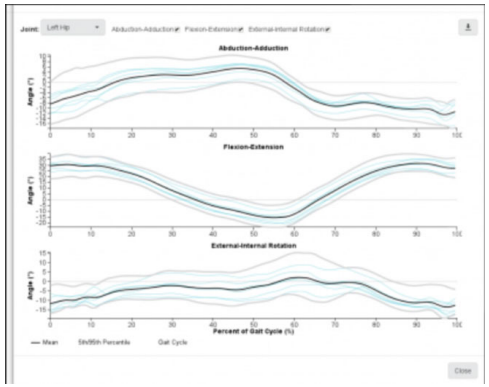
Standing Angles	RIGHT LIMB	LEFT LIMB
Pelvic Obliquity (deg):	-1.5 ± .2	1.5 ± .2
Pelvic Tilt (deg):	23.1 ± 1.2	23.1 ± 1.2
Pelvic Rotation (deg):	1.1 ± .2	-1.1 ± .2
Hip Ab-Adduction (deg):	-5 ± .2	-.6 ± .1
Hip Flex-Extension (deg):	13.9 ± 1	15.1 ± 1
Hip Rotation (deg):	4.3 ± .2	-2.4 ± .2
Knee Flex-Extension (deg):	-4.8 ± .2	-2.6 ± .1
Ankle Dors-Plantarflex (deg):	5.8 ± .1	7.2 ± .1
Foot Progression (deg):	0.8 ± .1	-5.8 ± 0

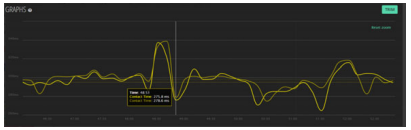


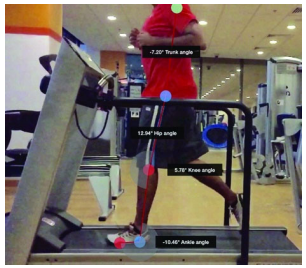


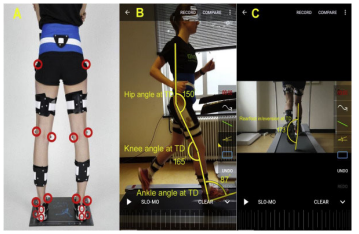
Joint angle [deg]	Overall		Stance		Swing			
	Min	Max	Min	Max	Min	Max	At foot strike	At foot release
Left	-1.26	46.98	-1.26	31.81	0.63	46.98	8.90 ± 2.84	25.30 ± 6.14
Right	-3.60	33.67	-0.15	15.60	-3.60	33.67	2.32 ± 1.89	16.00 ± 2.25
Difference	2.34	13.32	-1.11	16.21	4.23	13.32	6.58	9.30

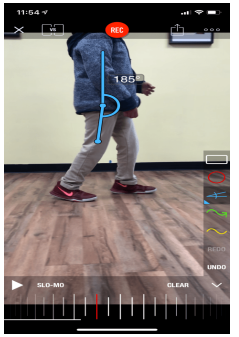
*Direction of Progression



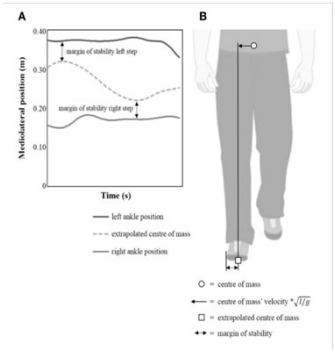


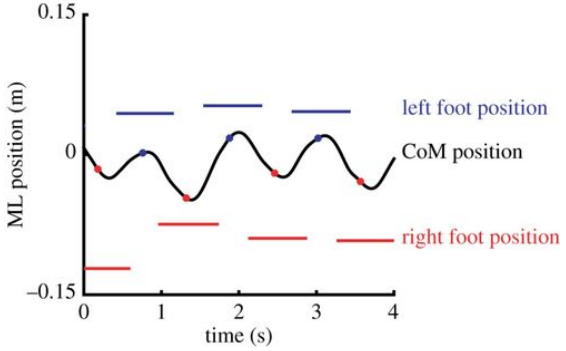


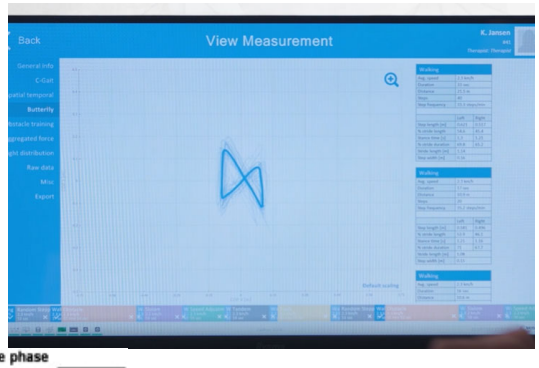


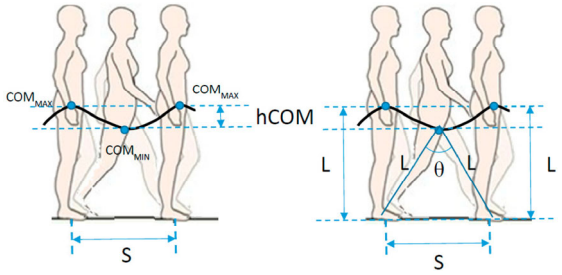


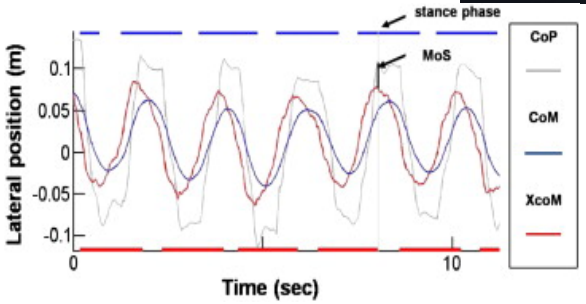
Gait Stability



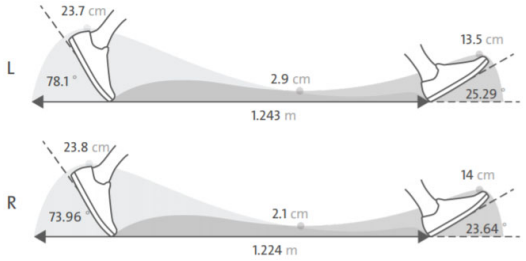








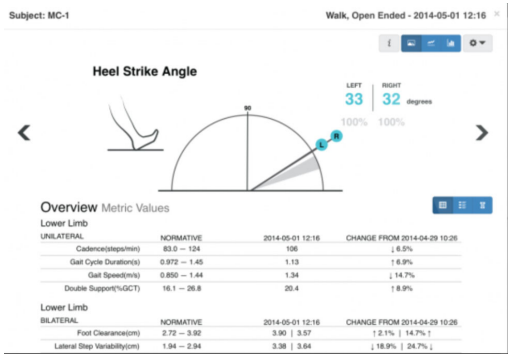
STRIDE, ANGLES, CLEARANCE

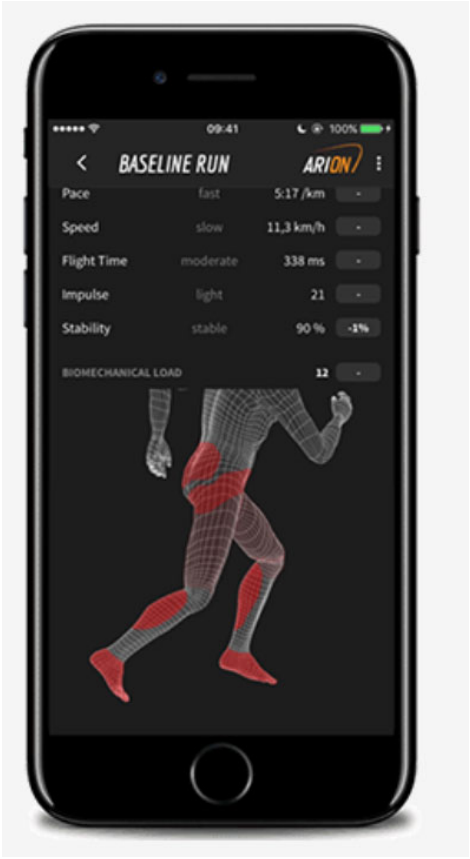


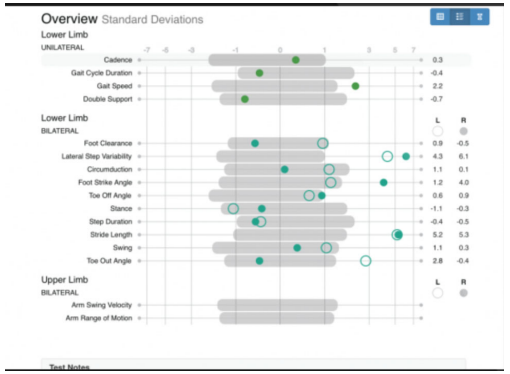
Spatial								
Parameter	Strike Angle		Pronation At IC		Lift Off Angle		Amplitude	
Units	degree		degree		degree		m	
Side	L	R	L	R	L	R	L	R
Mean	1.03	0.37	-14.36	-14.97	-36.63	-34.93	1.15	1.12
Std	2.01	1.75	4.37	4.58	3.74	3.84	0.28	0.24
Median	1.15	0.26	-14.92	-15.37	-36.71	-34.71	1.17	1.12
Iqr	2.33	1.94	4.7	6.32	4.88	4.88	0.38	0.38
Min	-39.34	-30.25	-28.3	-31.8	-57.92	-85.53	0.26	-0.06
Max	10.49	10.94	4.07	8.83	-12.64	-10.54	13.09	3.44
Cv							24.28	22.09

Clearance								
Parameter	Max. Heel		Max. Toe 1		Min. Toe		Max Toe 2	
Unit	M		M		M		M	
Side	L	R	L	R	L	R	L	R
Mean	0.24	0.24	0.05	0.06	0.03	0.02	0.14	0.14
Median	0.24	0.24	0.05	0.06	0.03	0.02	0.14	0.14
Std	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Iqr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Min	0.19	0.16	0.02	0.04	0	0	0.07	0.06
Max	0.26	0.26	0.08	0.08	0.08	0.04	0.16	0.18
Ratio	1	1	0.9	1.11	1.37	0.73	0.96	1.04
Cv								

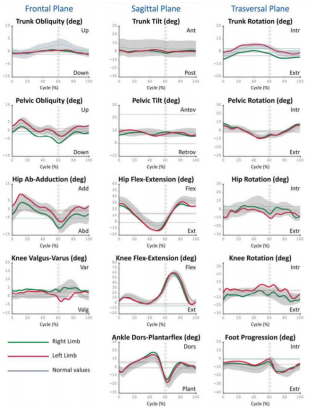
Normal Values



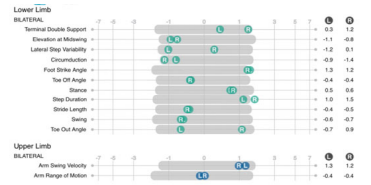




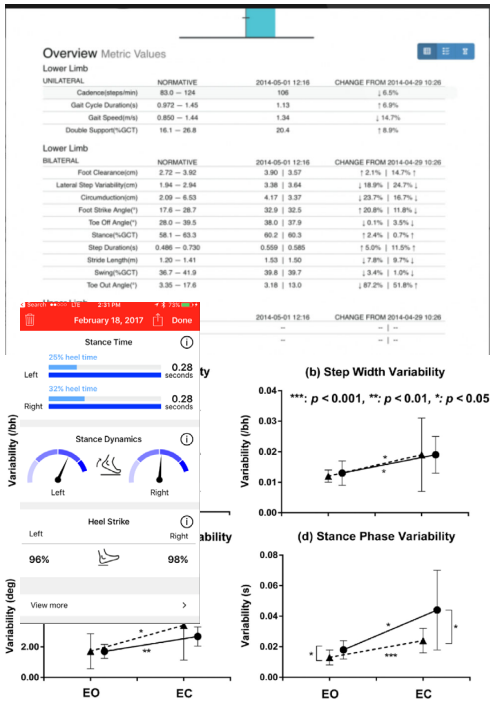
Temporal Parameters	RIGHT LIMB	LEFT LIMB	NORMAL VALUES
Stride Time (s):	1.07 ± .01	1.07 ± .01	*1.1 ± .09*
Stance Time (s):	0.64 ± 0	0.65 ± .01	*0.65 ± .07*
Swing Time (s):	0.43 ± .01	0.42 ± .01	*0.44 ± .05*
Stance Phase (%):	59.84 ± .53	61.07 ± .53	*58.98 ± 1.97*
Swing Phase (%):	40.16 ± .53	38.93 ± .53	*40.03 ± 3.56*
Single Support Phase (%)	39.11 ± .73	39.98 ± .8	*38.87 ± 2.57*
Double Support Phase (%):	10.2 ± .47	10.3 ± .73	*10.27 ± 3.09*
Mean Velocity (m/s):	1.2 ± 0		*1.2 ± .2*
Mean Velocity (%height/s):	70.77 ± 1.09		*80 ± 5*
Cadence (steps/min):	112.2 ± .849		*114 ± 4.2*

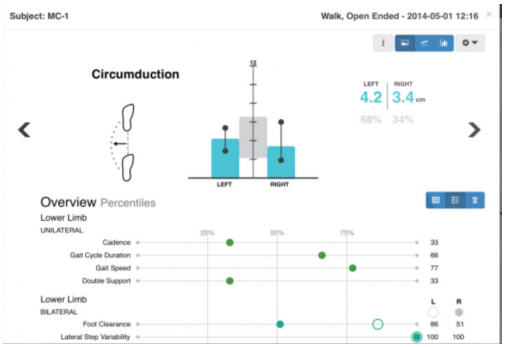


Comparison


Lower Limb
BILATERAL
Upper Limb
BILATERAL

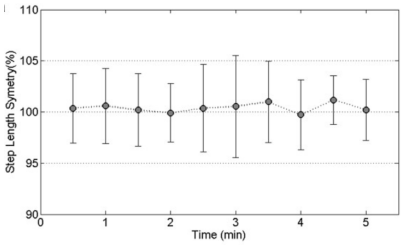

COMMUNITY COMPARISON
EFFICIENCY
HIGH
SHOCK
AVG
MOTION
LEFT
RIGHT
MID FOOTSTRIKE
AVG PRONATION
LOW VELOCITY
MID FOOTSTRIKE
LOW PRONATION
LOW VELOCITY

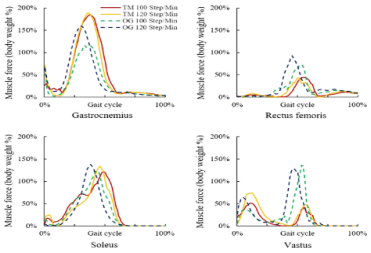

Overview Metric Values
Lower Limb
UNILATERAL
NORMATIVE
2014-05-01 12:16
CHANGE FROM 2014-04-29 10:26
Lower Limb
BILATERAL
NORMATIVE
2014-05-01 12:16
CHANGE FROM 2014-04-29 10:26
February 18, 2017
Done
Stance Time
25% heel time
Left
0.28
seconds
32% heel time
Right
0.28
seconds
Stance Dynamics
Left
Right
Heel Strike
Left
Right
96%
98%
View more
(b) Step Width Variability
***: p < 0.001, **: p < 0.01, *: p < 0.05
Variability (hh)
(d) Stance Phase Variability
Variability (deg)
Variability (s)
EO
EC

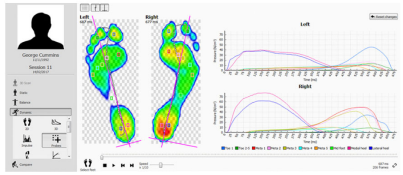

Subject: MC-1
Walk, Open Ended - 2014-05-01 12:16
Circumduction
LEFT
RIGHT
4.2
3.4
Overview Percentiles
Lower Limb
UNILATERAL
Lower Limb
BILATERAL
Foot Clearance
Lateral Step Variability

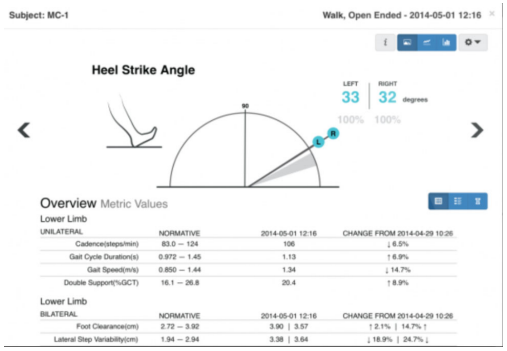

does it work?
09:41
DEMO OF FOOTSTRIKE RUN
ARION
SPLITS
METRICS
Stride Length
moderate
1,4 m
+31%
Cadence
high
172 spm
-3%
Balance
centered
0,0 %
Contact Time
short
200 ms
+3%
Heart Rate
moderate
133 bpm
-3%
Pace
fast
4:28 /km
-15%
Speed
slow
13,4 km/h
+17%
Flight Time
moderate
349 ms
+3%
Impulse
light
38
+81%
Power
moderate
218 W
Stability
stable
90 %

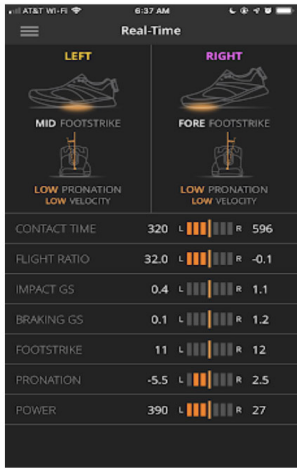

Subject: MC-1
Walk, Open Ended - 2014-06-12 15:21
Gait Speed
Overview Percentiles
Lower Limb
UNILATERAL
Lower Limb
BILATERAL
Foot Clearance
Lateral Step Variability

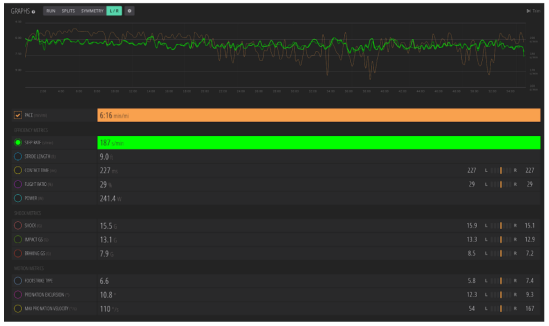

Step Length Symetry(%)
Time (min)

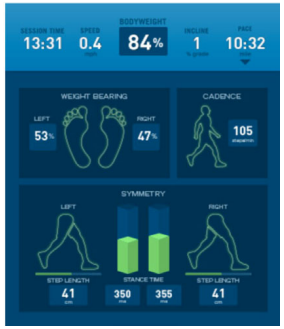

Muscle force (body weight %)
Gait cycle
Gastrocnemius
Rectus femoris
Soleus
Vastus




Subject: MC-1
Walk, Open Ended - 2014-05-01 12:16
Heel Strike Angle
LEFT
RIGHT
33
32
degrees
Overview Metric Values
Lower Limb
UNILATERAL
NORMATIVE
2014-05-01 12:16
CHANGE FROM 2014-04-29 10:26
Lower Limb
BILATERAL
NORMATIVE
2014-05-01 12:16
CHANGE FROM 2014-04-29 10:26


AT&T WI-FI
6:37 AM
Real-Time
LEFT
RIGHT
MID FOOTSTRIKE
FORE FOOTSTRIKE
LOW PRONATION
LOW VELOCITY
LOW PRONATION
LOW VELOCITY
CONTACT TIME
320
596
FLIGHT RATIO
32.0
-0.1
IMPACT GS
0.4
1.1
BRAKING GS
0.1
1.2
FOOTSTRIKE
11
12
PRONATION
-5.5
2.5
POWER
390
27




BODYWEIGHT
13:31
0.4
84%
1
10:32
WEIGHT BEARING
LEFT
53%
RIGHT
47%
CADENCE
105
SYMMETRY
LEFT
RIGHT
STEP LENGTH
41
STANCE TIME
350
355
STEP LENGTH
41


SHOE COMPARISON
Sept 23, 2014
RUNSCORE™
67
53
73
62
SHOE
Asics Gel Kinsei
Mizuno Wave Creation
New Balance WT1210
Merrel Women's Barefoot Vapor Glove
FOOTSTRIKE
IMPACT GS (G)
12.8
14.5
8.2
10.1
BRAKING GS (G)
9.3
8.7
7.2
8.2
PRONATION EXCURSION(°)
-23
+2
-18
+5
PRONATION VELOCITY (°/SEC)
678
723
645
653
CONTACT TIME (MS)
248
245
230
245
620 × 422

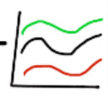
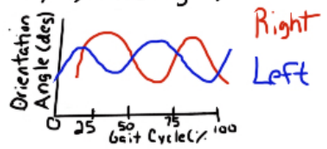
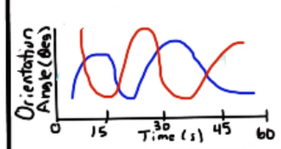
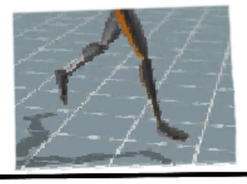
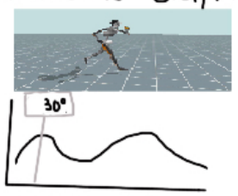
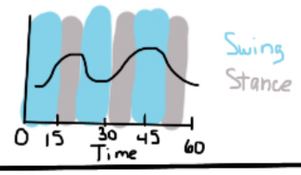
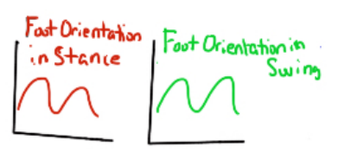
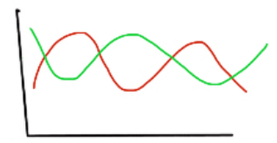
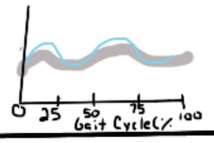
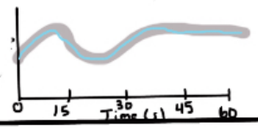
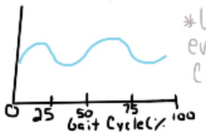
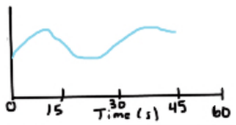
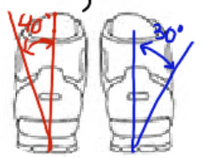
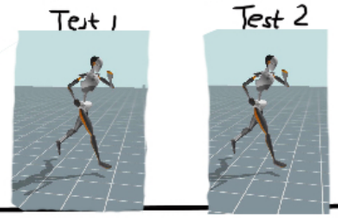
Appendix T. Morphological Chart

Foot Position

Top View of Foot Position Orientation (Stance + Swing)

Lateral View of Foot Position Orientation (Clearance in Swing)

Graphs + Animations

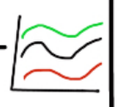
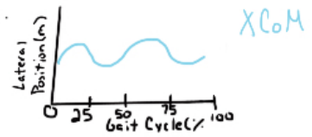
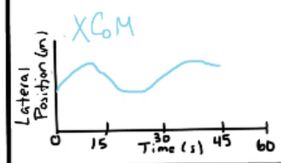
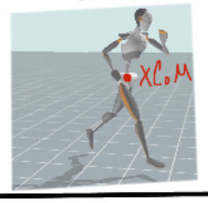
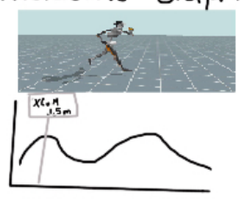
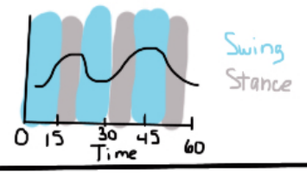
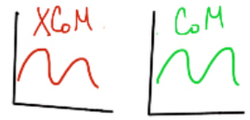
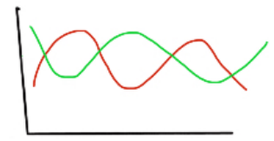
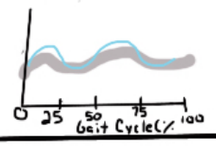
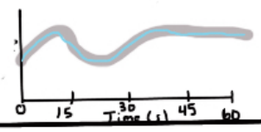
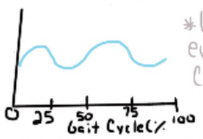
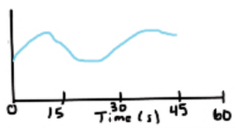
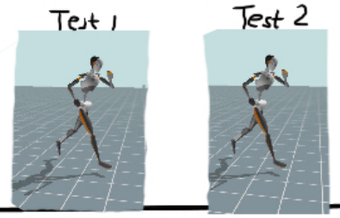
Solutions	1	2	3	4	5
Data Presented	Mean 6	Mean + Variance 6 ± 0.5 	Mean, Min, & Max Mean | Min | Max 6 | 2 | 10 		
End of Trial	Line Graph (Per Gait Cycle, Average) 	Line Graph (Over Time) 	Average + Icon 		
Features	Zoomed in Avatar 	Interactive Graph 	Swing + Stance Labels 	Stance + Swing Seperate Plots 	View on Same Plot 
Normal	Line Graph (Per Gait Cycle, Average) 	Line Graph (Over Time) 			
Real Time	Line Graph (Per Gait Cycle, Average)  * Update every gait Cycle	Line Graph (Over Time)  * Add over time	Average + Icon  * Update every gait cycle		
Comparison	Video Side by Side Test 1 Test 2 	Interactive Line Graph Plotted Together. 	Interactive Line Graph Plotted Side by Side 		

Graphs + Animations

Gait Stability

Position Center of Mass
XCoM

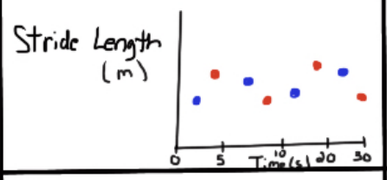
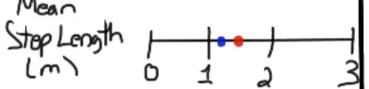
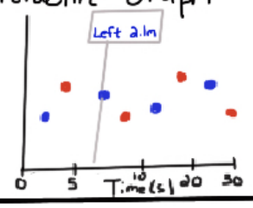
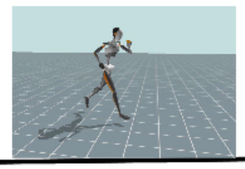
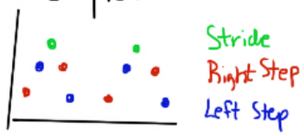
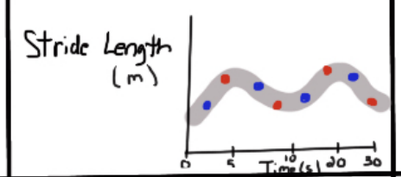
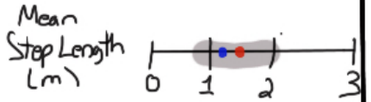
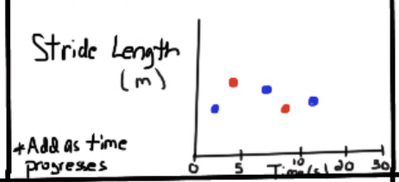
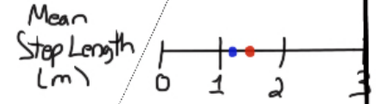
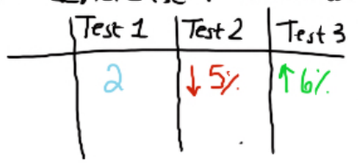
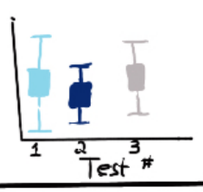
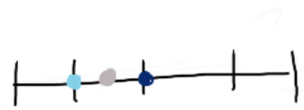
Graphs + Animations

Solutions	1	2	3	4	5
Data Presented	Mean 6	Mean + Variance 6 ± 0.5 	Mean, Min, & Max Mean | Min | Max 6 | 2 | 10 		
End of Trial	Line Graph (Per Gait Cycle, Average) 	Line Graph (Over Time) 			
Features	Position on Avatar 	Interactive Graph 	Swing & Stance Labels 	Seperate Plots 	View on Sa Plot 
Normal	Line Graph (Per Gait Cycle, Average) 	Line Graph (Over Time) 			
Real Time	Line Graph (Per Gait Cycle, Average)  *Update every gait cycle	Line Graph (Over Time)  *Add over time			
Comparison	Video Side by Side Test 1 Test 2 	Interactive Line Graph Plotted Together. 	Interactive Line Graph Plotted Side by Side 		

Graphs + Animations

Distance

Step/Stride Length
Base of Support
Distance Walked

Solutions	1	2	3	4
Data Presented	Mean 6	Mean + Variance 6 ± 0.5	Mean, Min, & Max Mean: 6 | Min: 2 | Max: 10	
End of Trial	Scatter Plot over Time 	Label & Number Mean Step Length (m): Right 1.27, Left 1.34	Label, Number, & Icon Mean Step Length (m): Right 1.27, Left 1.34	Mean Plotted on Line 
Features	Interactive Graph 	Avatar Video 	View all Parameters on Same plot 	
Normal	Scatter Plot over Time 	Label & Number Mean Step Length (m): Right 1.27, Left 1.34, Normal 2.4	Label, Number, & Icon Mean Step Length (m): Right 1.27, Left 1.34, Normal 2.4	Mean Plotted on Line 
Real Time	Scatter Plot over Time 	Label & Number Mean Step Length (m): Right 1.27, Left 1.34 *Update every step	Label, Number, & Icon Mean Step Length (m): Right 1.27, Left 1.34 *Update every step	Mean Plotted on Line 
Comparison Between Trials		Increase & Decrease 	Box & Whisker Plots 	Plotted on Line 

Numbers or Numbers & Graphs

Numbers

Time (Stance / Swing Time, Walking Speed)

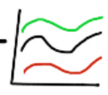
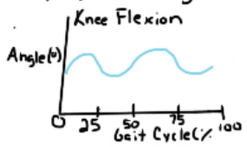
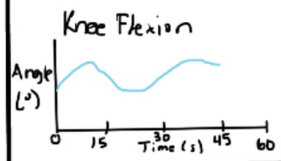
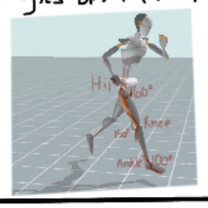
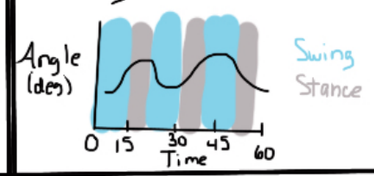
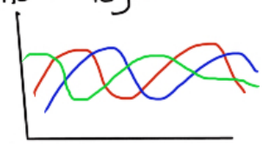
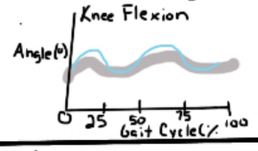
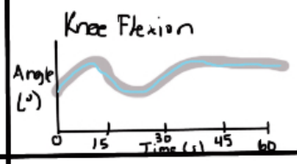
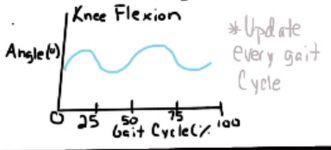
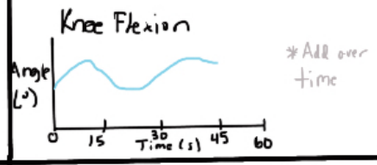
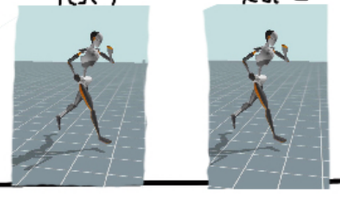
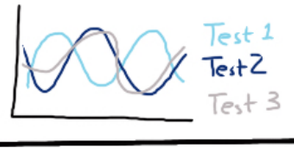
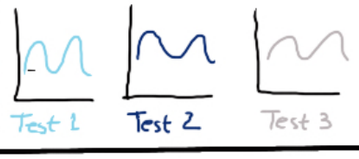
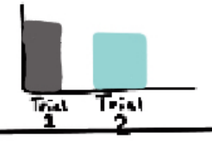
Solutions	1	2	3	4
Data Presented	Mean 6 m/s	Mean + Variance 6 ± 0.5 m/s	Mean, Min, & Max Mean: 6 m/s, Min: 2 m/s, Max: 10 m/s	
End of Trial	Label + Number Stance Time (s): Right 2, Left 1.5 Swing Time (s): Right 3, Left 2.5 Mean Speed (m/s): 5	Label, Number, + Icon Stance Time (s): Right 2, Left 1.5 Swing Time (s): Right 3, Left 2.5 Mean Speed (m/s): 5	Mean Plotted on Line Stance Time (s) 0 1 2 3 Swing Time (s) 0 1 2 3 Speed (m/s) 0 2 4 6	
Features	% Swing & Stance per Gait Cycle Right: Stance 62%, Swing 48% Left: Stance 61%, Swing 49%			
Normal	Label + Number Stance Time (s): Right 2, Left 1.5, Normal 2.2	Label, Number, & Icon Stance Time (s): Right 2, Left 1.5, Normal 2.2	Mean Plotted on Line Stance Time (s) 0 1 2 3 Swing Time (s) 0 1 2 3 Speed (m/s) 0 2 4 6	
Comparison	Average Value Table Test 1: 5; Test 2: 6; Test 3: 5.5	Bar Graph of Averages Normal 1 2 3 Test #	Box & Whisker Plots 1 2 3 Test #	Plotted on Line

Numbers & Graphs

Joint Angles

Hip, Trunk, Knee, Ankle

Numbers, Graphs, & Animations

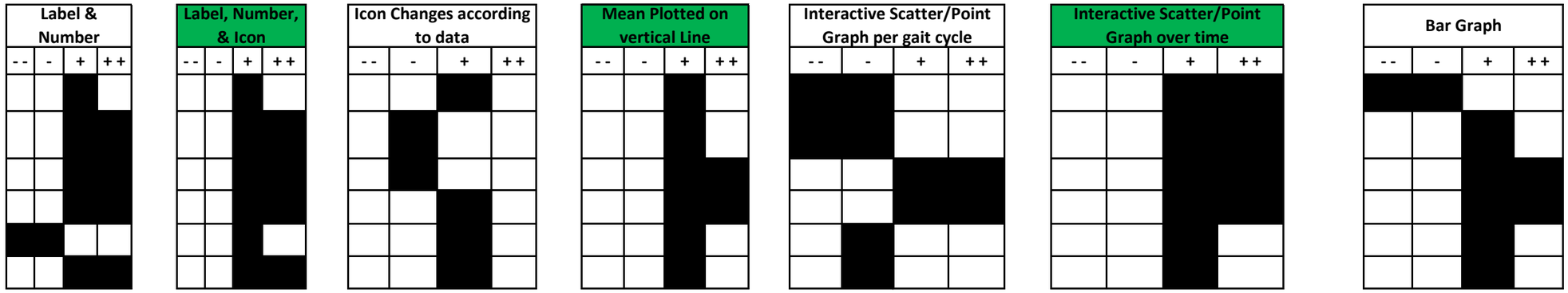
Solutions	1	2	3	4	5
Data Presented	Mean 6	Mean + Variance 6 ± 0.5 	Mean, Min, & Max Mean | Min | Max 6 | 2 | 10 		
End of Trial	Line Graph (Per Gait Cycle, Average) 	Line Graph (Over Time) 	Label & Number Overall Knee Angle | Min | Max | At Foot strike | At Foot release Left | -5 | 50 | 9 | 30 Right | -2 | 45 | 2 | 16	Number + Icon 	Plotted on Vertical Line 
Features	Angle on Avatar 	Interactive Graph 	Swing & Stance Labels 	Flexion, Abduction, & Rotation Seperate 	Flexion, Abduction, & Rotation Together 
Normal	Line Graph (Per Gait Cycle, Average) 	Line Graph (Over Time) 	Label & Number Overall | Normal Knee Angle | Min | Max | Min | Max Left | -5 | 50 | -10 | 40 Right | -2 | 45 | -2 | 60		
Real Time	Line Graph (Per Gait Cycle, Average) 	Line Graph (Over Time) 	Label & Number Overall Knee Angle | Min | Max | At Foot strike | At Foot release Left | -5 | 50 | 9 | 30 Right | -2 | 45 | 2 | 16 *Update every gait cycle		
Comparison	Video Side by Side Test 1 Test 2 	Interactive Line Graph Plotted Together. 	Interactive Line Graph Plotted Side by Side 	Bar Graph of Average 	Bar Graph with Variance 

Numbers, Graphs, & Animations

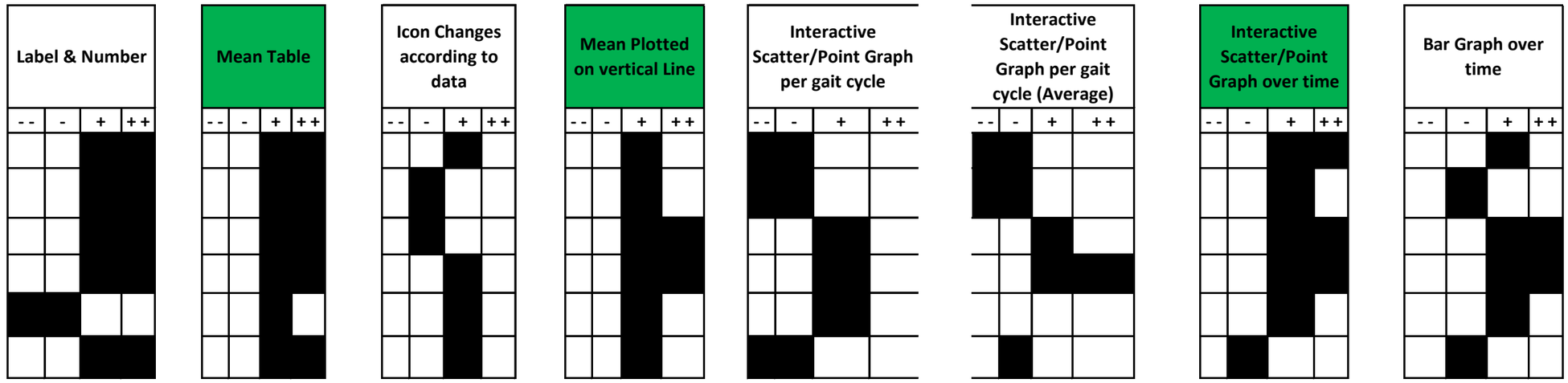
Appendix U. Visualization Harris Profiles

Time (Single/Double Support Time, Walking Speed, Stand/Swing Time)

Visualization: Numbers



Distance (Step/Stride Length, Base of Support)
Visualization: Numbers & Graphs



5.3 Amount of information presented
5.2 Can be understand with minimal pre-existing knowledge on gait analysis

Feasbility

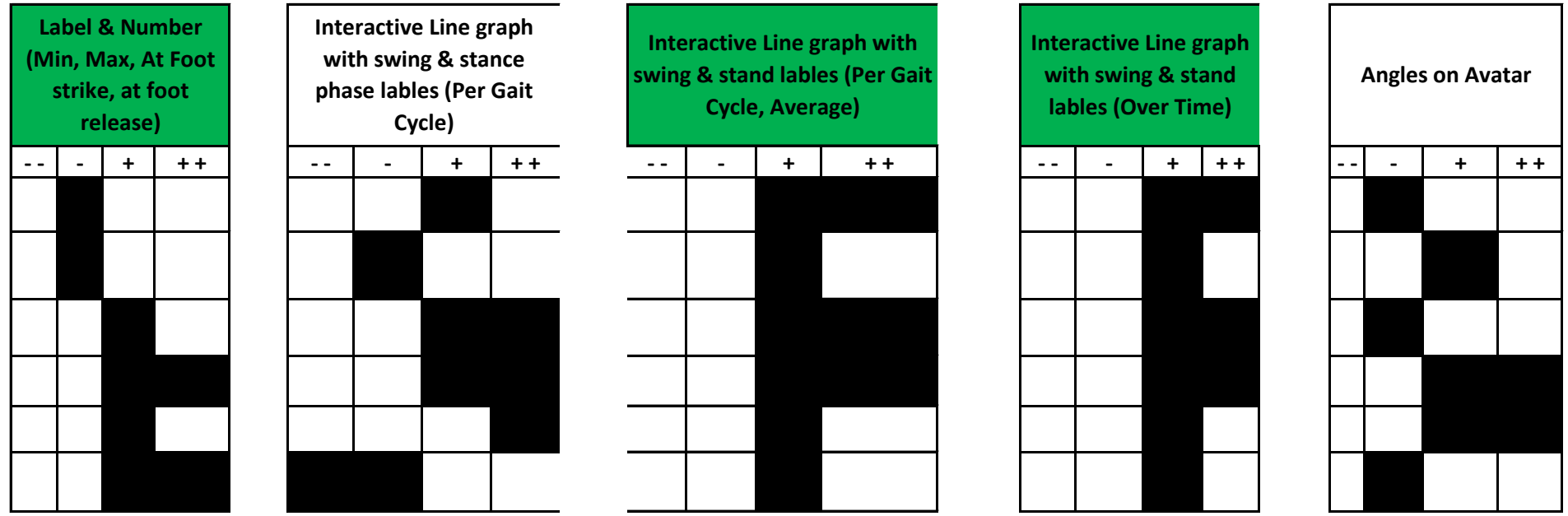
3.1 Objectivity

6.1. Aesthetically appealing

4.1 & 4.2 Interepret data time efficiently

Joint Angles

Numbers, Graphs, & Animations



5.3 Amount of information presented

5.2 Can be understand with minimal pre-existing knowledge on gait analysis

Feasbility

3.1 Objectivity

6.1. Aesthetically appealing

4.1 & 4.2 Interepret data time efficiently

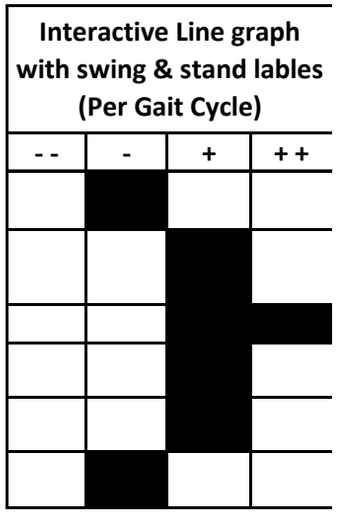
Gait Stability (Position Center of Mass (CoM), XCoM)
Graphs & Animations

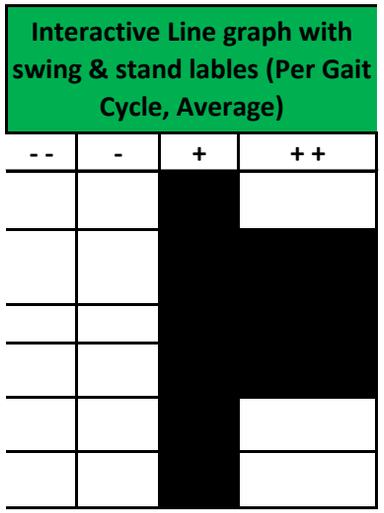
5.3 Amount of information presented
5.2 Can be understand with minimal pre-existing knowledge on gait analysis
Feasbility

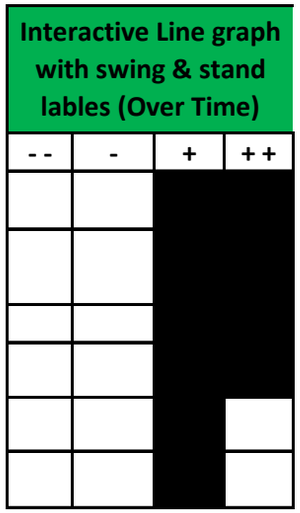
3.1 Objectivity

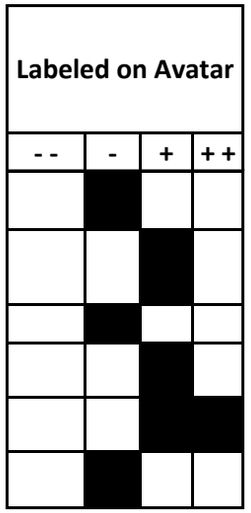
6.1. Aesthetically appealing

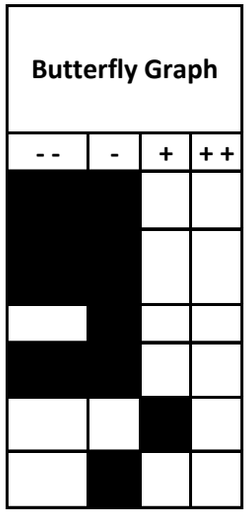
4.1 & 4.2 Interepret data time efficiently



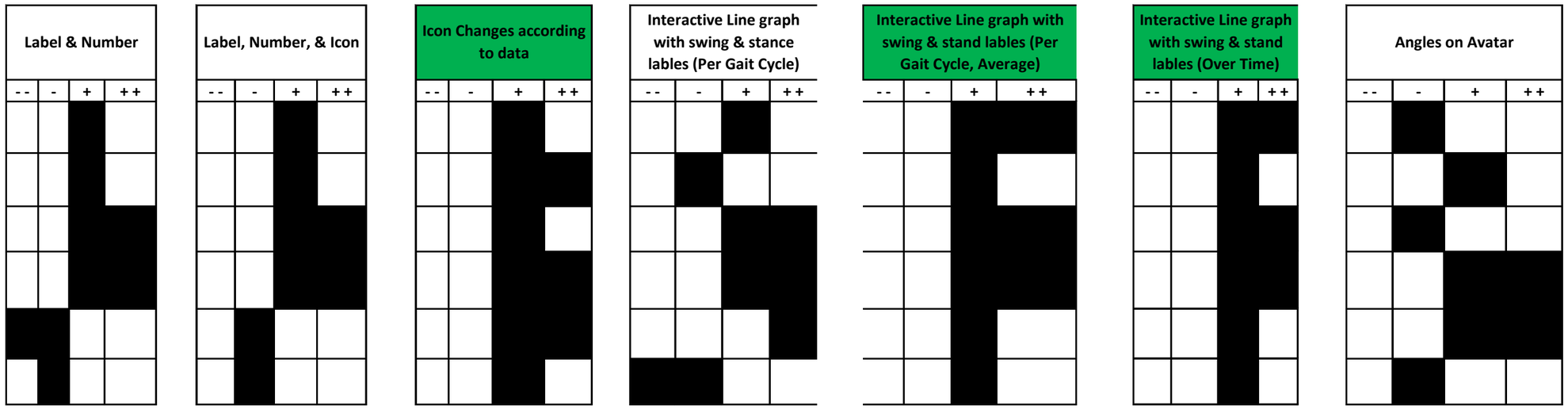








Kinematics / Foot Position (Prepositioning of Foot in Swing , Foot Placement in Stance, Clearance in Swing)
Graphs & Animations



Appendix V. Visualization Concepts

Time

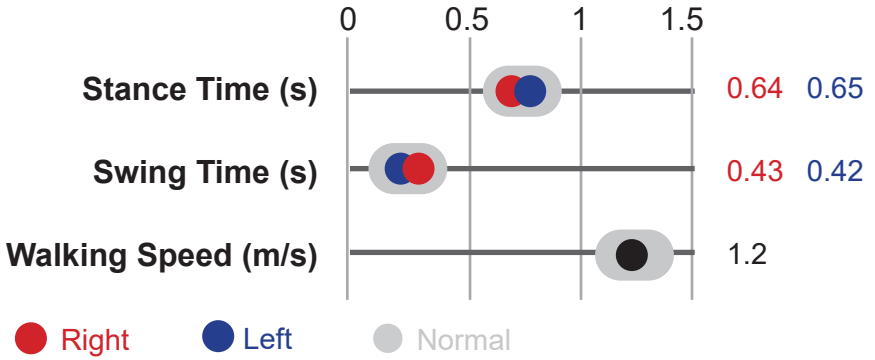
Stance Time, Swing Time, Walking Speed

Visualizations

Option 1 - Mean Table

Parameter	Right	Left	Normal Values
Stance Time (s)	0.64	0.65	0.65
Swing Time (s)	0.43	0.42	0.44
Walking Speed (m/s)	1.2		1.2

Option 2 - Mean Horizontal Plot



Features

Phase Percentage

Parameter	Right	Left	Normal Values
Stance Phase (%)	59.84	61.07	58.98
Swing Time (s)	40.16	38.98	40.03

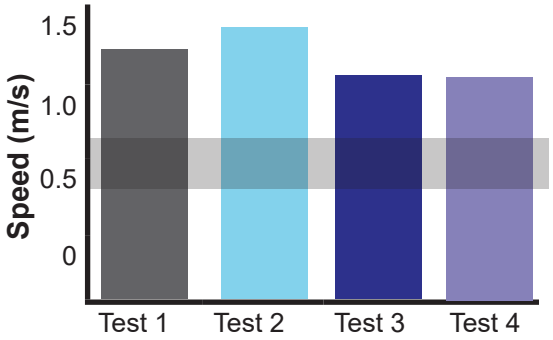
Comparison

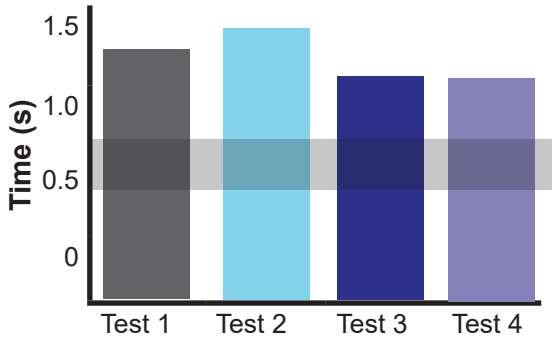
Option 1 - Average Values Table

	Test 1		Test 2		Test 3	
Parameter	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Stance Time (s)	0.64	0.65	0.70	0.71	0.60	0.58
Swing Time (s)	0.43	0.42	0.50	0.49	0.44	0.40
Walking Speed (m/s)	1.2		1.4		1.1	

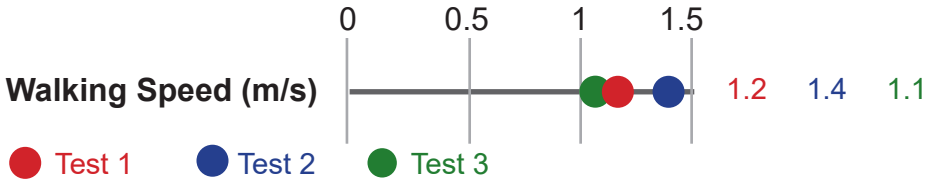
Option 2 - Bar Graph of Averages

Walking Speed





Option 3 - Average Horizontal Plot



Distance

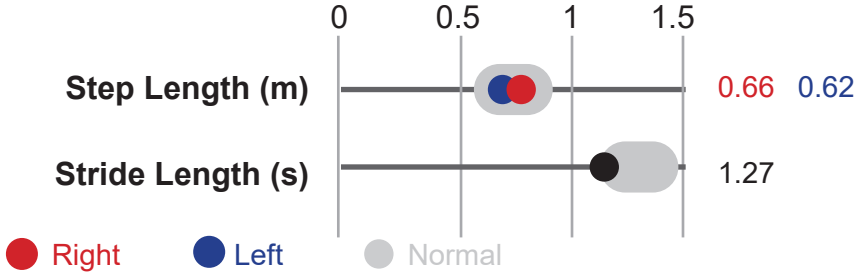
Step Length, Stride Length, & Distance Walked

Visualizations

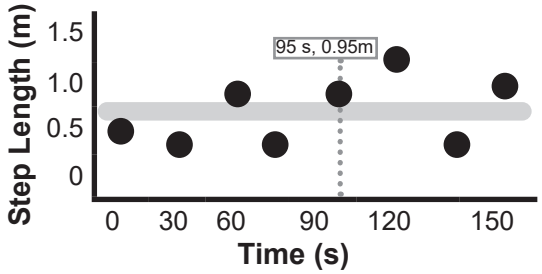
Option 1 - Mean Table

Parameter	Right	Left	Normal Values
Step Length (m)	0.66	0.62	0.62
Stride Length (m)	1.27		1.36
Distance Walked (m)	10		

Option 2 - Mean Horizontal Plot



Option 3 - Scatter Plot over Time

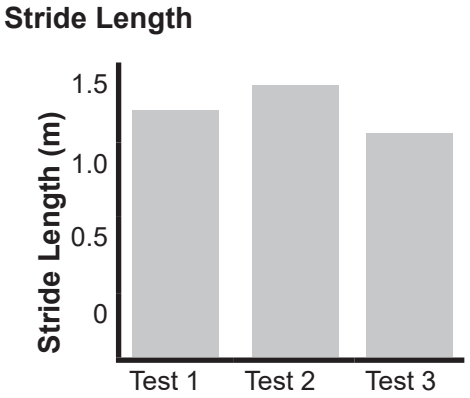


Comparison

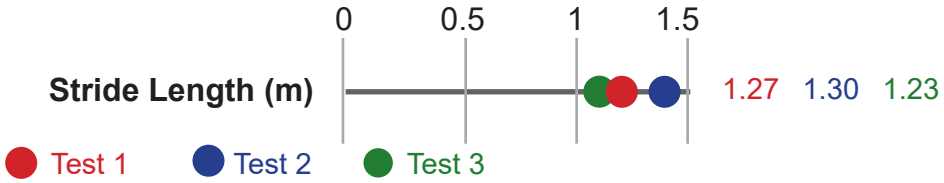
Option 1 - Average Values Table

	Test 1		Test 2		Test 3	
Parameter	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Step Length (m)	0.66	0.62	0.70	0.64	0.64	0.62
Stride Length (m)	1.27		1.30		1.23	

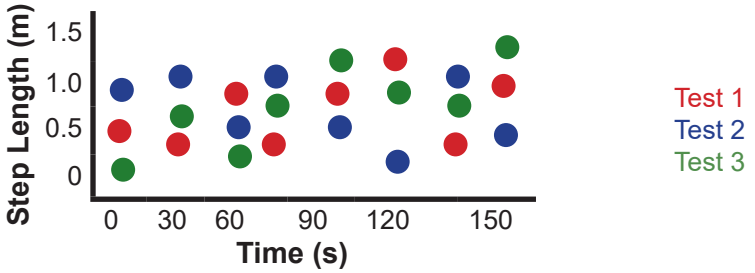
Option 2 - Bar Graph of Averages



Option 3 - Average Horizontal Plot



Option 4 - Scatter Plot



Joint Angles

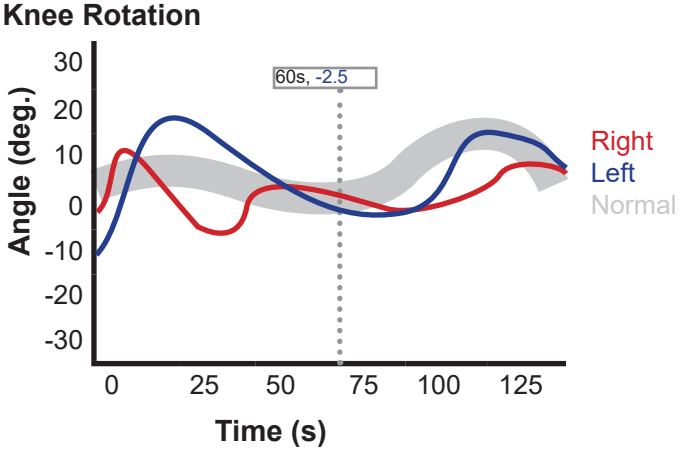
Hip, Knee, Ankle, & Trunk

Visualizations

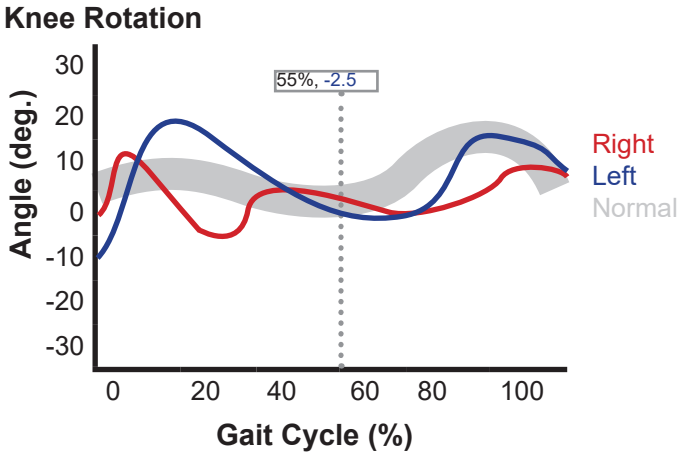
Option 1 - Table

Knee Angle (deg)	Overall		Stance Phase		Swing Phase		At foot strike	At foot release
	Min.	Max.	Min.	Max.	Min.	Max.		
Right	-3.26	33.67	-0.15	15.60	-3.60	33.67	2.32	16.00
Left	-1.26	46.98	-1.26	31.81	0.63	46.98	8.90	25.30
Normal	-2.00	35.00	-1.00	25.00	-3.00	45.00	5.00	26.00

Option 2 - Graph, Average over Time

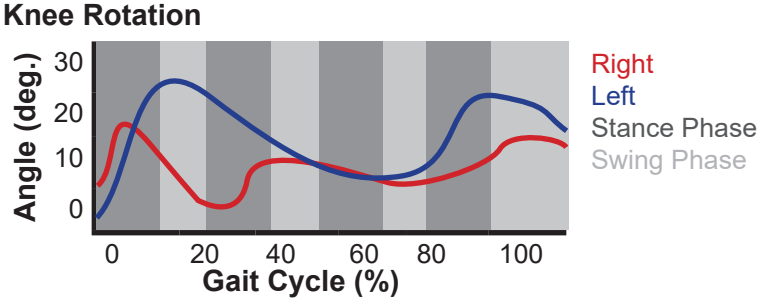


Option 3 - Graph, Average per Gait Cycle

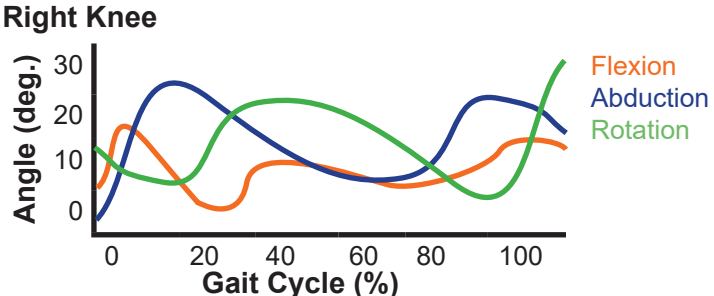


Features

Swing & Stance Phase Labels

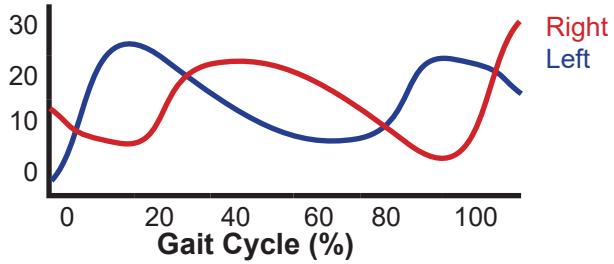


Flexion, Abduction, & Rotation on Same Graph

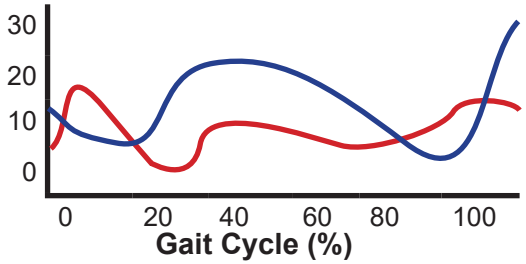


Flexion, Abduction, & Rotation on Seperate Graphs

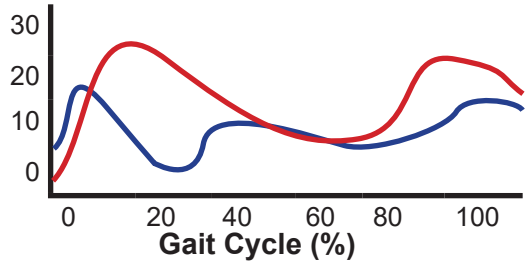
Knee Rotation

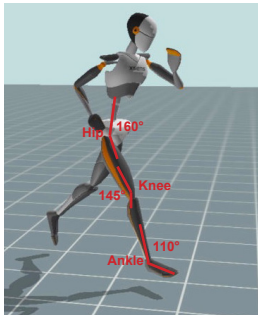


Knee Flexion



Knee Abduction





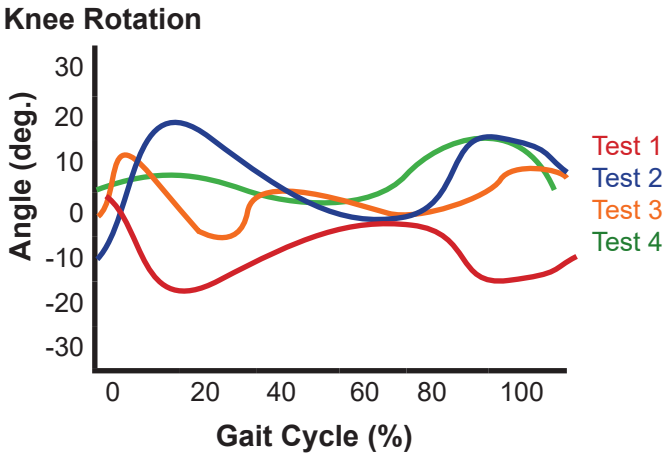
Comparison

Option 1 - Video Side by Side

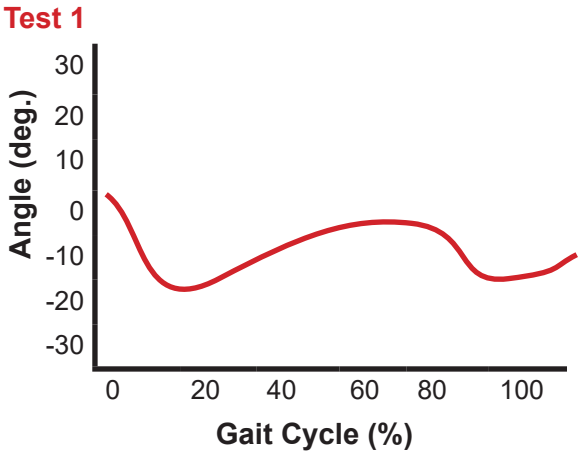
Test 1

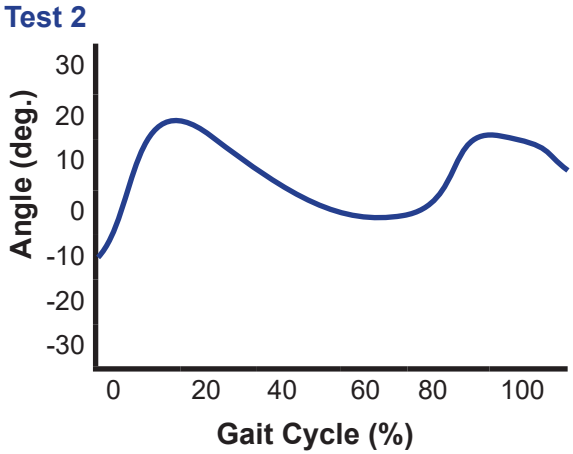
Test 2

Option 2 - Graph, Plotted Together



Option 3 - Graphs, Plotted Side by Side

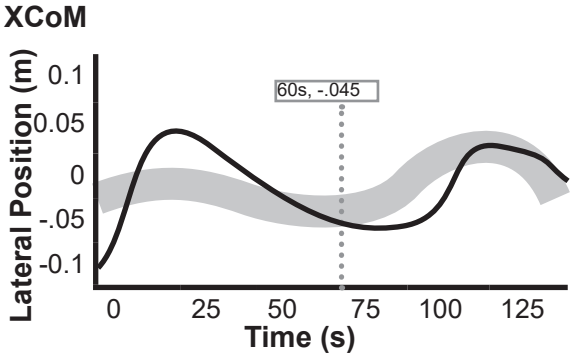




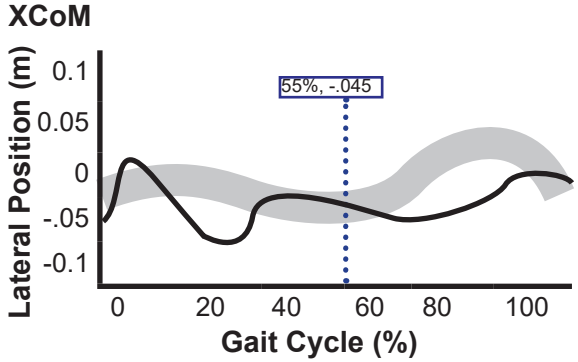
Gait Stability

Visualizations - Position Center of Mass (CoM) & X (CoM)

Option 1 - Graph, Average over Time

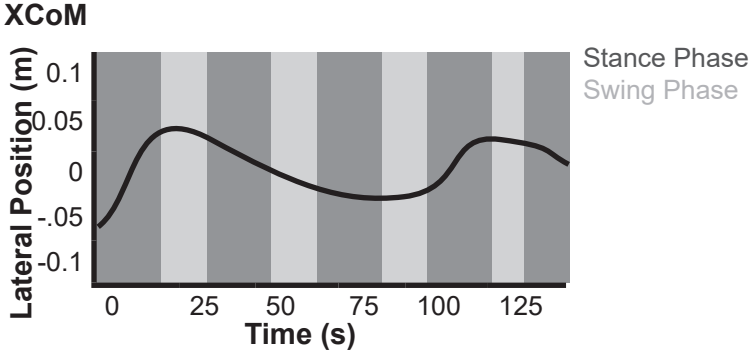


Option 2 - Graph, Average per Gait Cycle

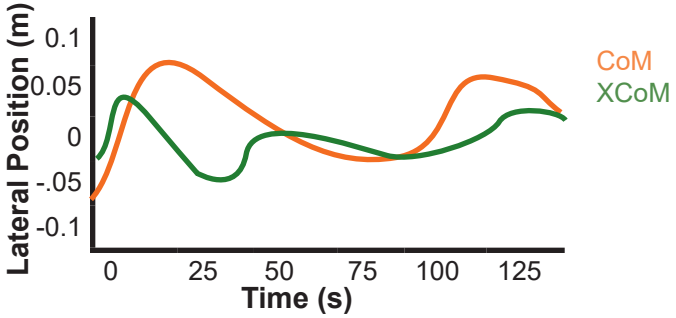


Features - Position Center of Mass (CoM) & X (CoM)

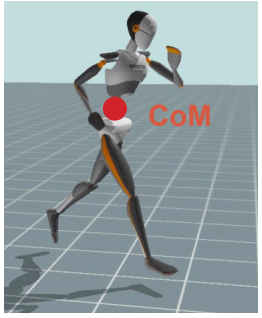
Swing & Stance Phase Labels



Same Plot



Position on Avatar

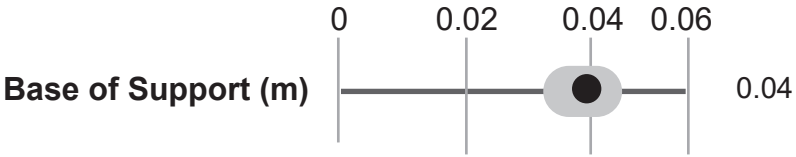


Visualizations - Base of Support

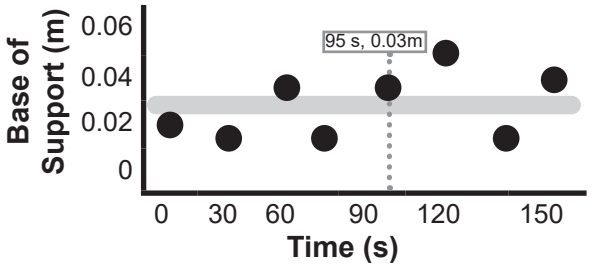
Option 1 - Mean Table

Parameter		Normal Values
Base of Support (m)	0.04	0.08

Option 2 - Mean Horizontal Plot



Option 3 - Scatter Plot over Time



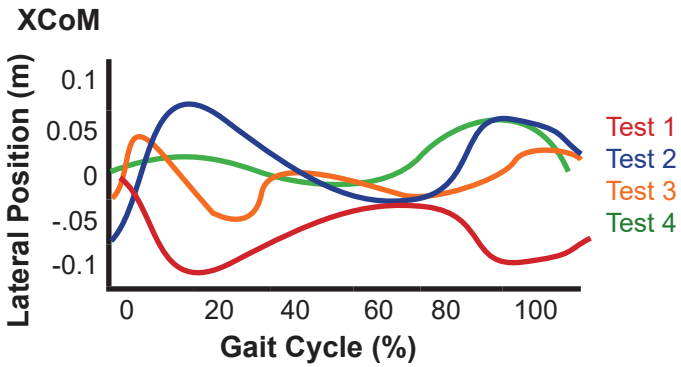
Comparison

Option 1 - Video Side by Side

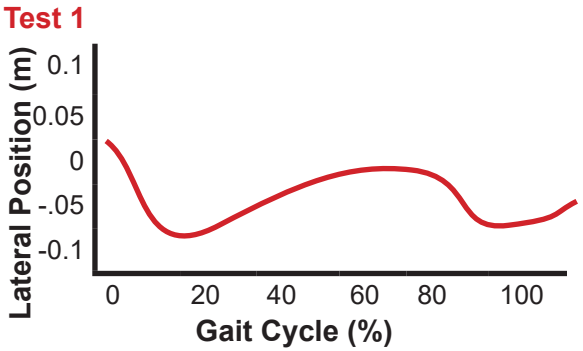
Test 1

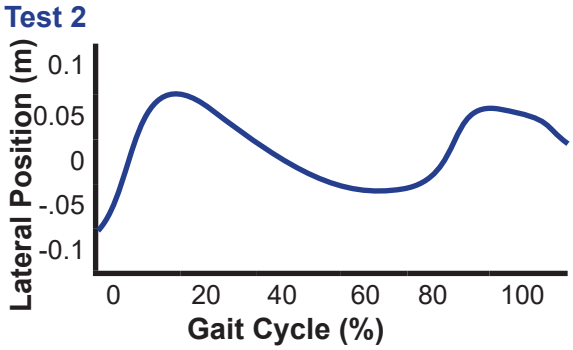
Test 2

Option 2 - Graph, Plotted Together



Option 3 - Graphs, Plotted Side by Side





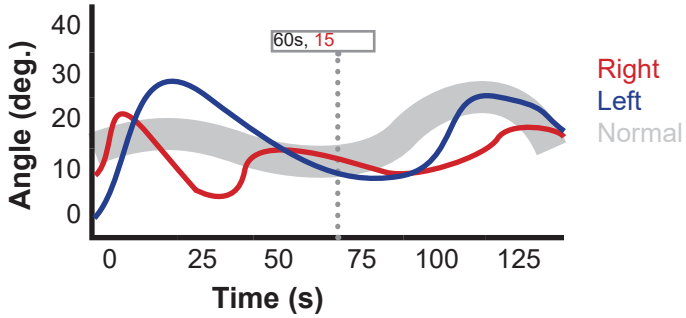
Foot Position

Prepositioning of Foot in Swing, Foot Placement in Stance, & Clearance in Swing

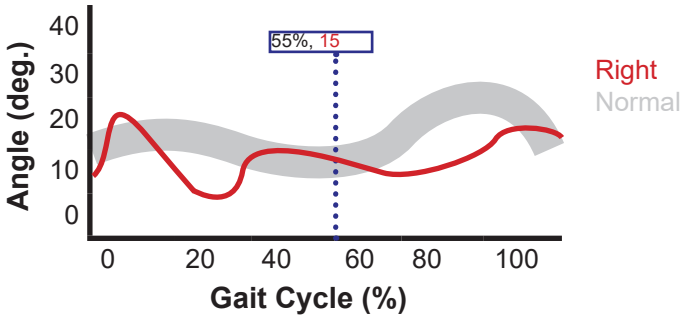
Visualizations

Option 2 - Graph, Average over Time

Prepositioning of Foot in Swing

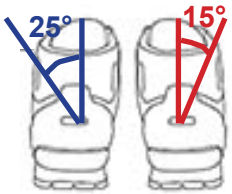


Option 2 - Graph, Average per Gait Cycle



Option 3 - Average & Icon

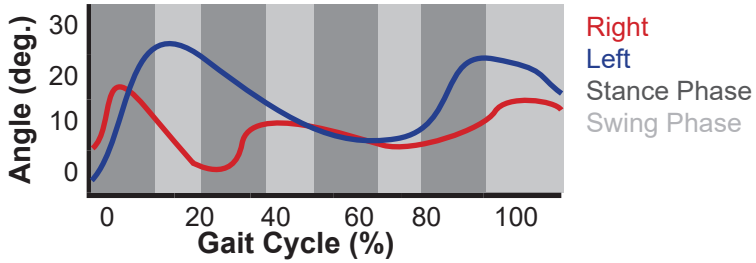
Prepositioning of Foot in Swing



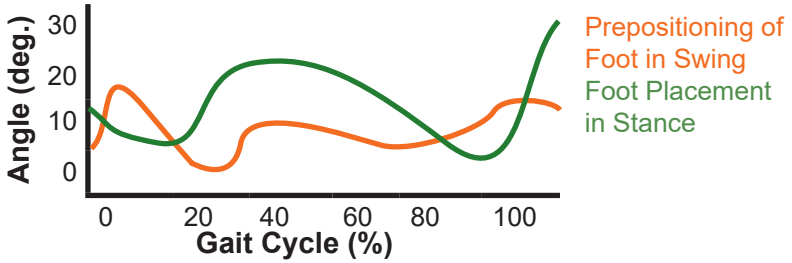
Prepositioning of Foot in Swing

Features

Swing & Stance Phase Labels



Prepositioning & Foot Placement on Same Plot



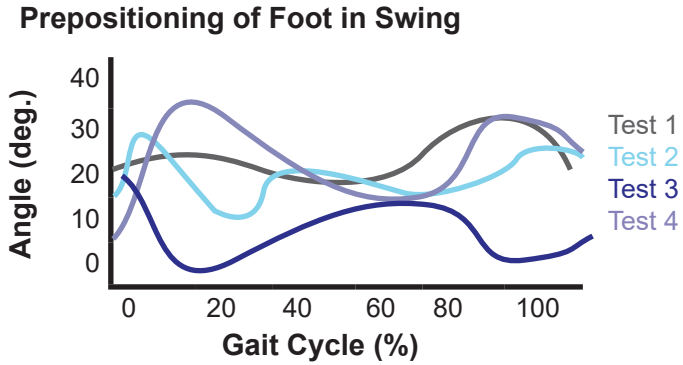
Comparison

Option 1 - Video Side by Side

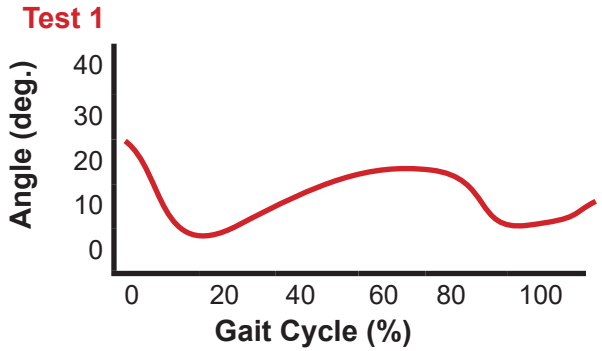
Test 1

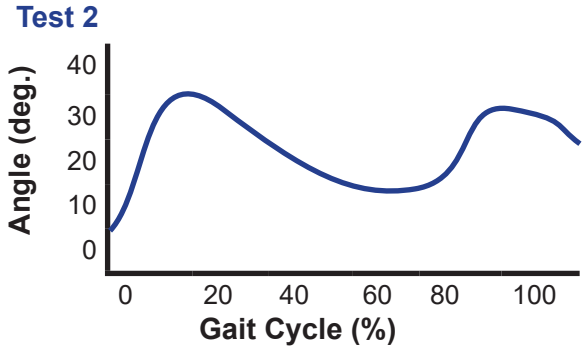
Test 2

Option 2 - Graph, Plotted Together



Option 3 - Graphs, Plotted Side by Side

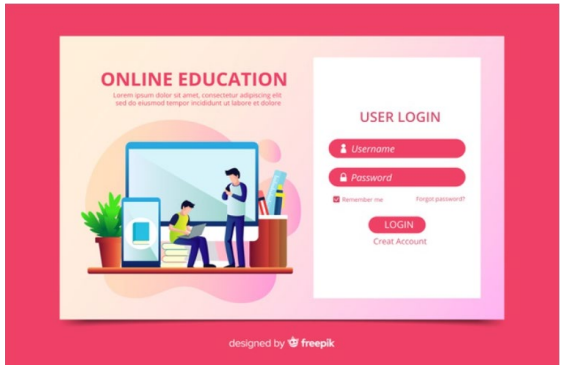


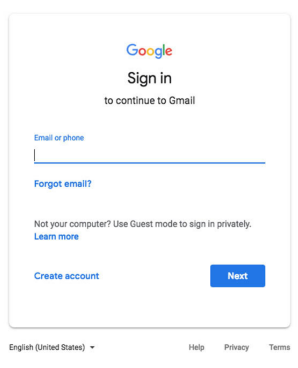


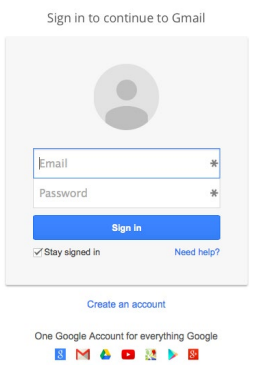
Appendix W. Interface Layout Collages

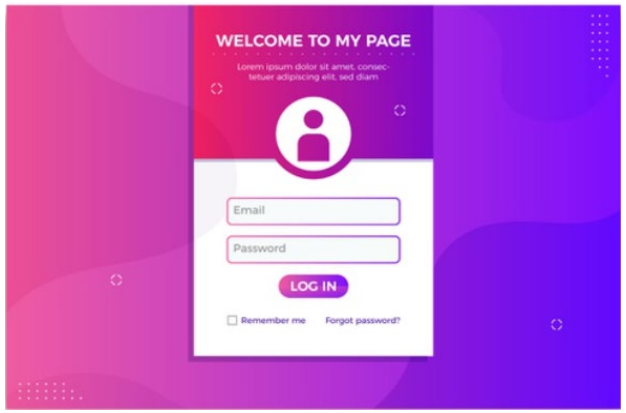
Open Interface

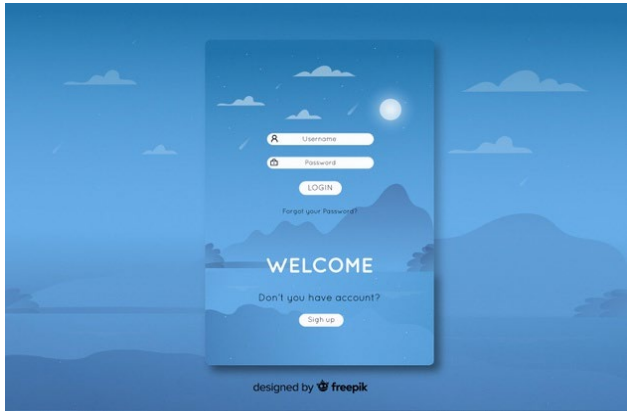
Start Page - Login

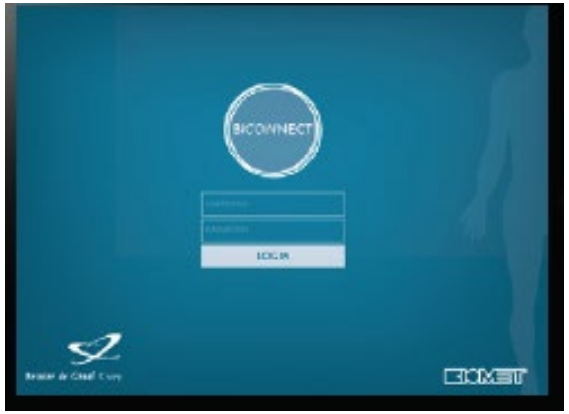




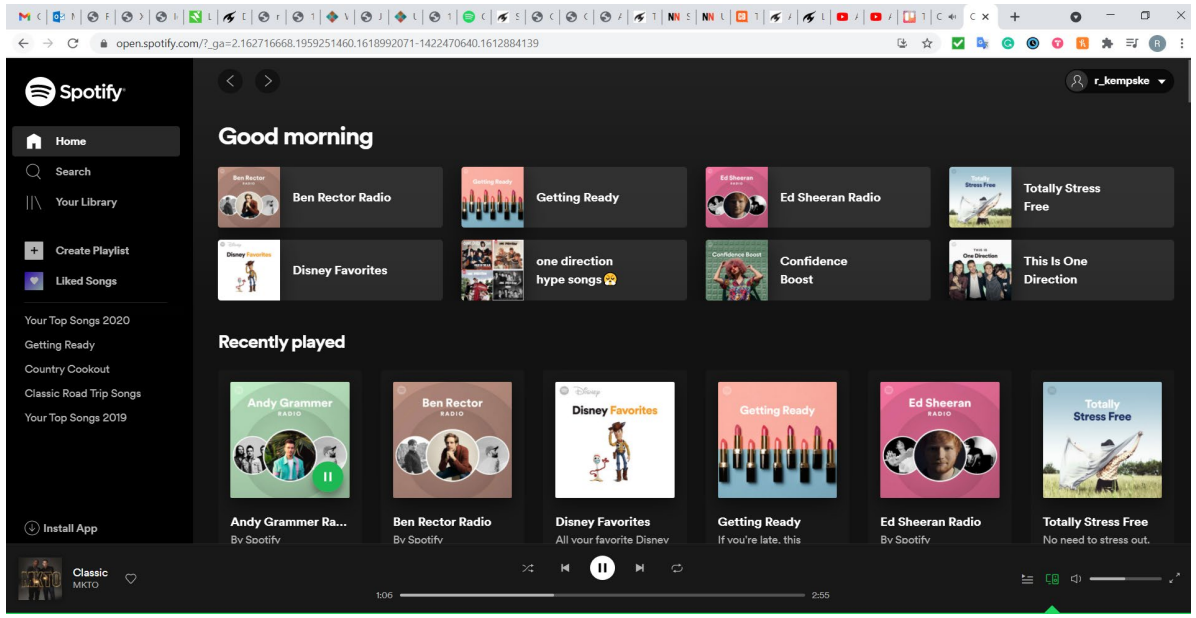


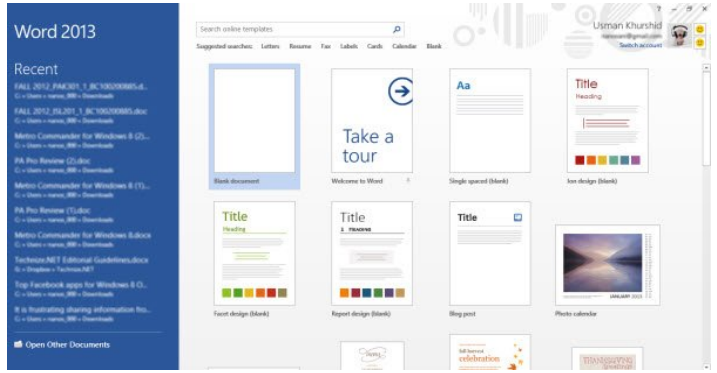


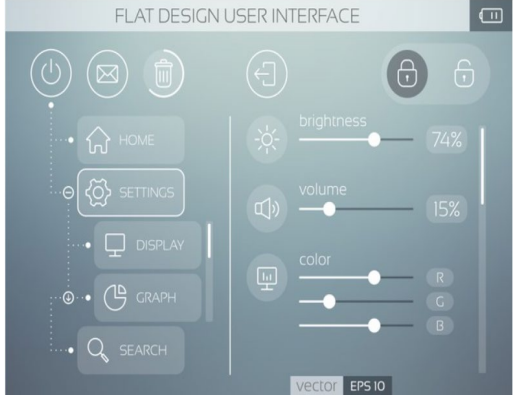


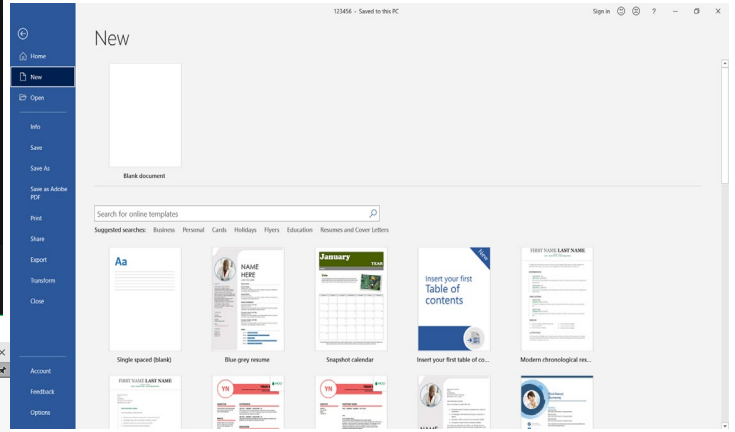


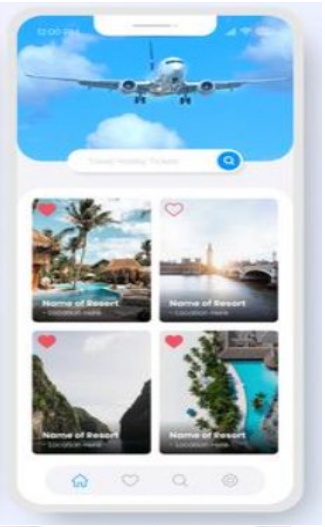
Start Page – Select What To Do

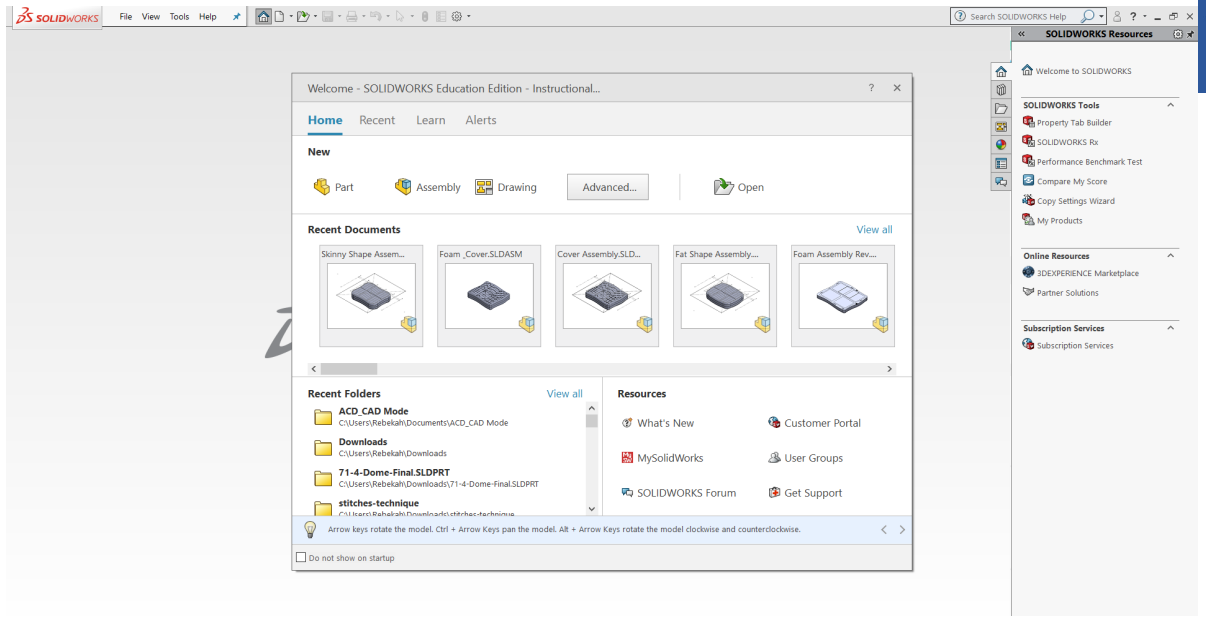




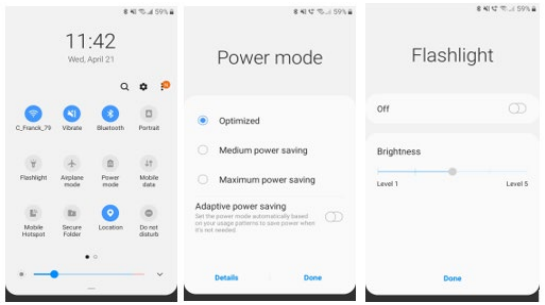


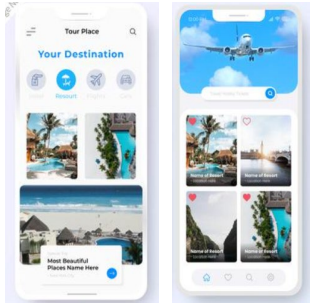


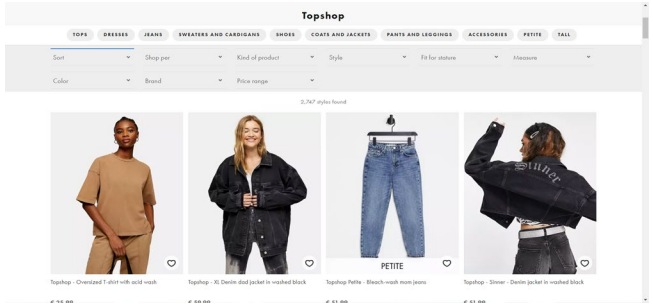


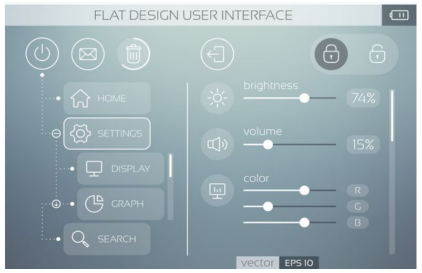


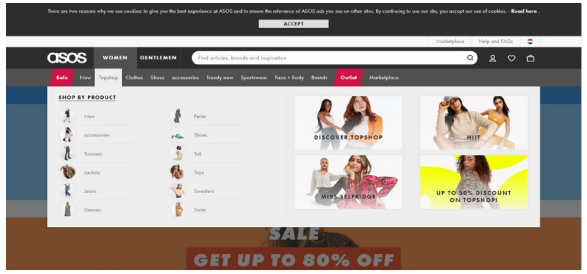
Data Visualization & Selection

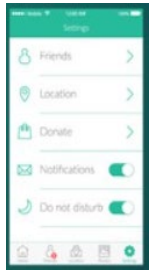


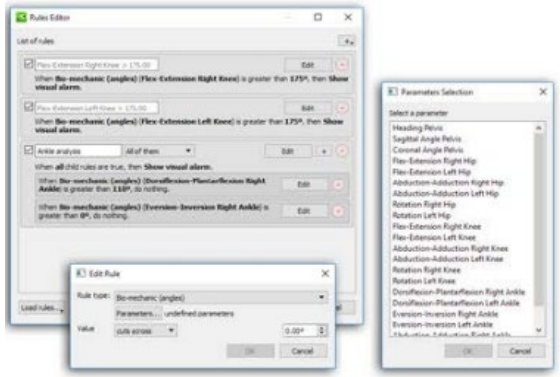




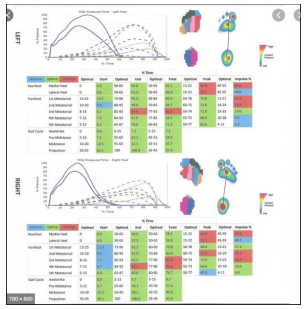


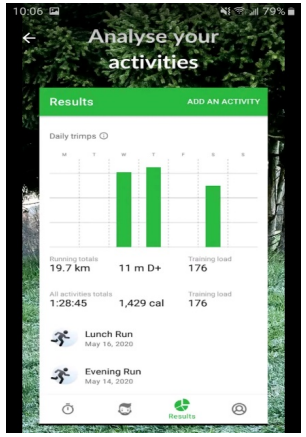


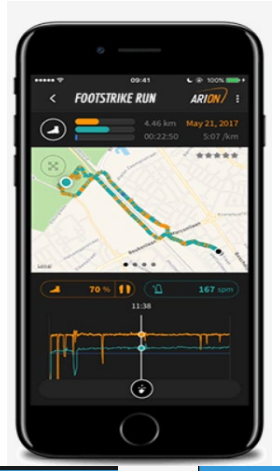


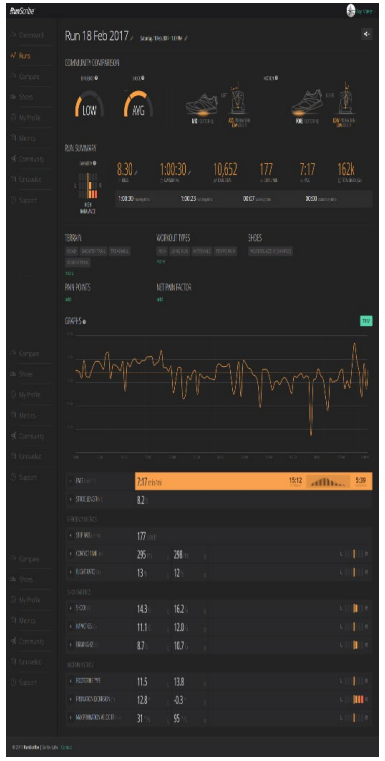


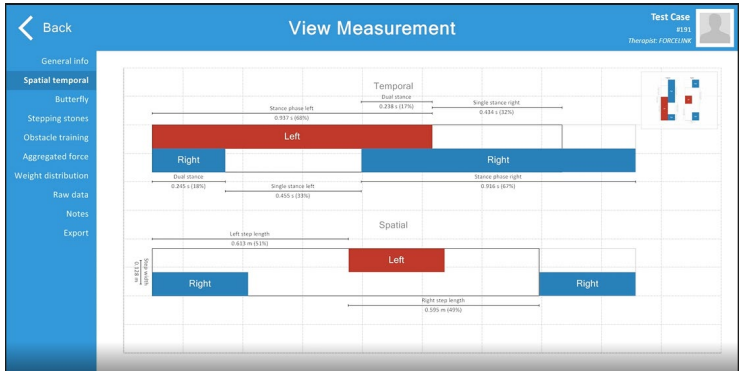
View Data in Real Time & at End of Trial

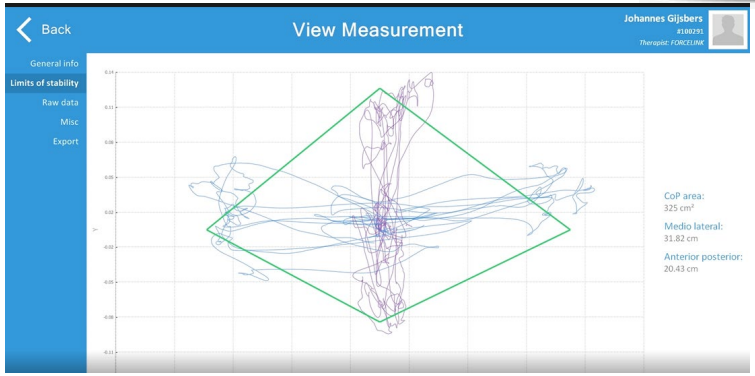


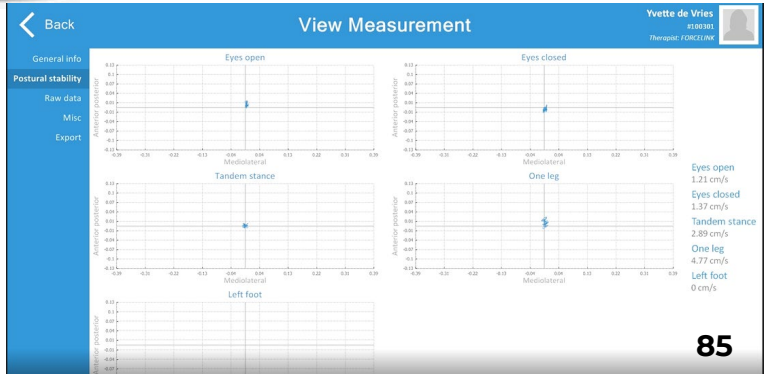


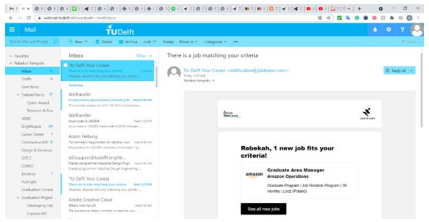


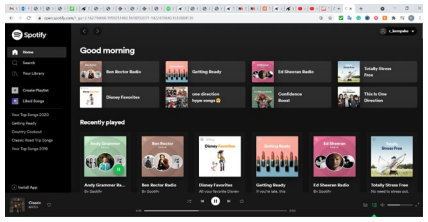


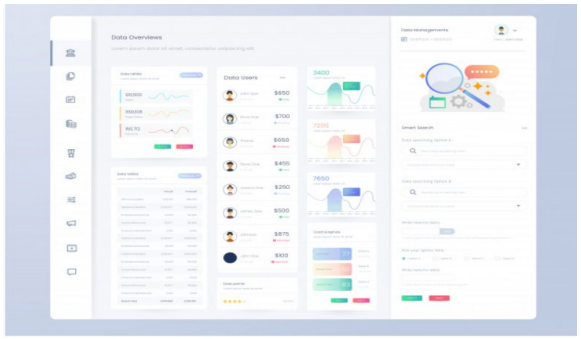


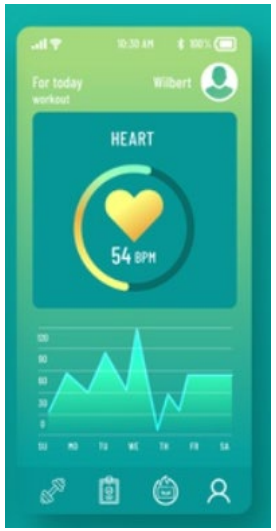





Rebekah, 1 new job fits your criteria!

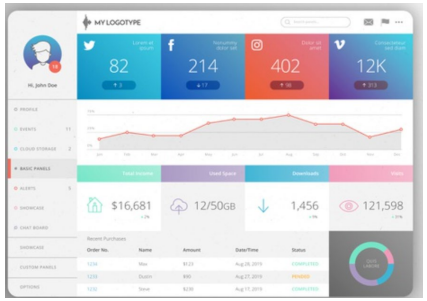

Good morning
Recently played



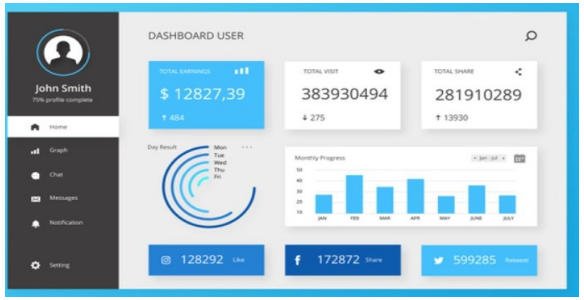

For today workout
Wilbert
HEART
54 BPM


JUNE
989.9 mts
Months for road
2.411
245

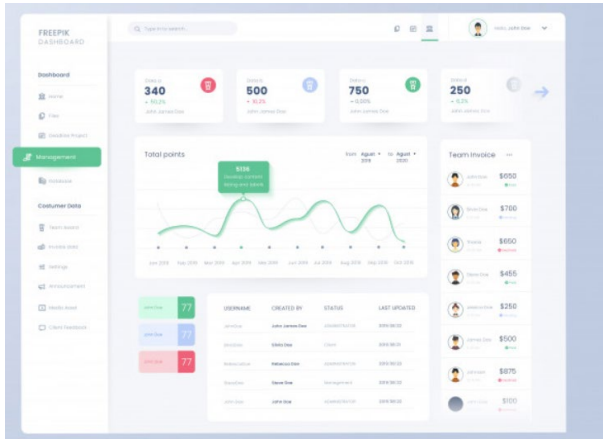

Name Surname

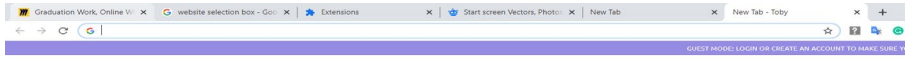

MY LOGOTYPE
82
214
402
12K
$16,681
12/50GB
1,456
121,598


2.100
758
7.25
35K
$45,000
$1,000
$545
35%

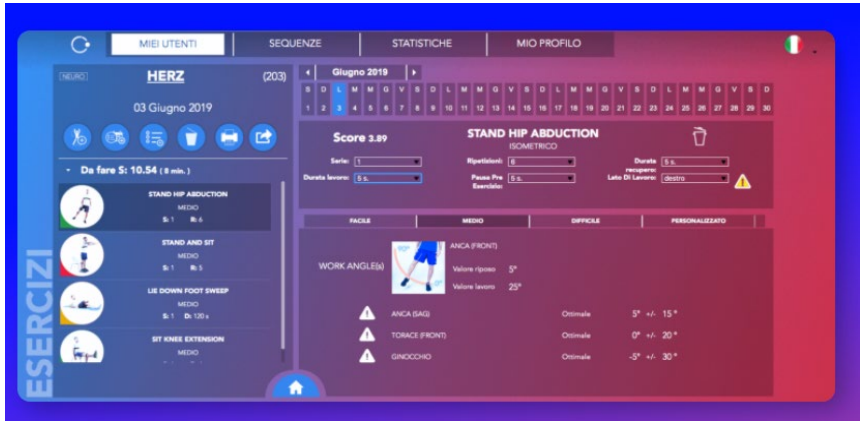

DASHBOARD USER
John Smith
$ 12827,39
383930494
281910289
128292
172872
599285

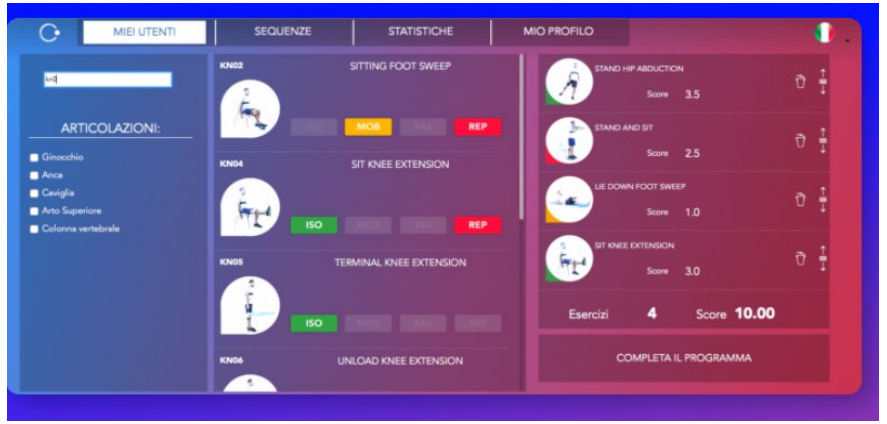

COMMUNITY COMPARISON
EFFICIENCY
HIGH
SHOCK
AVG
MOTION
LEFT
MID FOOTSTRIKE
AVG PRONATION
LOW VELOCITY
RIGHT
MID FOOTSTRIKE
LOW PRONATION
LOW VELOCITY


FREEPIK DASHBOARD
340
500
750
250
Total points
Team Invoice




NORAXON


MIEI UTENTI
SEQUENZE
STATISTICHE
MIO PROFILO
HERZ
(203)
03 Giugno 2019
Giugno 2019
Score 3.89
STAND HIP ABDUCTION
(ISOMETRICO)
Da fare S: 10.54 (8 min.)
STAND HIP ABDUCTION
STAND AND SIT
LIE DOWN FOOT SWEEP
SIT KNEE EXTENSION
ESERCIZI
FACILE
MEDIO
DIFFICILE
PERSONALIZZATO
WORK ANGLE(s)
ANCA (FRONT)
ANCA (SAG)
TORACE (FRONT)
GINOCCHIO

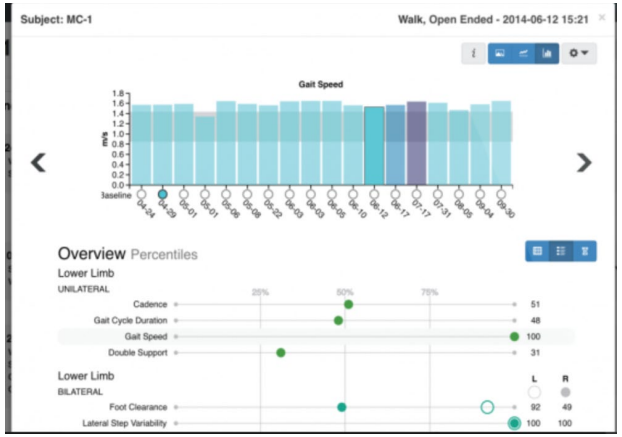

MIEI UTENTI
SEQUENZE
STATISTICHE
MIO PROFILO
ARTICOLAZIONI:
Ginocchio
Anca
Caviglia
Arto Superiore
Colonna vertebrale
KN02
SITTING FOOT SWEEP
MOB
REP
KN04
SIT KNEE EXTENSION
ISO
REP
KN05
TERMINAL KNEE EXTENSION
ISO
KN06
UNLOAD KNEE EXTENSION
STAND HIP ABDUCTION
Score 3.5
STAND AND SIT
Score 2.5
LIE DOWN FOOT SWEEP
Score 1.0
SIT KNEE EXTENSION
Score 3.0
Esercizi 4
Score 10.00
COMPLETA IL PROGRAMMA

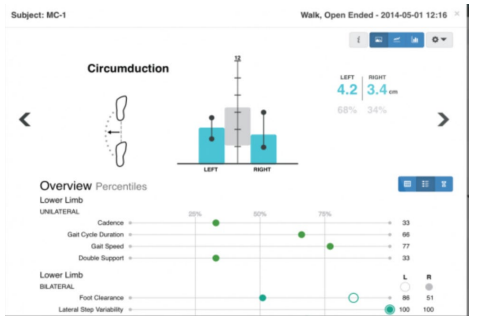

Lower train

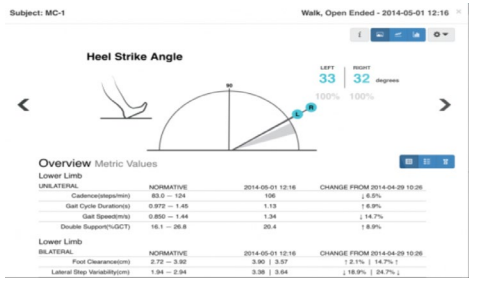

Tren inferior
stt

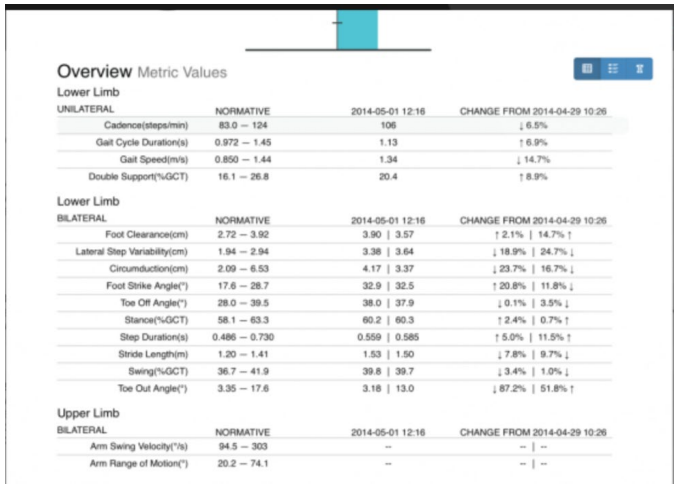

NORAXON

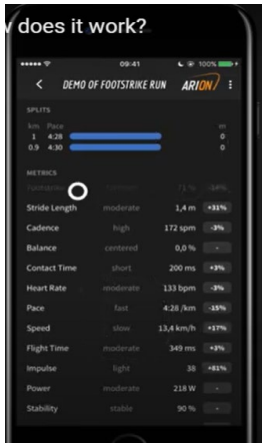
Comparison Between Tests

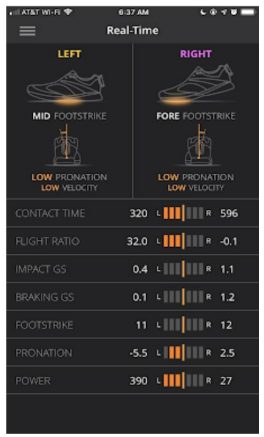


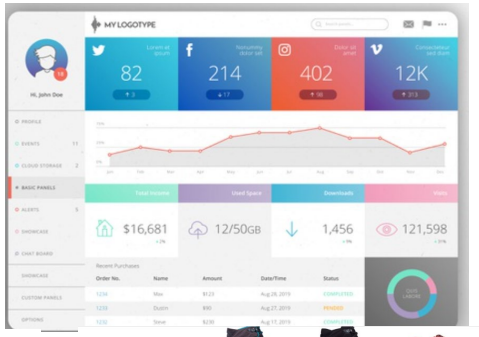


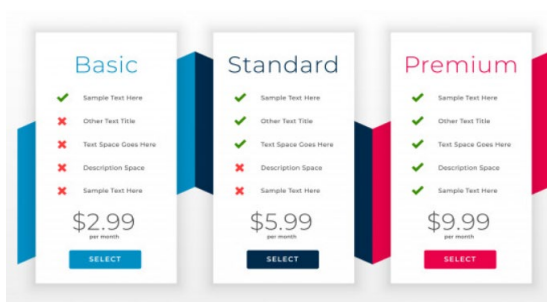


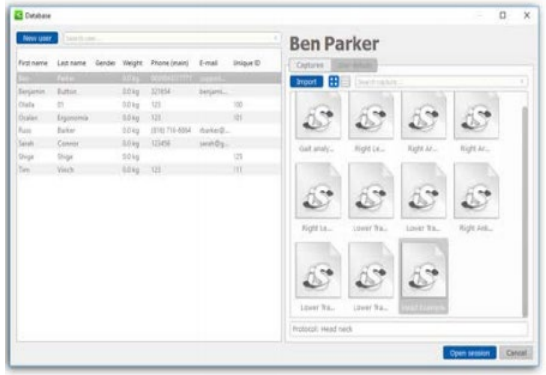


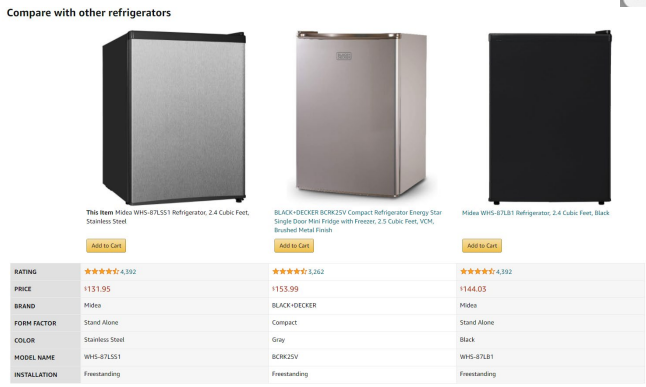


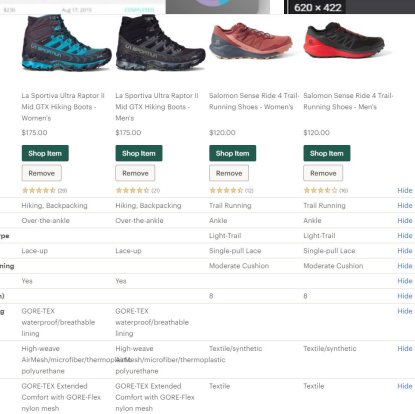


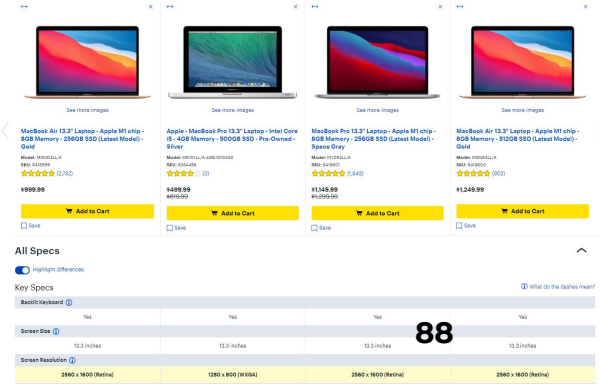


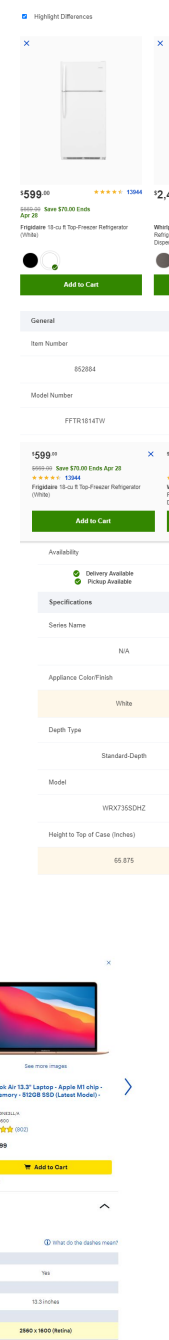




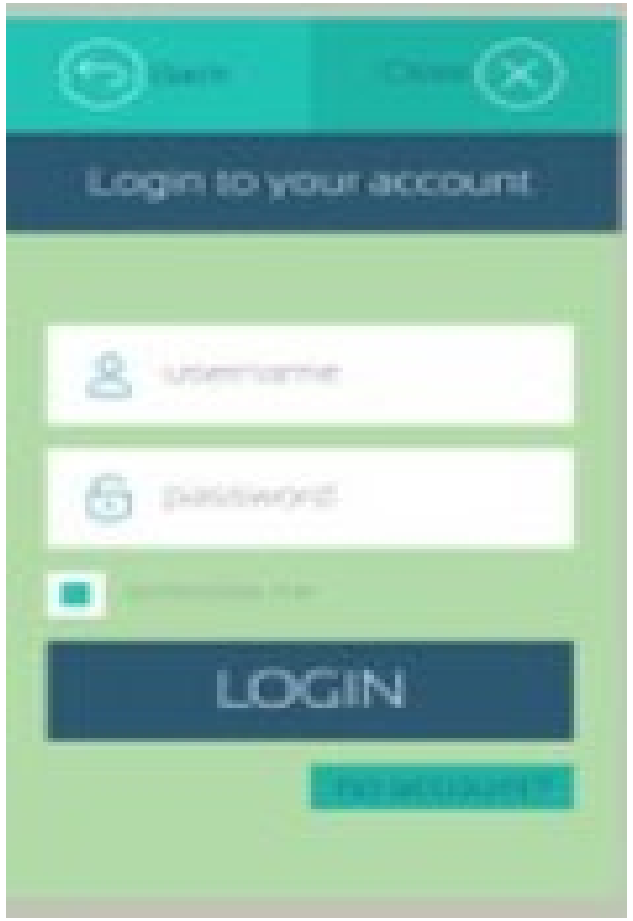








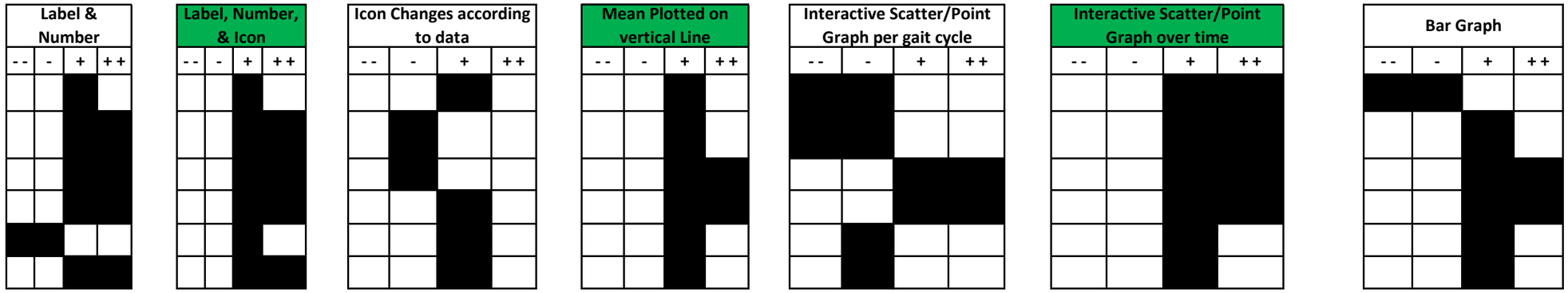
Done Viewing Data



Appendix X. Interface Layout Harris Profiles

Time (Single/Double Support Time, Walking Speed, Stand/Swing Time)

Visualization: Numbers



Distance (Step/Stride Length, Base of Support)
Visualization: Numbers & Graphs

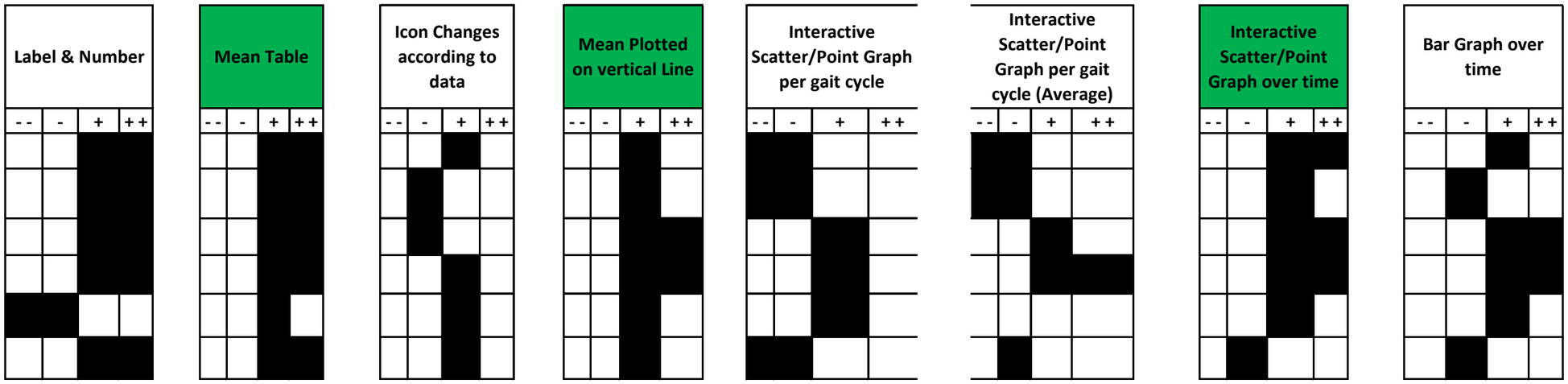
5.3 Amount of information presented
5.2 Can be understand with minimal pre-existing knowledge on gait analysis

Feasbility

3.1 Objectivity

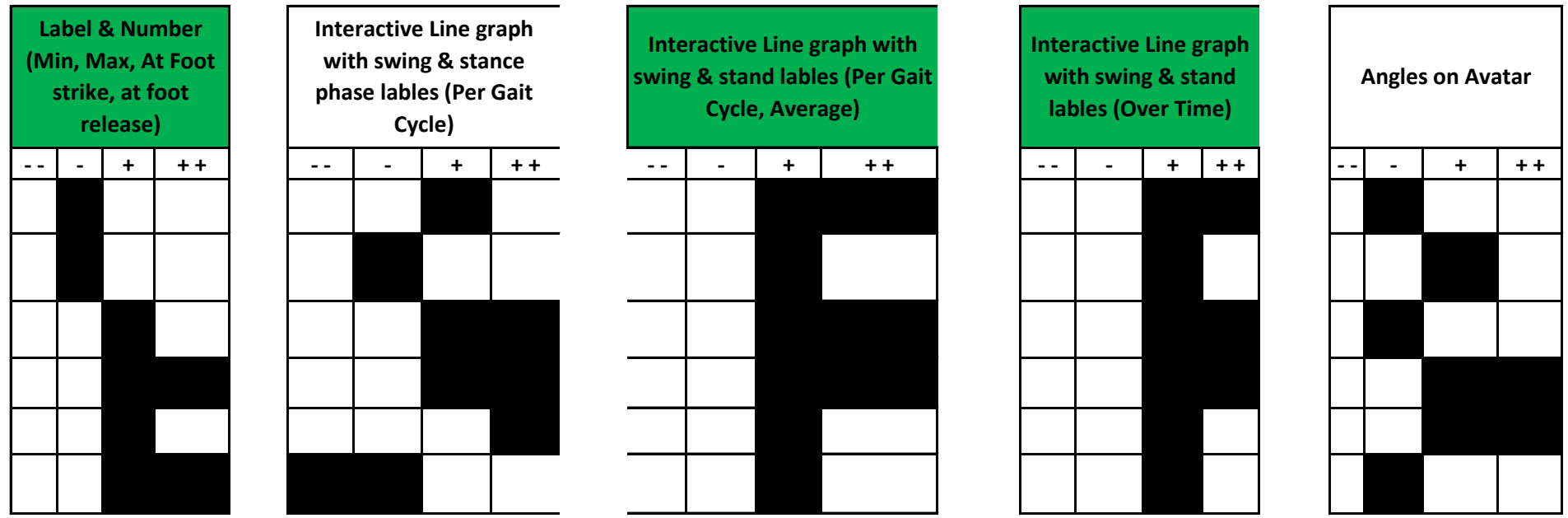
6.1. Aesthetically appealing

4.1 & 4.2 Interepret data time efficiently



Joint Angles

Numbers, Graphs, & Animations



5.3 Amount of information presented

5.2 Can be understand with minimal pre-existing knowledge on gait analysis

Feasbility

3.1 Objectivity

6.1. Aesthetically appealing

4.1 & 4.2 Interepret data time efficiently

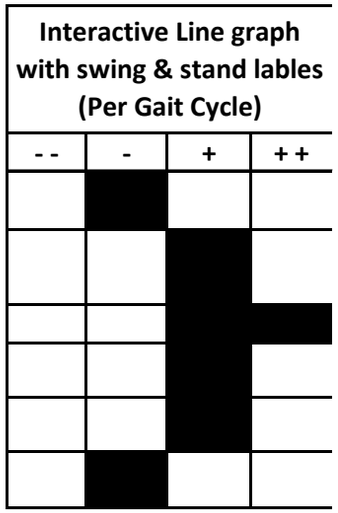
Gait Stability (Position Center of Mass (CoM), XCoM)
Graphs & Animations

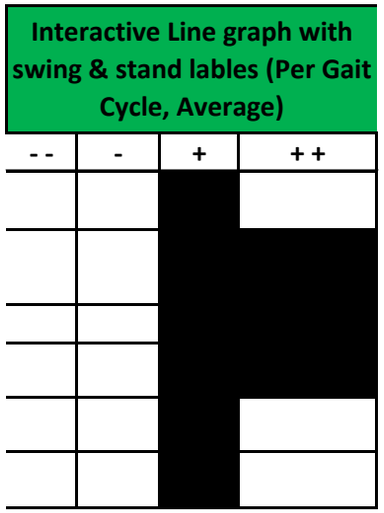
5.3 Amount of information presented
5.2 Can be understand with minimal pre-existing knowledge on gait analysis
Feasbility

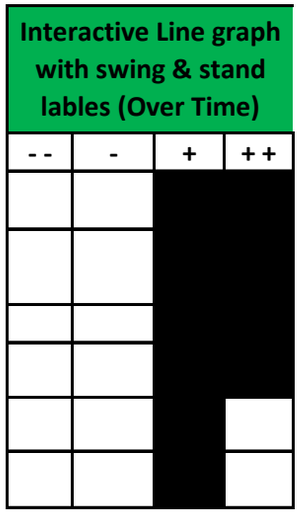
3.1 Objectivity

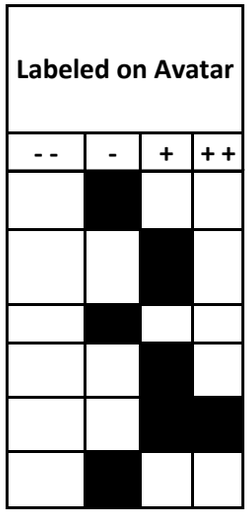
6.1. Aesthetically appealing

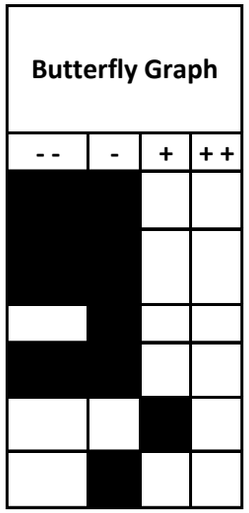
4.1 & 4.2 Interepret data time efficiently



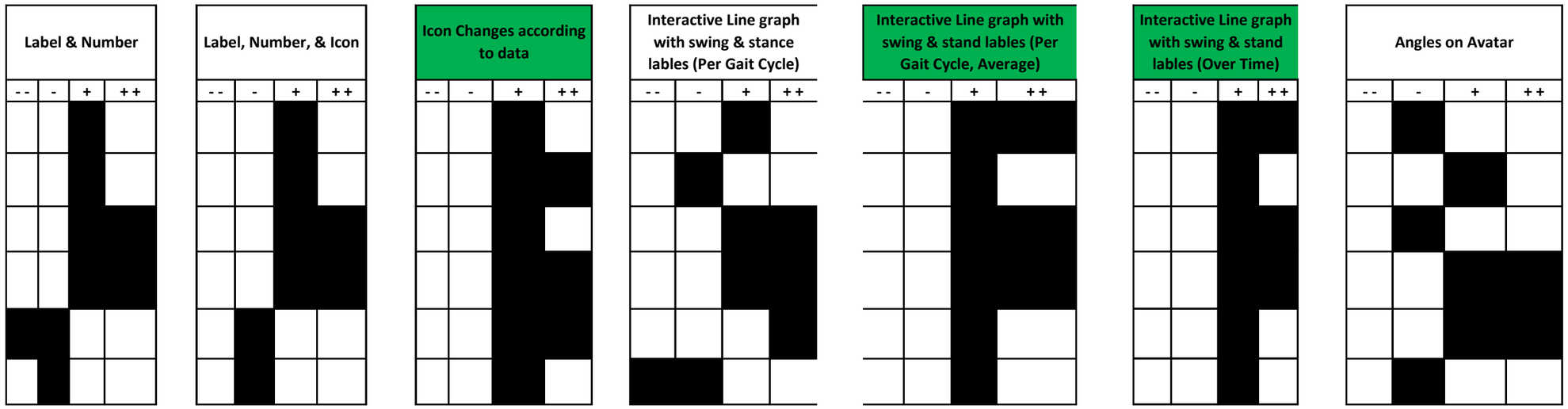








Kinematics / Foot Position (Prepositioning of Foot in Swing , Foot Placement in Stance, Clearance in Swing)
Graphs & Animations



5.3 Amount of information presented

5.2 Can be understand with minimal pre-existing knowledge on gait analysis

Feasbility

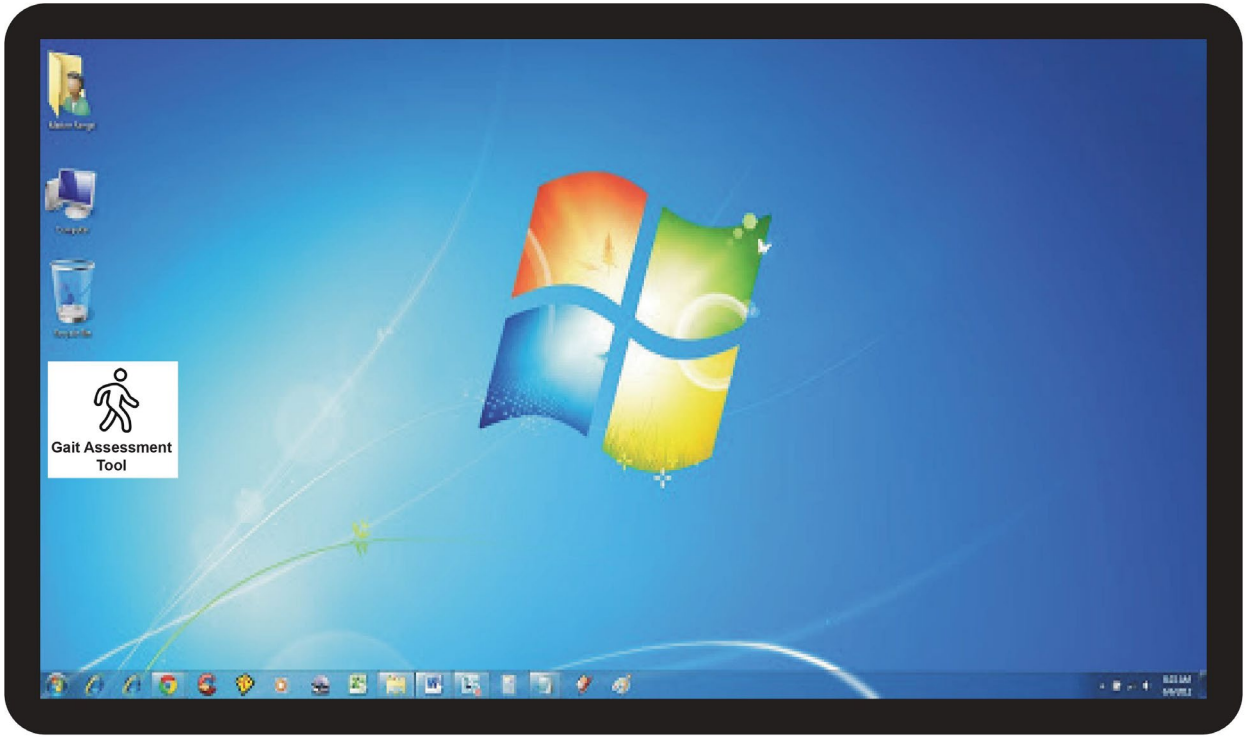
3.1 Objectivity

6.1. Aesthetically appealing

4.1 & 4.2 Interepret data time efficiently

Appendix Y. Interface Layout Concepts

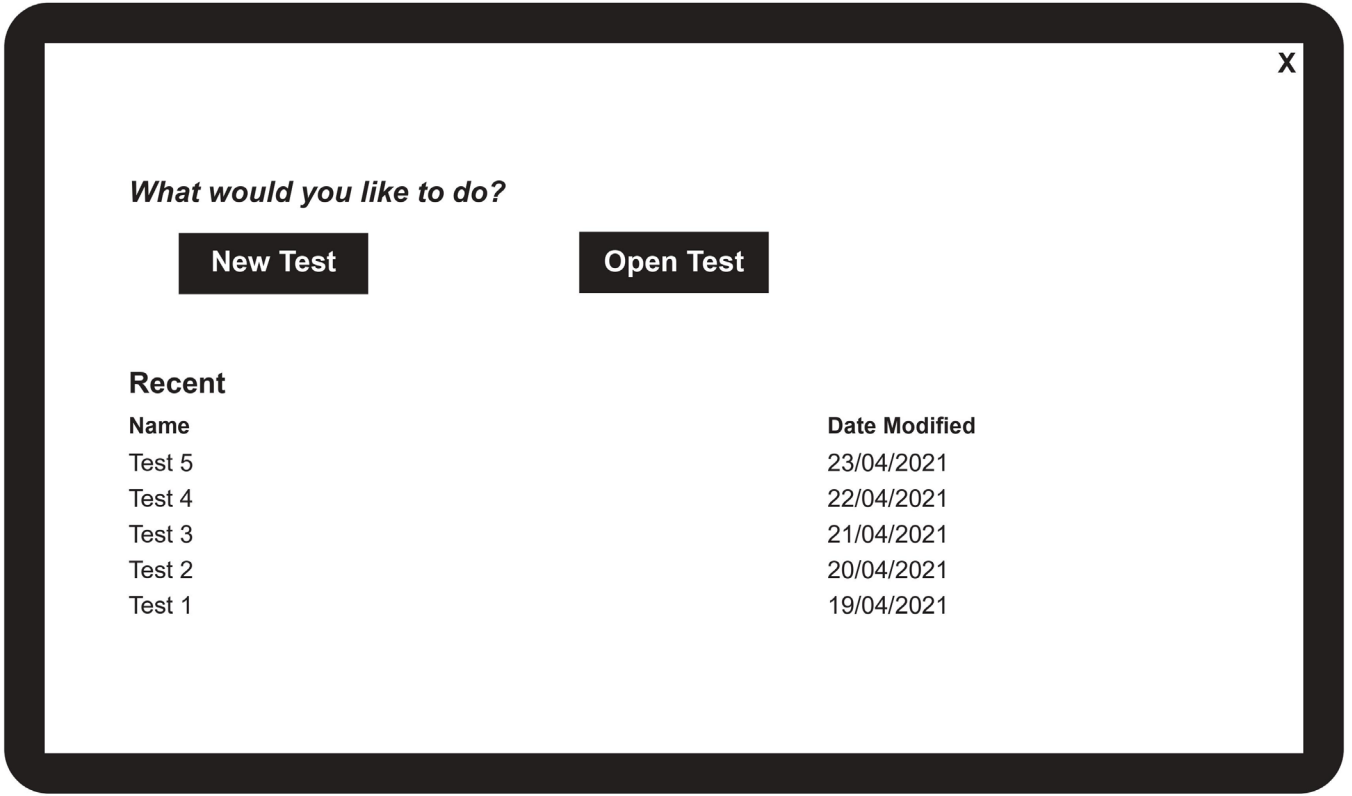
Step 1. Click On Interface Icon



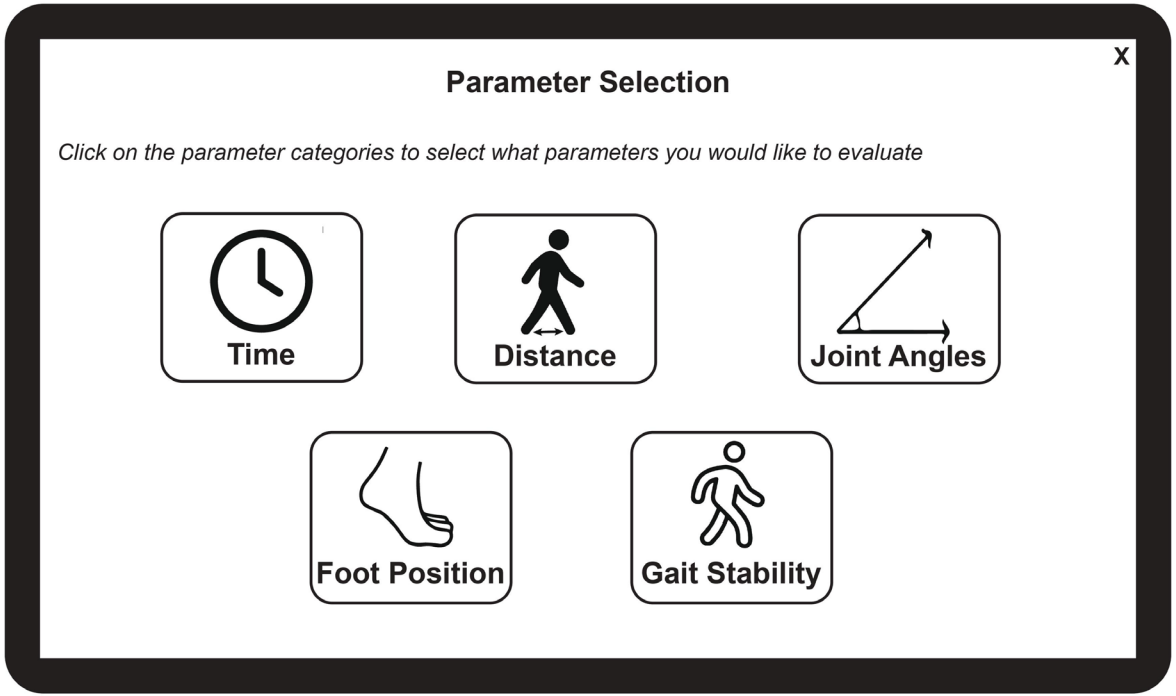
Step 2. Login


Gait Assessment Tool
LOGIN
Username
Password
Login
Remember Me

Step 3. Open Test

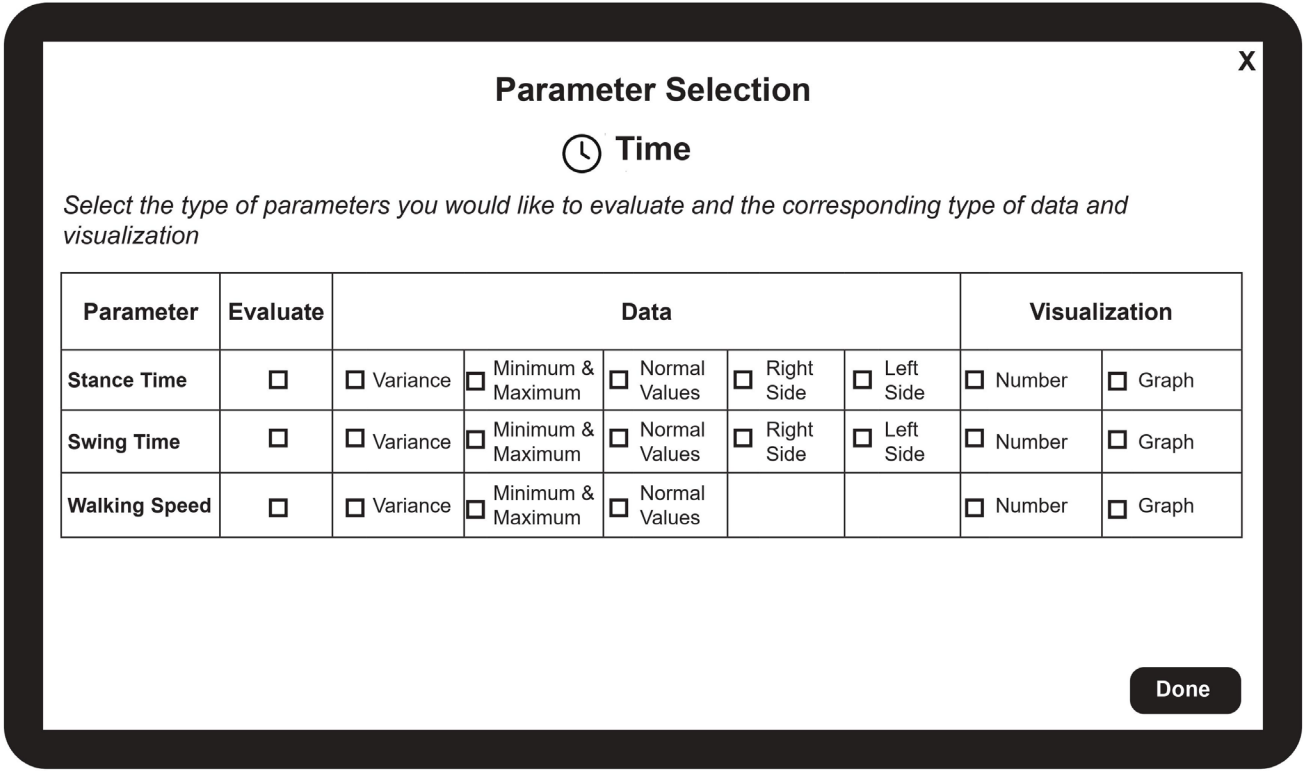


Step 4. Select Parameters & Visualizations Option 1



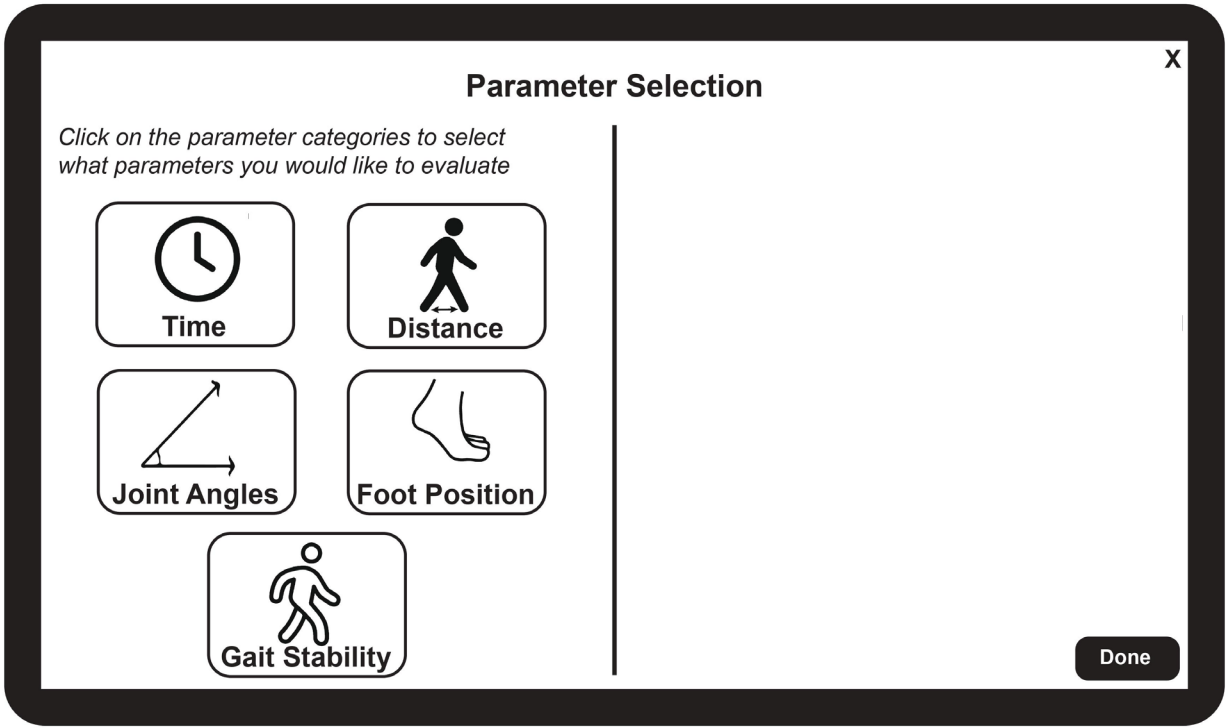
100

Step 4. Select Parameters & Visualizations Option 1



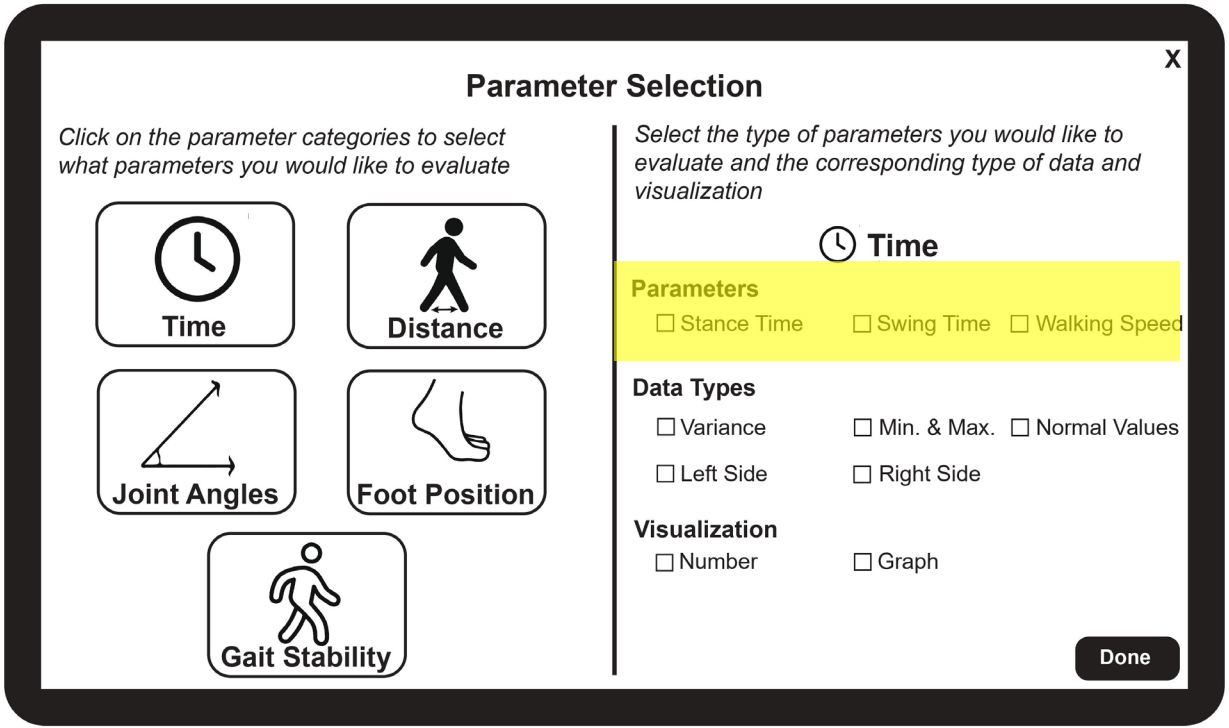
101

Step 4. Select Parameters & Visualizations Option 2

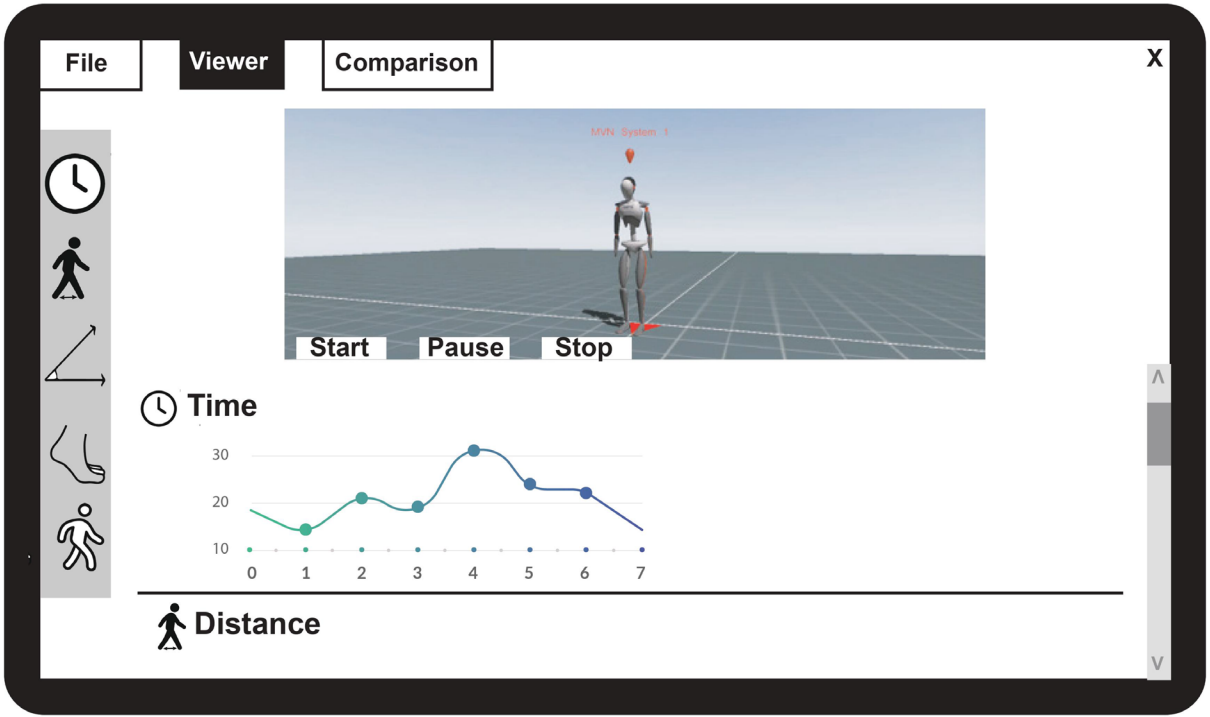


102

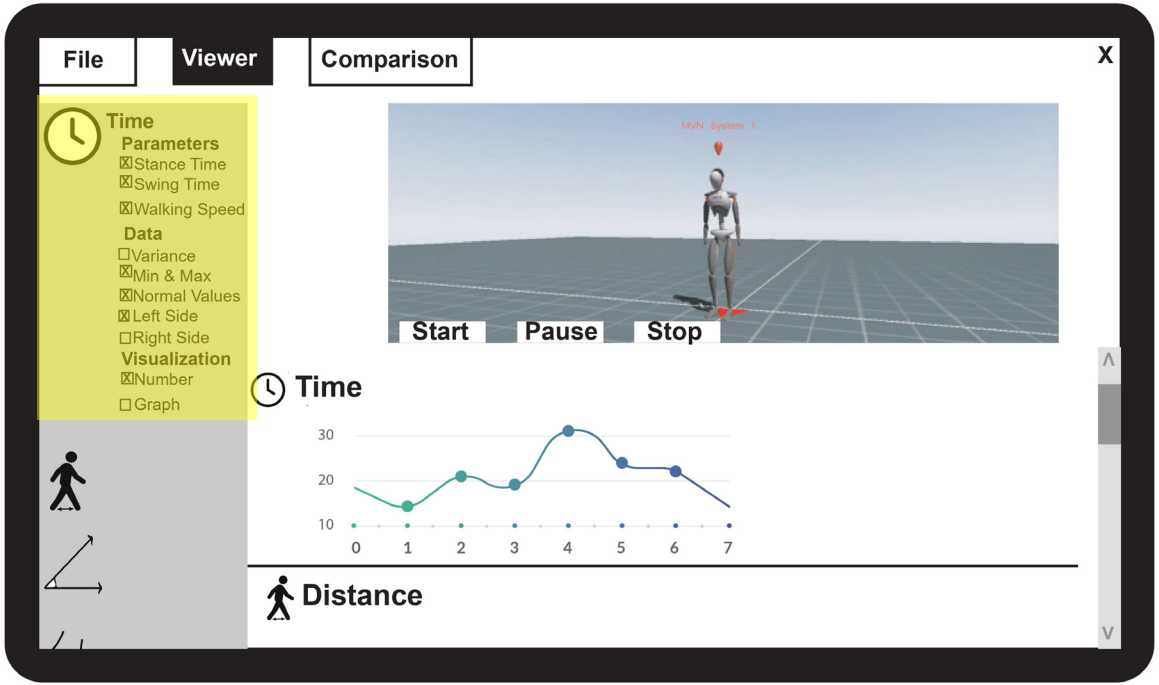
Step 4. Select Parameters & Visualizations Option 2



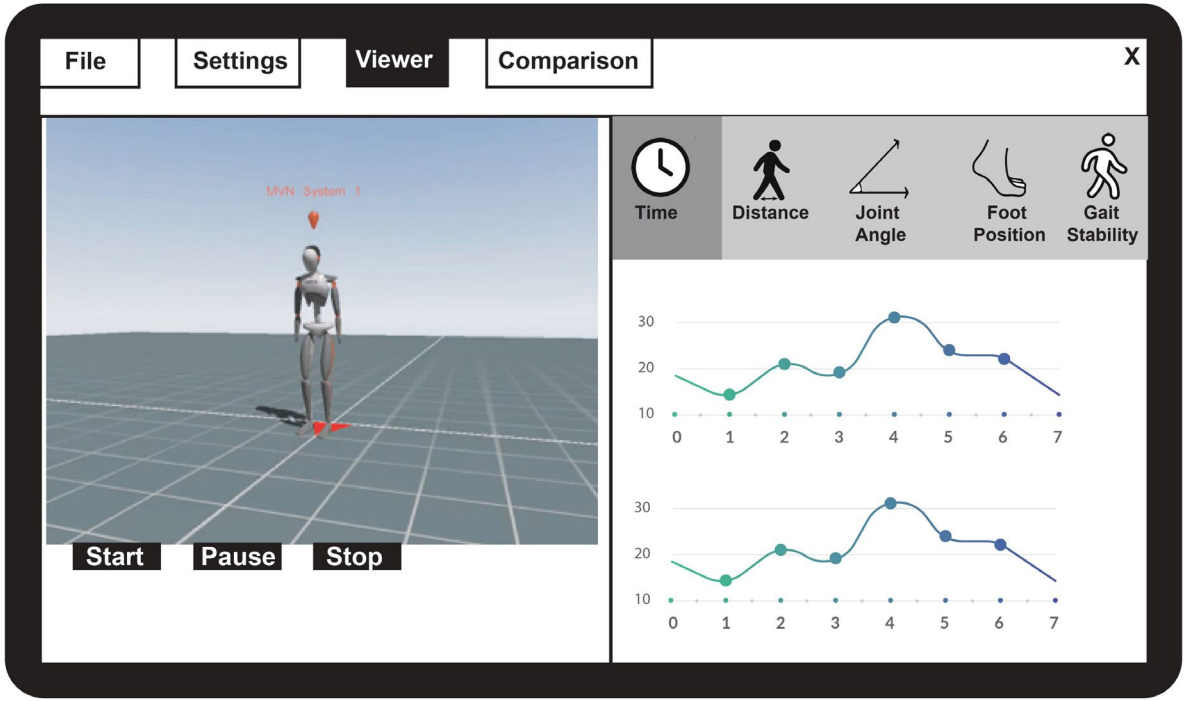
Step 5. View Data
Option 1



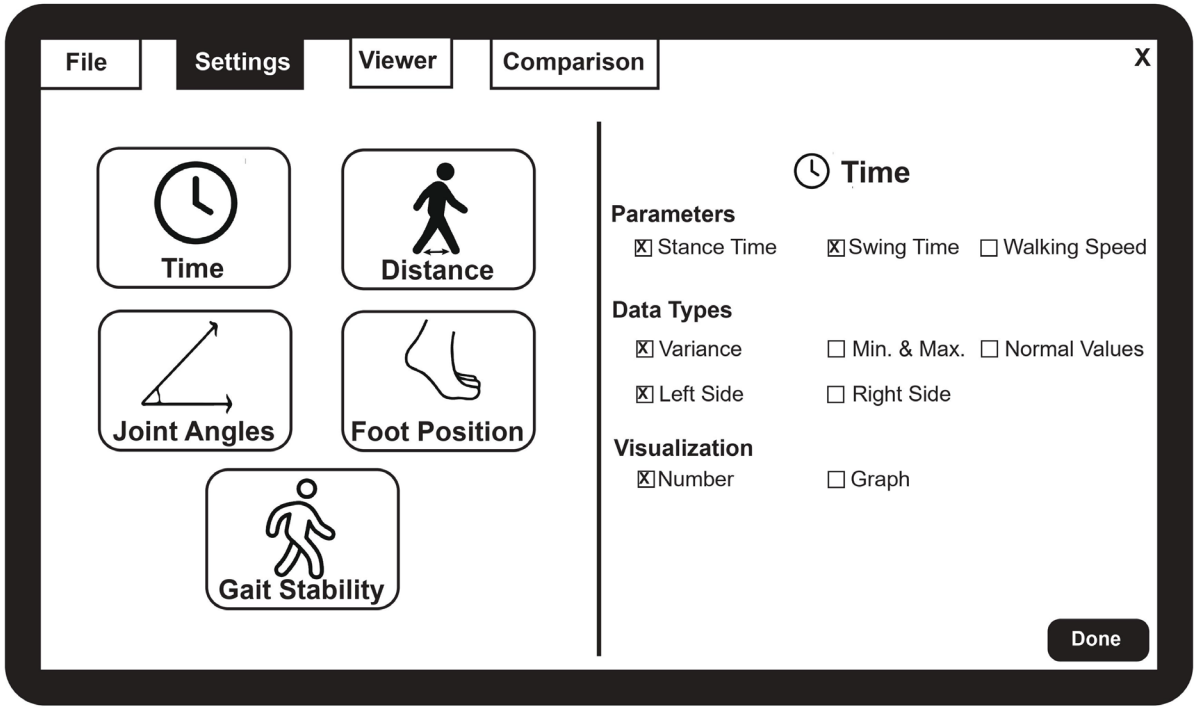
Step 5. View Data
Option 1



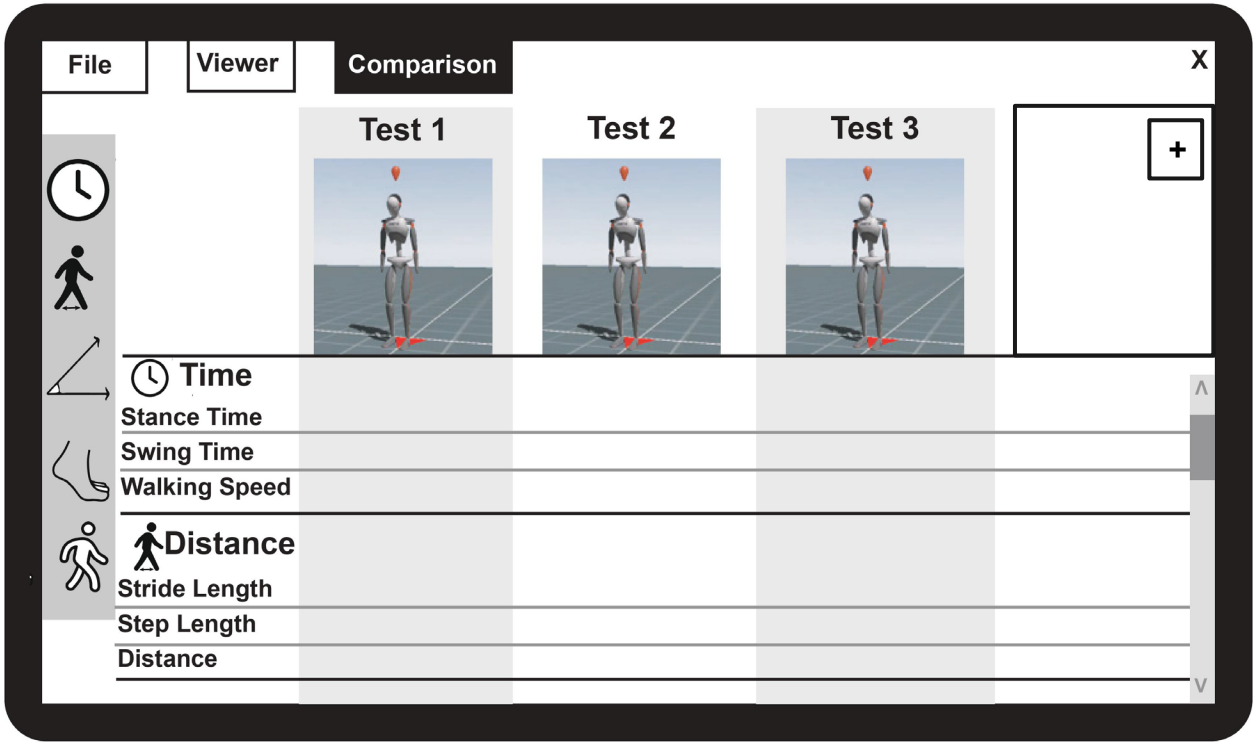
Step 5. View Data
Option 2



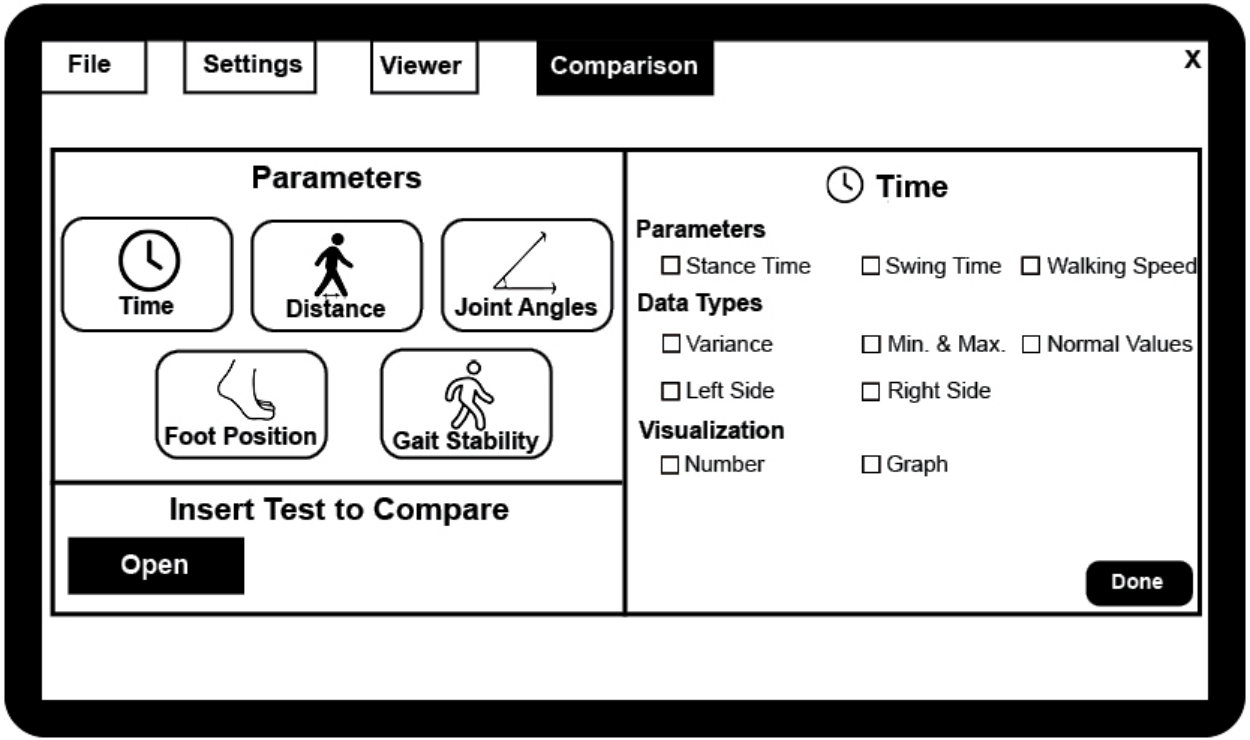
Step 5. View Data
Option 2



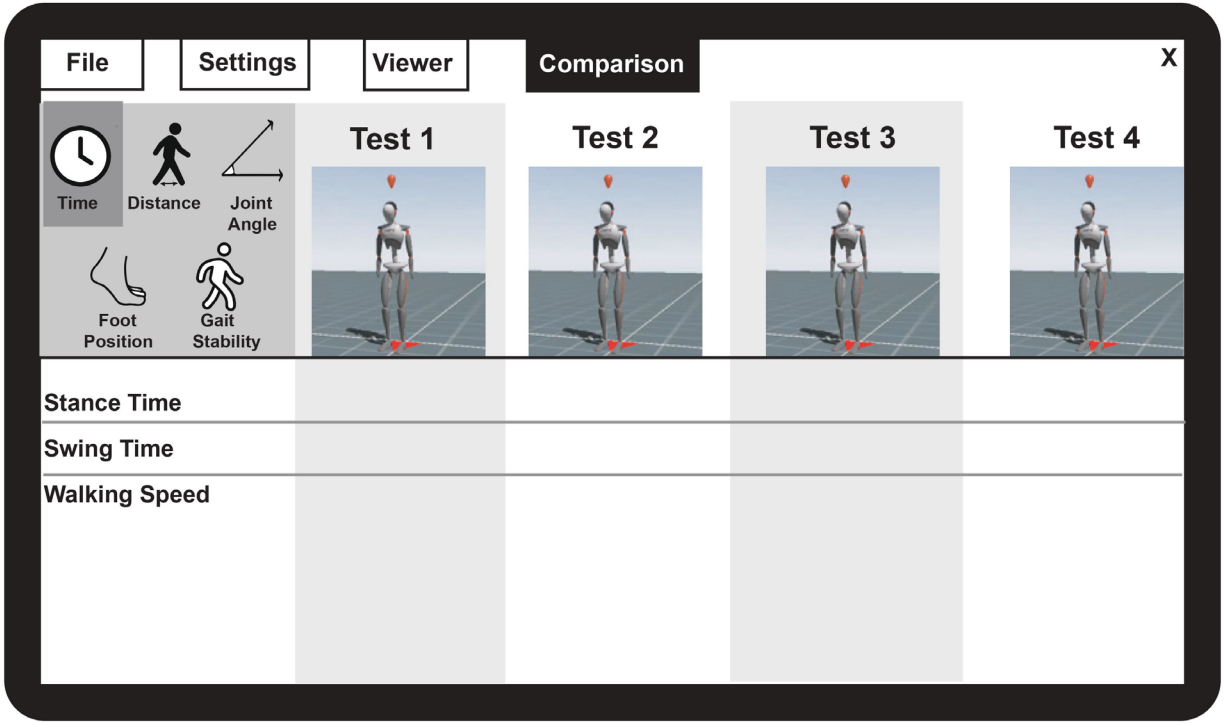
Step 6. Compare Orthosis Option 1



Step 6. Compare Orthosis Option 2

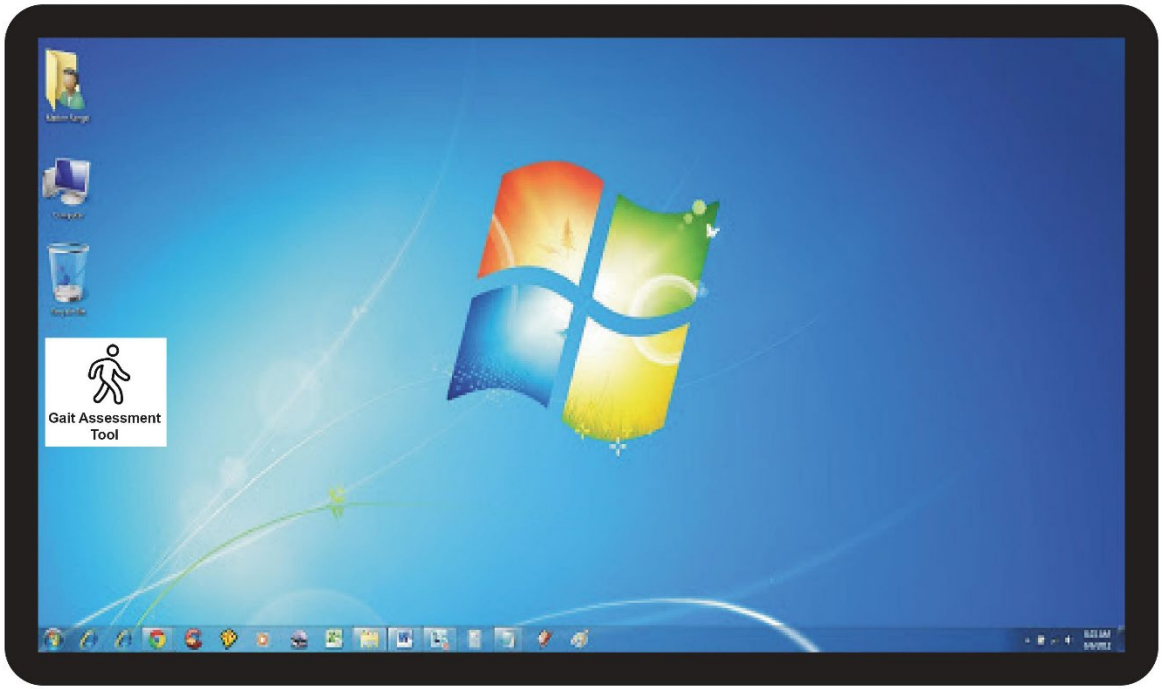


Step 6. Compare Orthosis Option 2



Appendix Z . Concept Evaluation Focus Group - Interface Layout Booklet

Step 1. Click-On User Interface to Enter



How easy is it to understand and operate?

O	O	O	O	O
Very Difficult		**Moderate**		**Very Easy**

_____

_____

_____

_____

_____

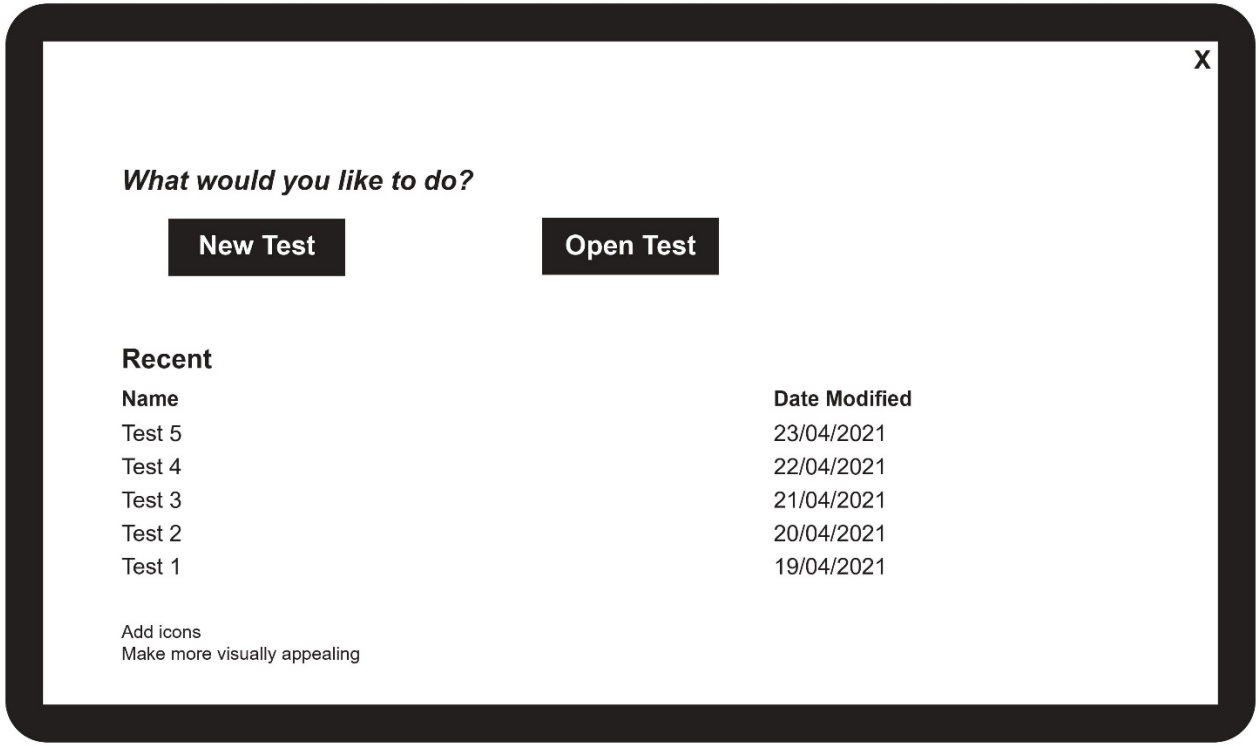
_____

Step 2. Login

How easy is it to understand and operate?

O	O	O	O	O
Very Difficult		**Moderate**		**Very Easy**

Step 3. Start New Test or Open Existing Test

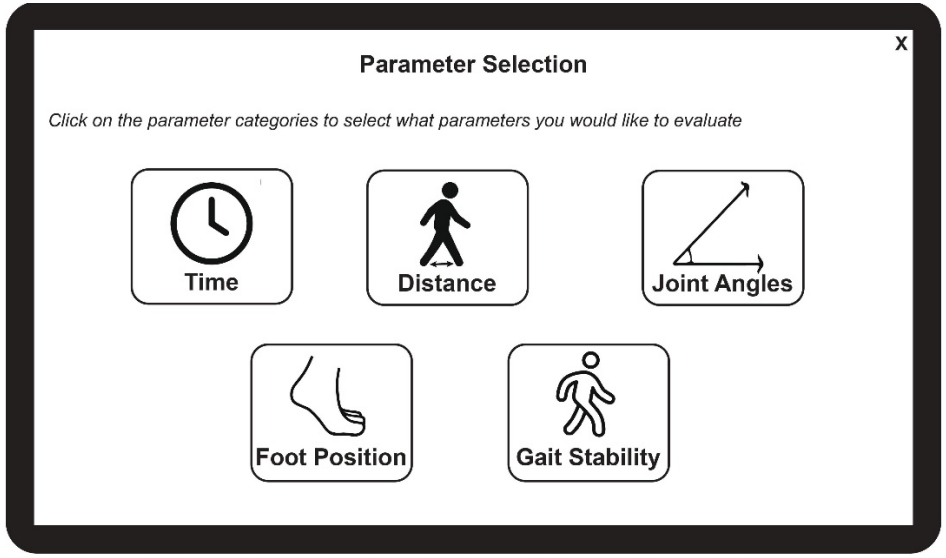


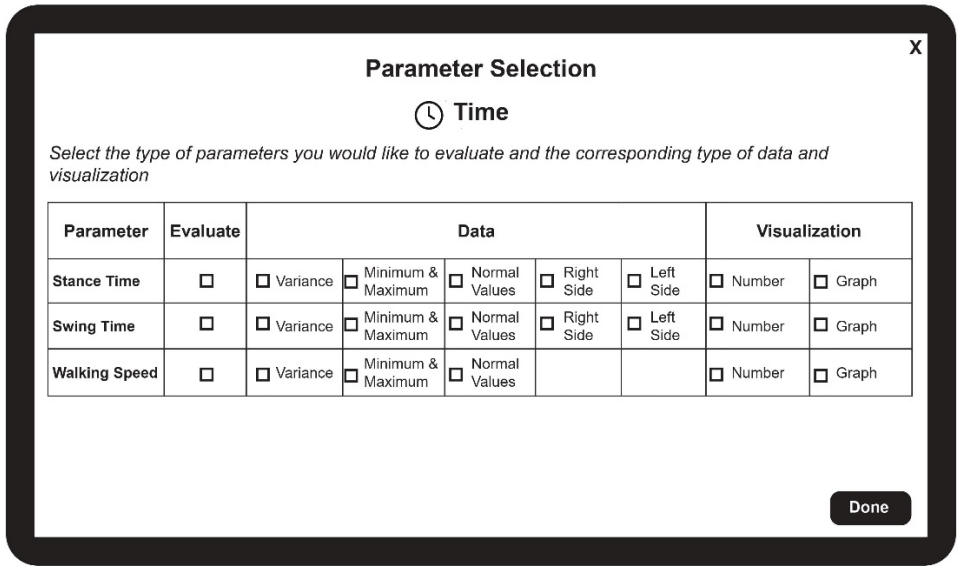
How easy is it to understand and operate?

O	O	O	O	O
Very Difficult		**Moderate**		**Very Easy**

Step 4. Select Parameters to Evaluate & Visualizations

Option 1



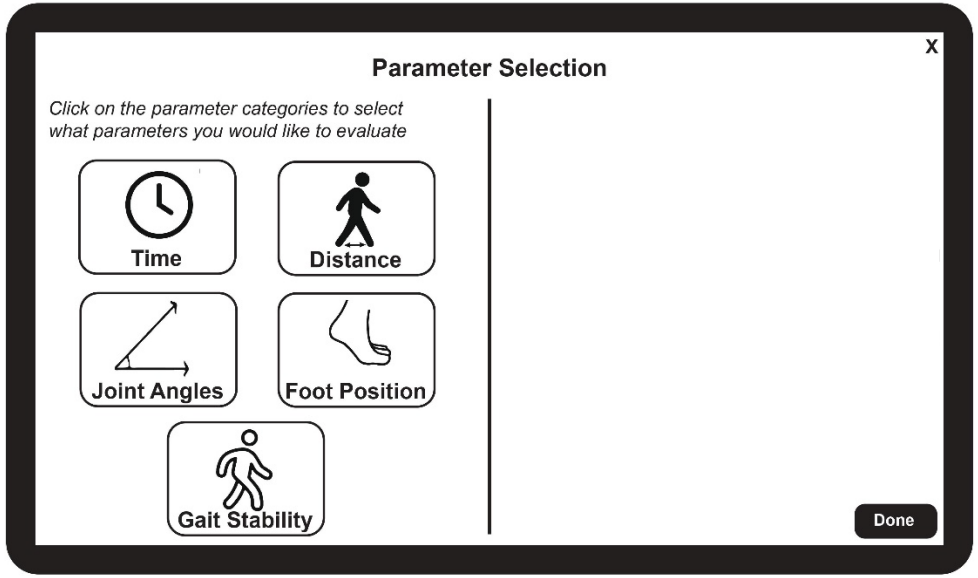


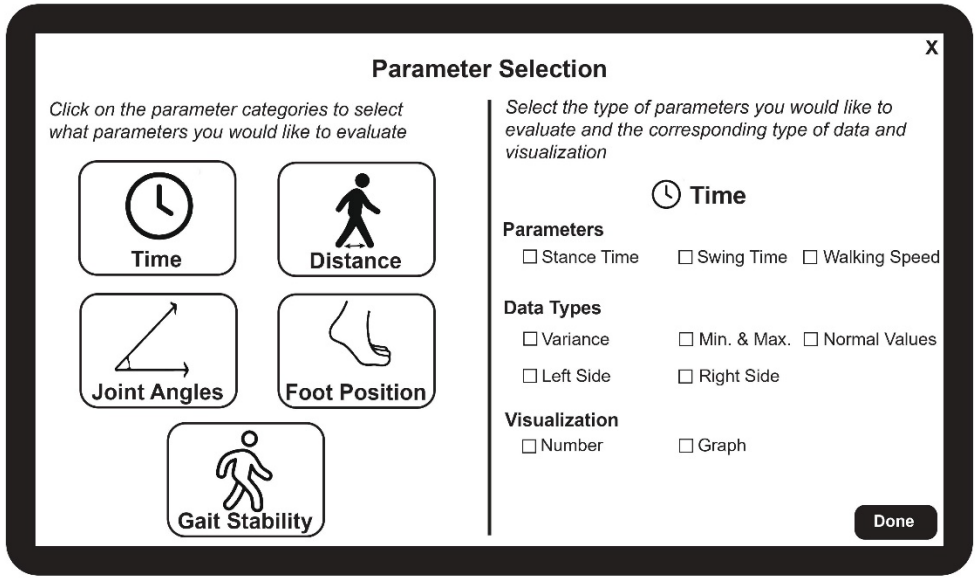
How easy is it to understand and operate?

O O O O O

Very Difficult **Moderate** **Very Easy**

Option 2



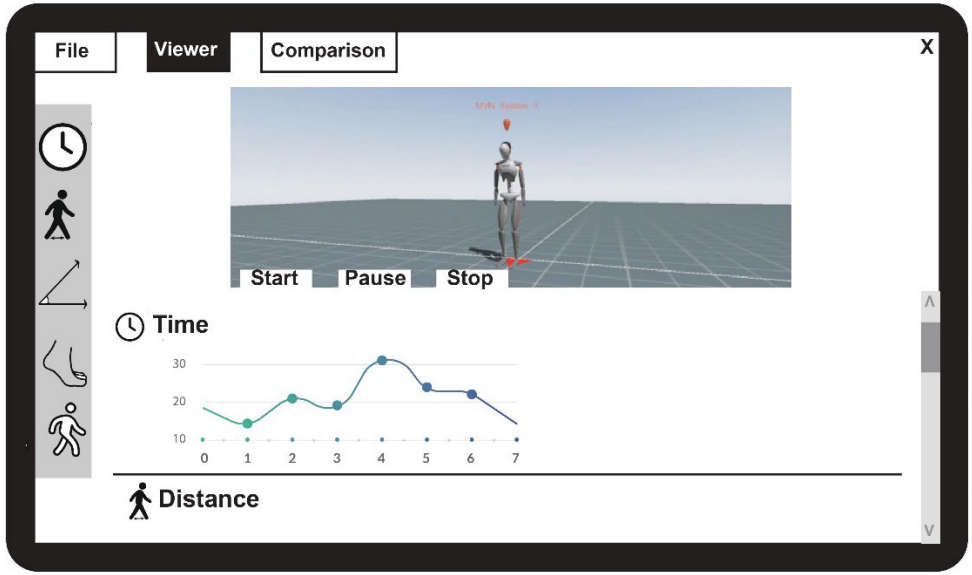


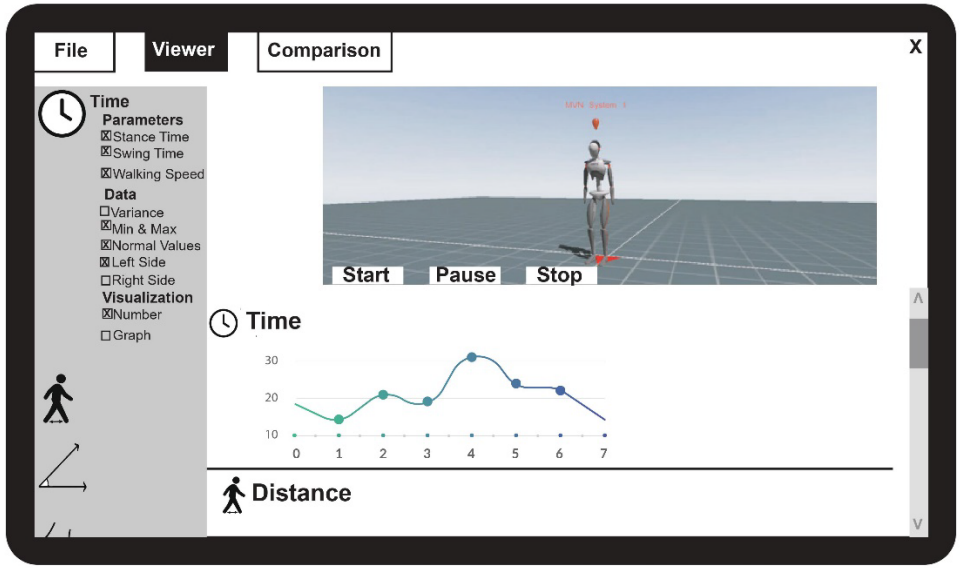
How easy is it to understand and operate?

O	O	O	O	O
Very Difficult		**Moderate**		**Very Easy**

Step 5. View Data

Option 1



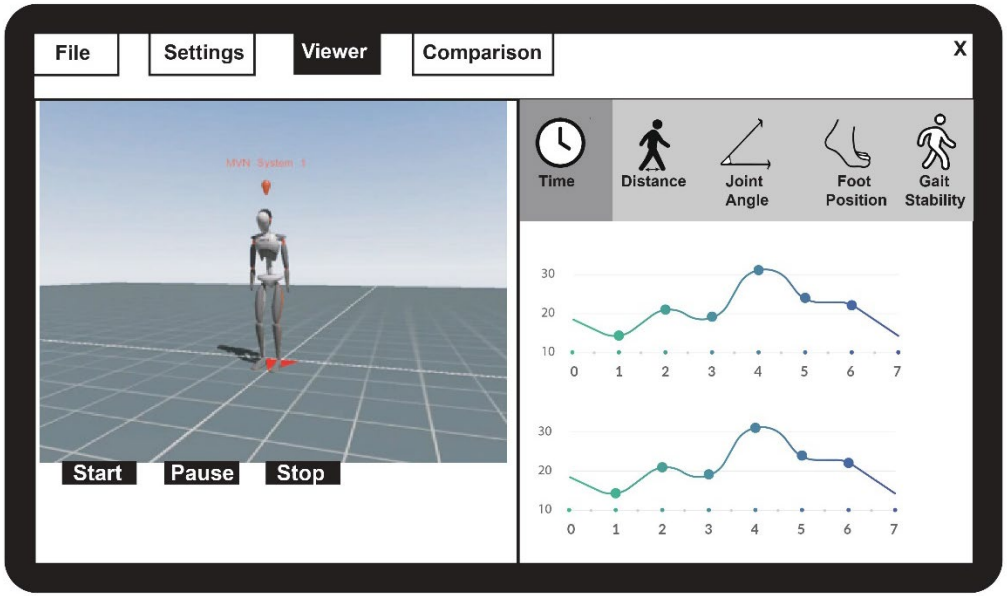


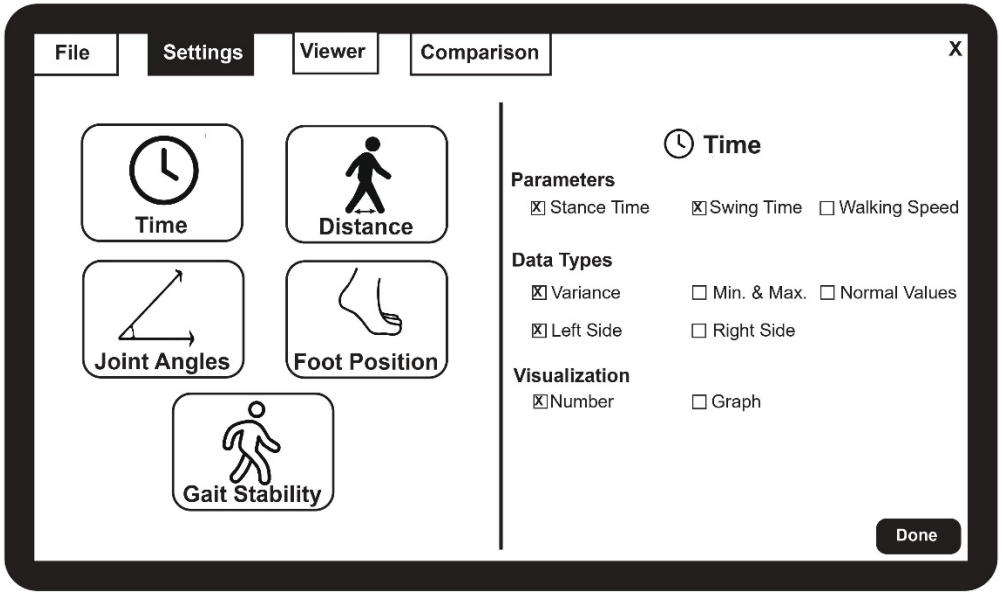
How easy is it to understand and operate?

O O O O O

Very Difficult **Moderate** **Very Easy**

Option 2





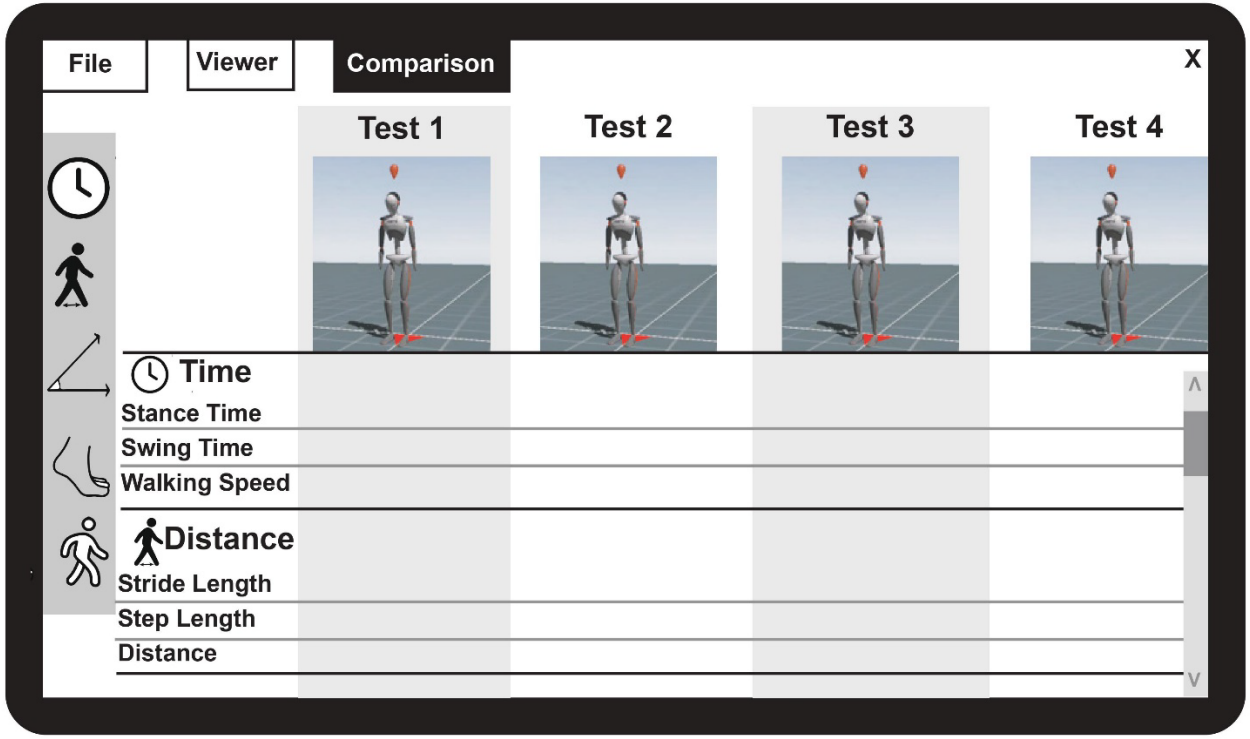
How easy is it to understand and operate?

O O O O O

Very Difficult **Moderate** **Very Easy**

Step 6. Comparison

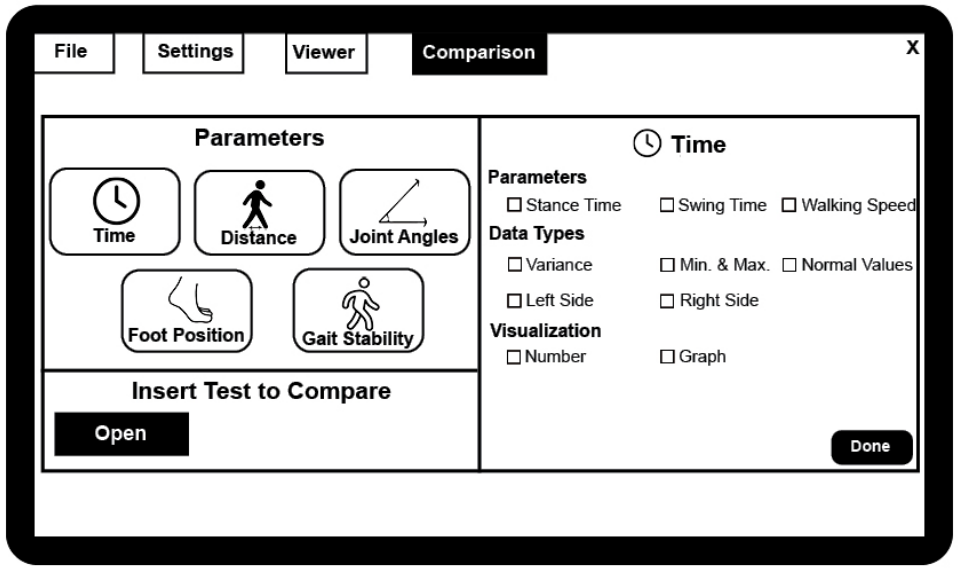
Option 1

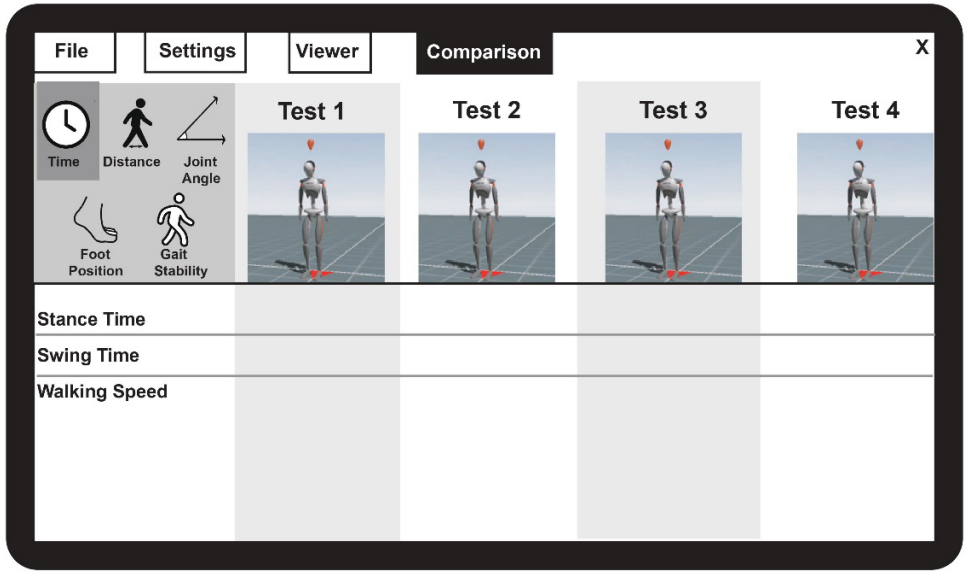


How easy is it to understand and operate?

O	O	O	O	O
Very Difficult		**Moderate**		**Very Easy**

Option 2





How easy is it to understand and operate?

O O O O O

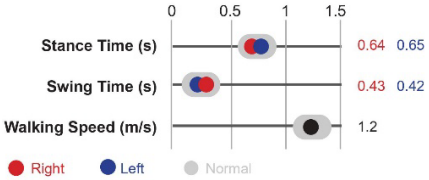
Very Difficult **Moderate** **Very Easy**

Appendix AA . Concept Evaluation Focus Group - Data Visualizations Booklet

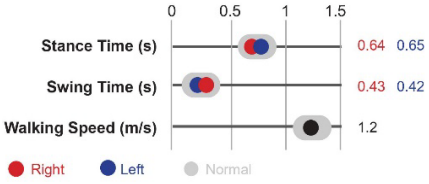
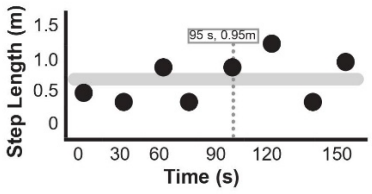
Visualizations

Circle the visualization(s) you favor.

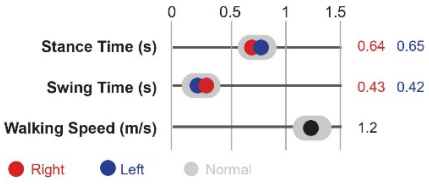
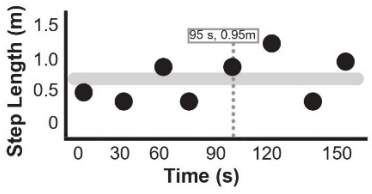
Time: Swing Time, Stance Time, Walking Speed

Data	Average	Average + Standard Deviation	Average + Min & Max
Visualization	1. Average Table **Parameter** / **Right** / **Left** / **Normal** **Stance Time (s)** 0.64 0.65 0.65 **Swing Time (s)** 0.43 0.42 0.44 **Walking Speed (m/s)** 1.2 1.2	2. Average Horizontal Plot 	

Distance: Stride Length, Step Length, Distance Walked

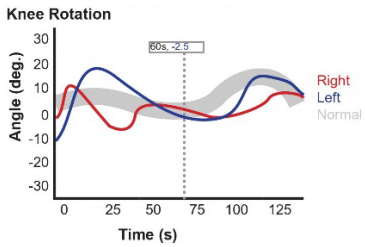
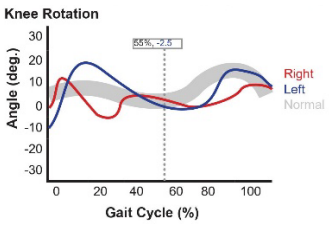
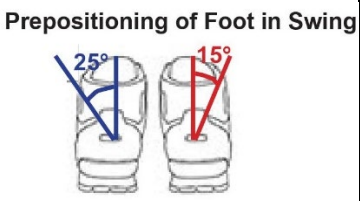
Data	Average	Average + Standard Deviation	Average + Min & Max
Visualization	1. Average Table **Parameter** / **Right** / **Left** / **Normal** **Stance Time (s)** 0.64 0.65 0.65 **Swing Time (s)** 0.43 0.42 0.44 **Walking Speed (m/s)** 1.2 1.2	2. Average Horizontal Plot 	3. Scatter Plot 

Gait Stability: Base of Support

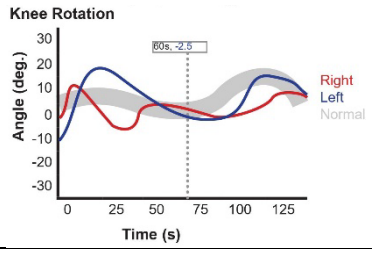
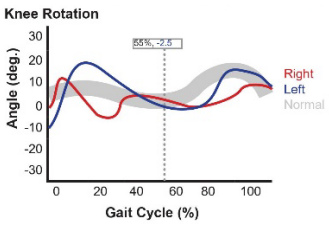
Data	Average	Average + Standard Deviation	Average + Min & Max
Visualization	1. Average Table **Parameter** / **Right** / **Left** / **Normal** **Stance Time (s)** 0.64 0.65 0.65 **Swing Time (s)** 0.43 0.42 0.44 **Walking Speed (m/s)** 1.2 1.2	2. Average Horizontal Plot 	3. Scatter Plot 

Circle the visualization(s) you favor.

Foot Position: Prepositioning of Foot in Swing, Foot Placement in Stance, & Clearance in Swing

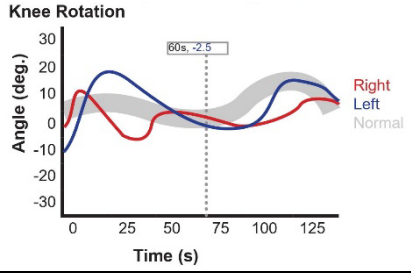
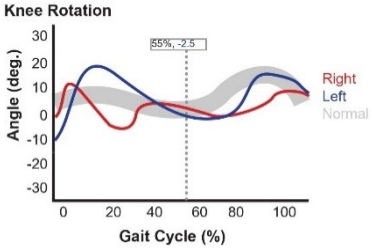
Data	Average	Average + Standard Deviation	Average + Min & Max
Visualization	1. Graph, Average over Time 	2. Graph, Average over Gait Cycle 	3. Average & Icon 

Joint Angle: Trunk, Hip, Knee, Ankle

Data	Average	Average + Standard Deviation	Average + Min & Max
Visualization	1. Graph, Average over Time 	2. Graph, Average over Gait Cycle 	3.Table

Knee Angle (deg)	Overall		Stance Phase		Swing Phase		At foot strike	At foot release
	Min.	Max.	Min.	Max.	Min.	Max.		
Right	-3.26	33.67	-0.15	15.60	-3.60	33.67	2.32	16.00
Left	-1.26	46.98	-1.26	31.81	0.63	46.98	8.90	25.30
Normal	-2.00	35.00	-1.00	25.00	-3.00	45.00	5.00	26.00

Gait Stability: Position Center of Mass (CoM), Extrapolated Center of Mass (XCoM)

Data	Average	Average + Standard Deviation	Average + Min & Max
Visualization	1. Graph, Average over Time 	2. Graph, Average over Gait Cycle 	

Comparison

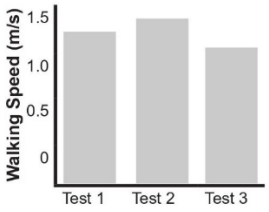
Circle the visualization(s) you favor.

Time: Swing Time, Stance Time, Walking Speed

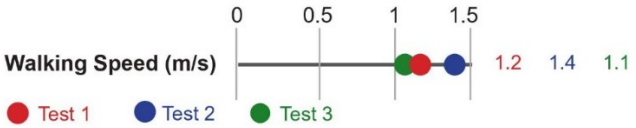
1. Average Values Table

	Test 1		Test 2		Test 3	
Parameter	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Step Length (m)	0.66	0.62	0.70	0.64	0.64	0.62
Stride Length (m)	1.27		1.30		1.23	

2. Bar Graphs of Averages



3. Horizontal Plot of Averages

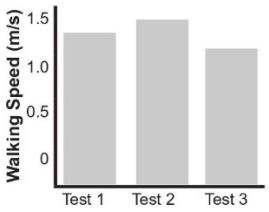


Distance: Stride Length, Step Length, Distance Walked

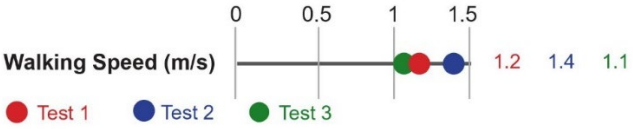
1. Average Values Table

	Test 1		Test 2		Test 3	
Parameter	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Step Length (m)	0.66	0.62	0.70	0.64	0.64	0.62
Stride Length (m)	1.27		1.30		1.23	

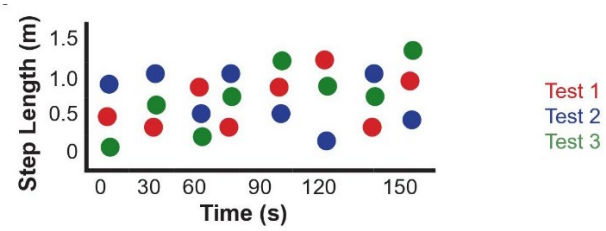
2. Bar Graphs of Averages



3. Horizontal Plot of Averages



4. Scatter Plot

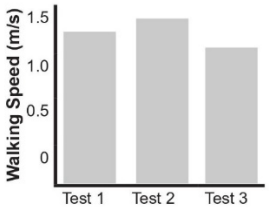


Gait Stability: Base of Support

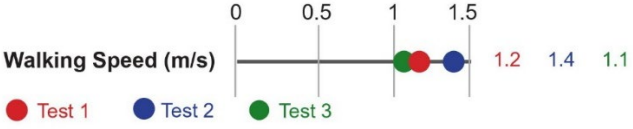
1. Average Values Table

	Test 1		Test 2		Test 3	
Parameter	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Step Length (m)	0.66	0.62	0.70	0.64	0.64	0.62
Stride Length (m)	1.27		1.30		1.23	

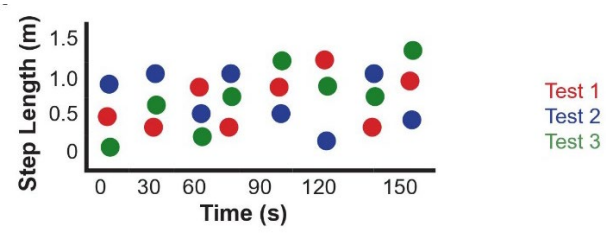
2. Bar Graphs of Averages



3. Horizontal Plot of Averages



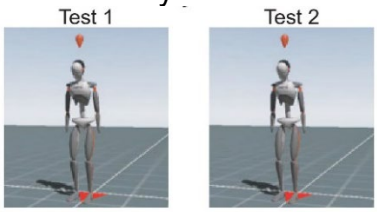
4. Scatter Plot



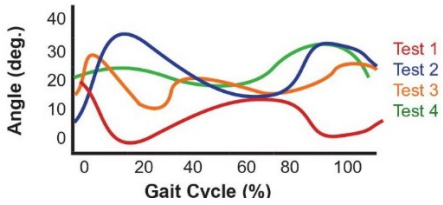
Circle the visualization(s) you favor.

Foot Position: Prepositioning of Foot in Swing, Foot Placement in Stance, & Clearance in Swing

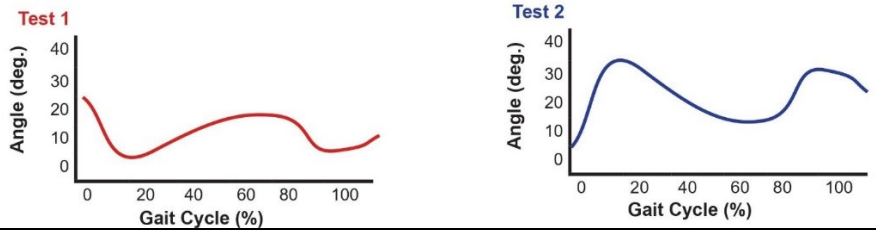
1. Side by Side Video



2. Graph Plotted Together

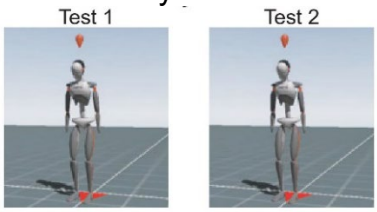


3. Graphs, Plotted Side by Side

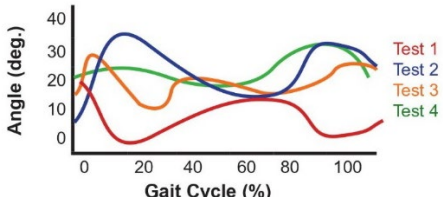


Joint Angle: Trunk, Hip, Knee, Ankle

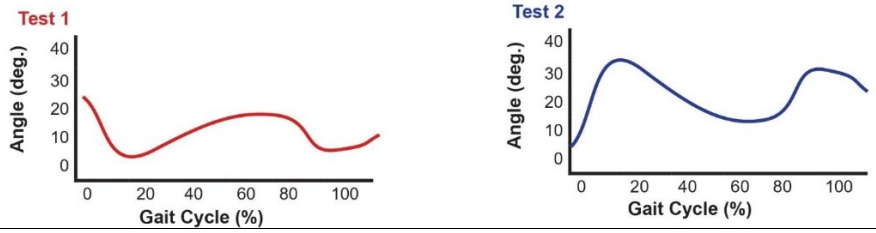
1. Side by Side Video



2. Graph Plotted Together

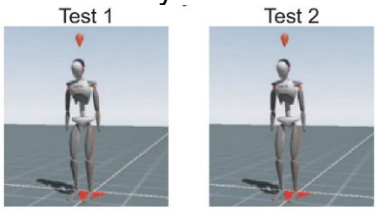


3. Graphs, Plotted Side by Side

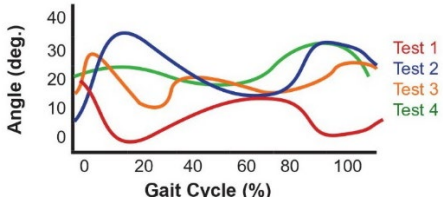


Gait Stability: Position Center of Mass (CoM), Extrapolated Center of Mass (XCoM

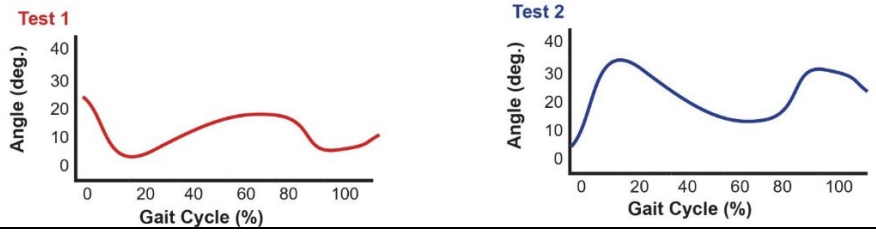
1. Side by Side Video



2. Graph Plotted Together



3. Graphs, Plotted Side by Side



What parameters would you like to show patients?

Circle the parameters

Time

Swing / Stance Time

Walking Speed

Distance

Step / Stride Length

Distance Walked

Joint Angles

Joint Angles

Foot Position

Prepositioning of Foot in Swing

Foot Placement in Stance

Clearance in Swing

Gait Stability

Position Center of Mass

Base of Support

Appendix BB. Incomplete SCI Patient Interview Questions

Tell me a little about yourself

-Injury

-How long they have been a Rijndam

-Walking ability: wheelchair, walker, crutches

-Occupation / Former Occupation

-Treatment received so far

Current Experience

-Motivation levels throughout treatment

-Do you ever get down on yourself. What do you want to do to improve?

-Is there anything you think would be an added benefit in helping you understand how to improve your walking?

-When you walk in physiotherapy and the PT explain what to fix, are you sometimes confused? By what?

-Are you confused when the physician explains your progress

Interface

-Would you want to see your progress? How often?

-Do they want an app to check their progress or just report or just rely on physiotherapist and physician?

-What additional information would patients like to see that is currently not included in the interface?

Visualizations

-What do you like about the visualizations and what do they find confusing?

Appendix CC. Final Design Prototype

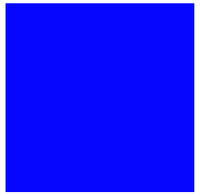
RGB: 131, 210, 234

RGB: 9, 42, 113

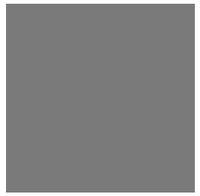
RGB: 243, 245, 250
Background

RGB: 1, 1, 1 20%
Parameter Category
Section Border

RGB: 254, 6, 14



RGB: 6, 6, 254



RGB: 0, 0, 0 52%
Normal Font Color

RGB: 1, 1, 1
Text

Font: Roboto

Tab Titles: Roboto 25 Medium

Menu Bar Parameter Category Title: Roboto 20 Medium

Menu Bar Parameters: Roboto 15 Regular

Parameter Category Title: Roboto 25 Regular

Parameter Title in Visualization: Roboto 15 Medium

Size: Web 1366 x 768 px

TU Delft

Erasmus MC
Universitair Medisch Centrum Rotterdam

Welcome Karin

New Test

Open Test

Recent

Name	Date Modified
Braam_R_23/4/21_10m	23/4/2021
de Jong_K_10/4/21_5m	10/4/2021
Dekker_A_09/4/21_10m	9/4/2021
van der Boor_E_01/4/21_20m	01/4/2021

Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

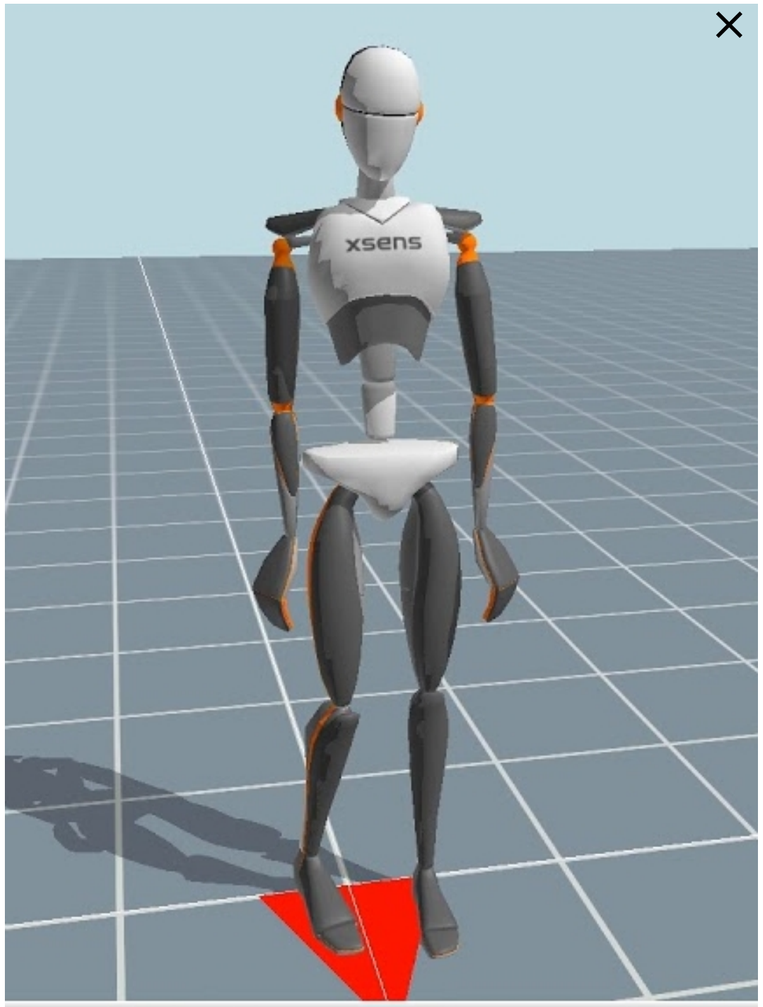
Joint Angles
- [ ] Trunk
- [ ] Hip
- [ ] Knee
- [ ] Ankle

Foot Position
- [ ] Clearance in Swing
- [ ] Foot Orientation in Stance & Swing

Gait Stability
- [ ] Gait Width
- [ ] Position of Center of Mass (CoM)
- [ ] Extrapolated Center of Mass (XCoM)

Time
- [ ] Gait Speed
- [ ] Stance Phase Duration
- [ ] Swing Phase Duration

Distance
- [ ] Step Length
- [ ] Stride Length
- [ ] Distance Walked



Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

Joint Angles
- [x] Trunk
- [x] Hip
- [x] Knee
- [x] Ankle

Foot Position
- [x] Clearance in Swing
- [x] Foot Orientation in Stance & Swing

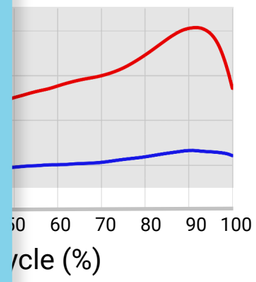
Gait Stability
- [x] Gait Width
- [ ] Position of Center of Mass (CoM)
- [ ] Extrapolated Center of Mass (XCoM)

Time
- [x] Gait Speed
- [x] Stance Phase Duration
- [x] Swing Phase Duration

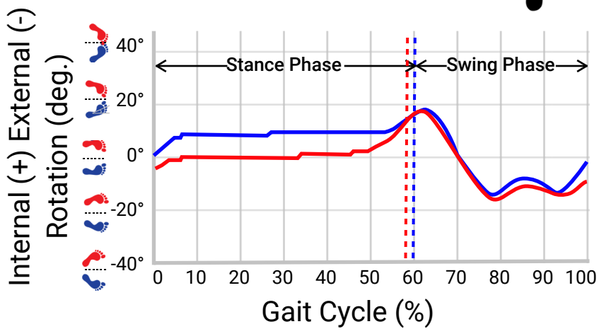
Distance
- [ ] Step Length
- [ ] Stride Length
- [x] Distance Walked

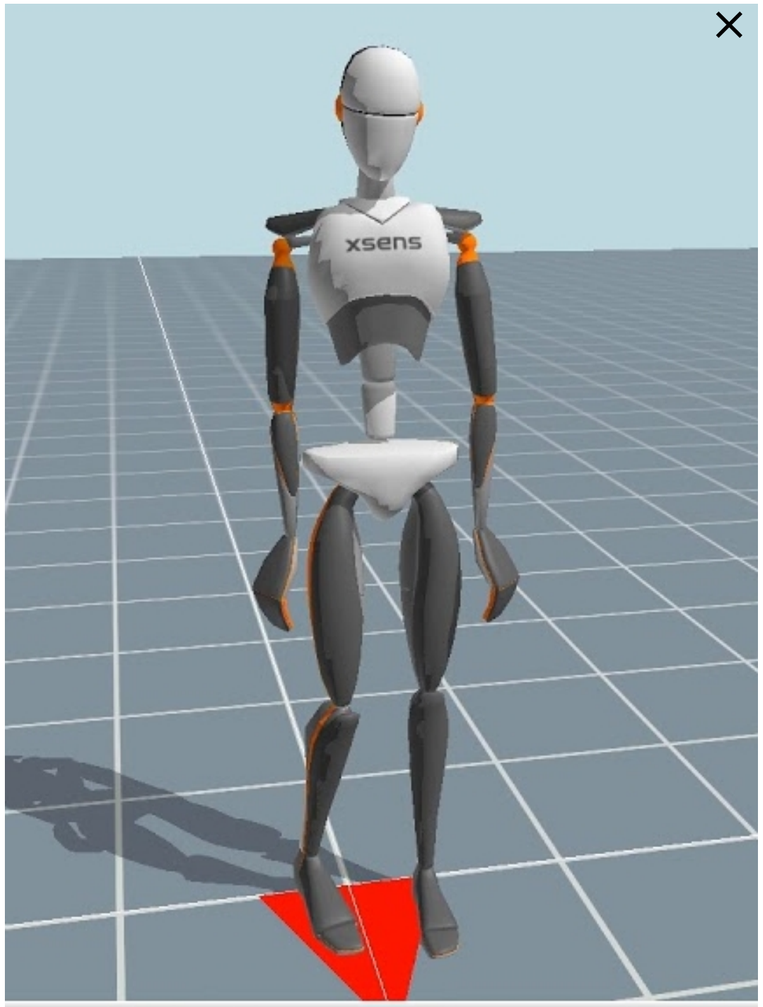
ng [x] Left [x] Right [ ] Normal

arance



Foot Orientation





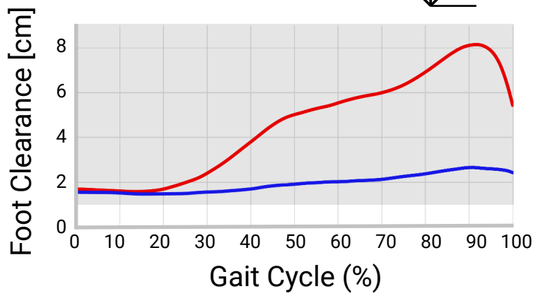
1x

Joint Angle
Foot Position
Gait Stability
Time
Distance

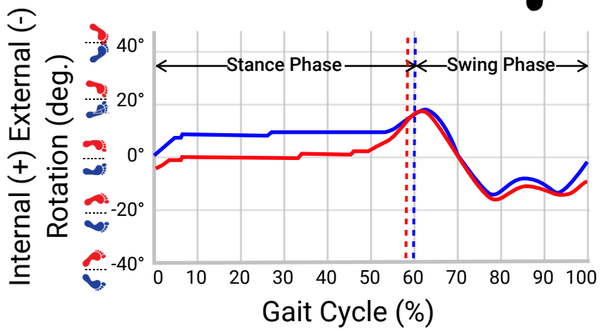
Foot Positioning

Left ☑ Right ☑ Normal ☑

Foot Clearance

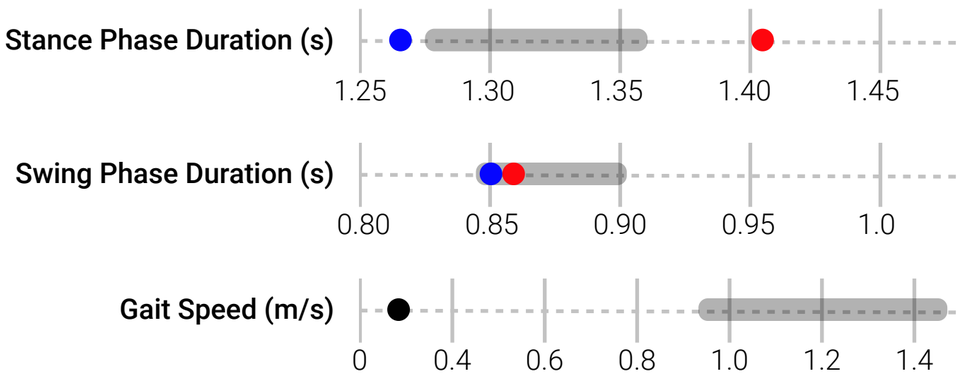


Foot Orientation

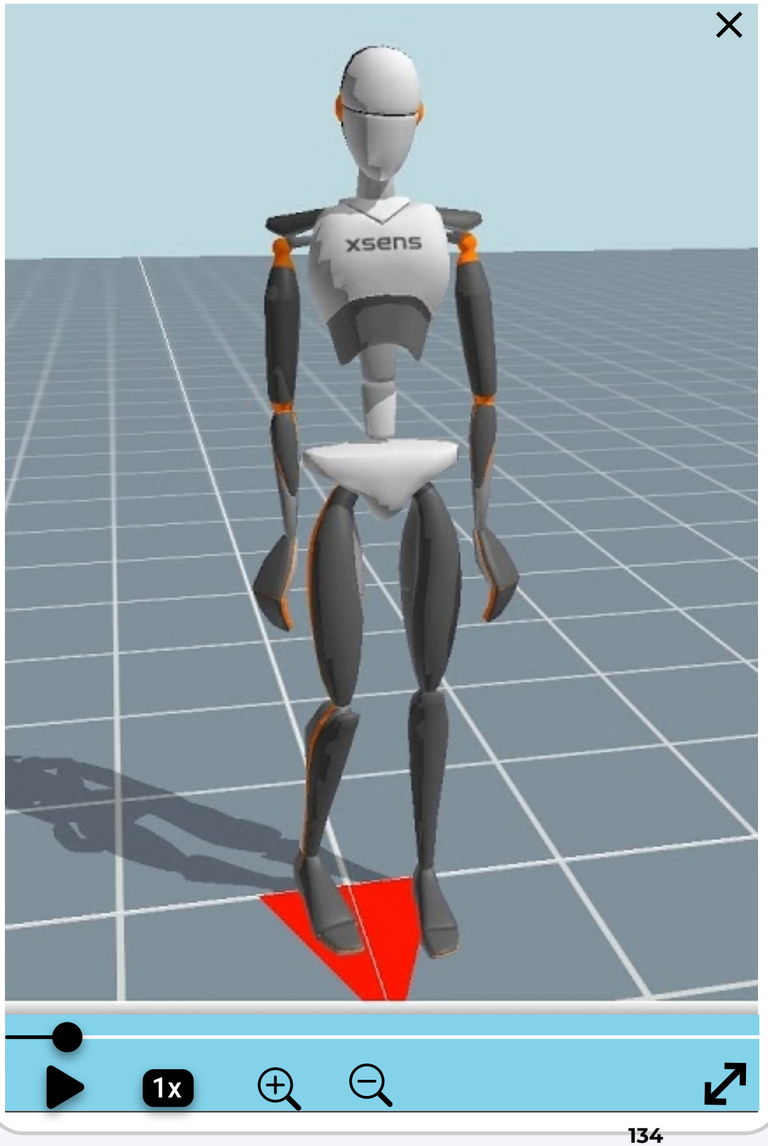


Time

Left ☑ Right ☑ Normal ☑



	Left	Right	Normal
Stance Phase Duration (s)	1.27 s 59.35 %	1.40 s 62.20 %	1.28 - 1.35 s 60 %
Swing Phase Duration (s)	0.87 s 40.65%	0.85 s 37.80%	0.85 - 0.90 s 40 %
Gait Speed (m/s)	0.28 m/s		0.94 - 1.43 m/s



Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

Joint Angle

Foot Position

Gait Stability

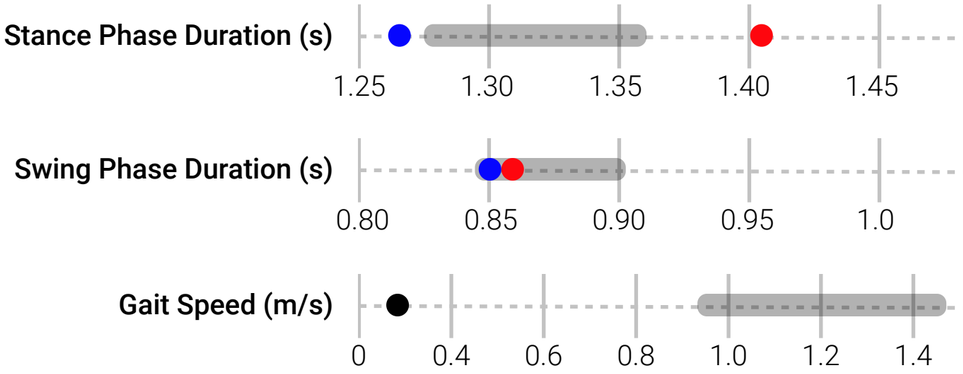
Time

Distance

Time

Left Right Normal

	Left	Right	Normal
Stance Phase Duration (s)	1.27 s 59.35 %	1.40 s 62.20 %	1.28 - 1.35 s 60 %
Swing Phase Duration (s)	0.87 s 40.65%	0.85 s 37.80%	0.85 - 0.90 s 40 %
Gait Speed (m/s)	0.28 m/s		0.94 - 1.43 m/s

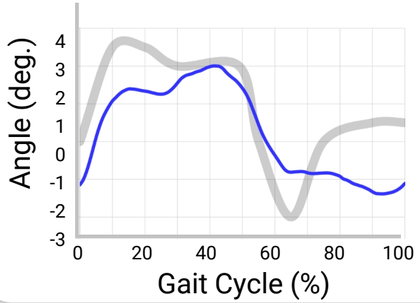


Joint Angle

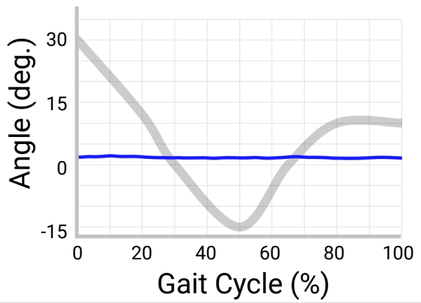
Trunk | Hip | Knee | Ankle

Left Right Normal

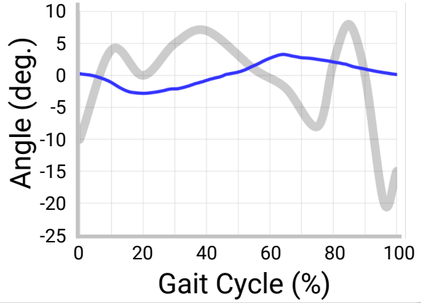
Abduction (+) / Adduction (-)

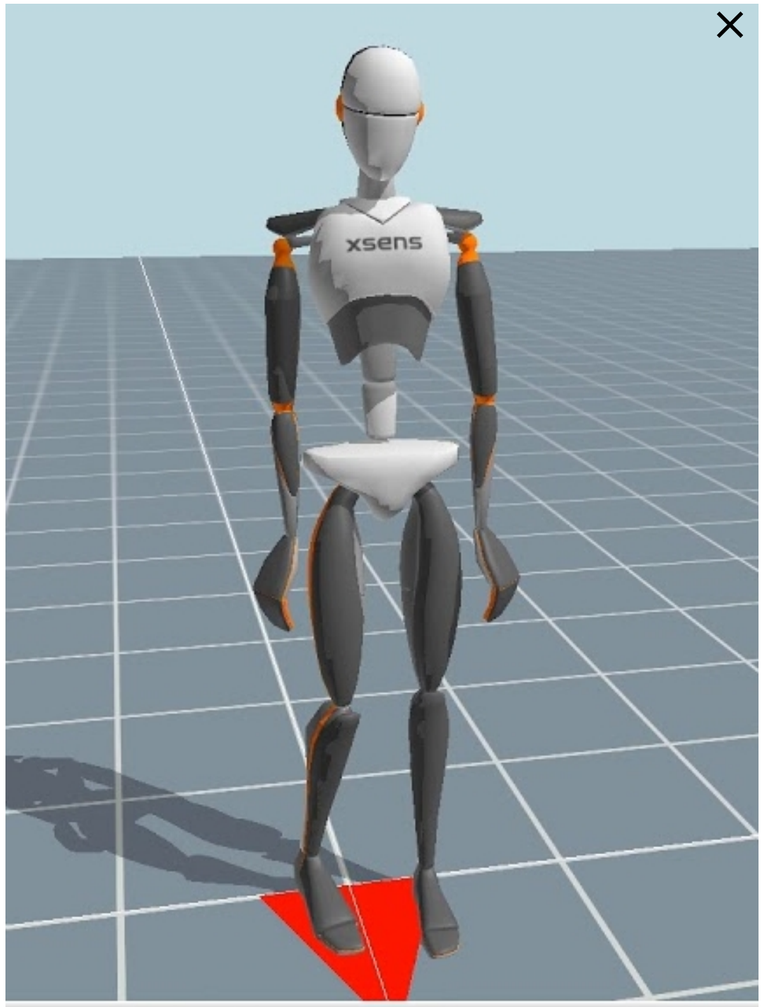


Flexion (+) / Extension (-)



Int(+)/External(-) Rotation





1x

Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

Joint Angle
Foot Position
Gait Stability
Time
Distance

Time

Left Right Normal

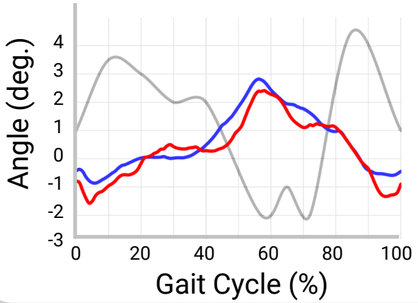
	Left	Right	Normal
Stance Phase Duration (s)	1.27 s 59.35 %	1.40 s 62.20 %	1.28 - 1.35 s 60 %
Swing Phase Duration (s)	0.87 s 40.65%	0.85 s 37.80%	0.85 - 0.90 s 40 %
Gait Speed (m/s)	0.28 m/s		0.94 - 1.43 m/s

Joint Angle

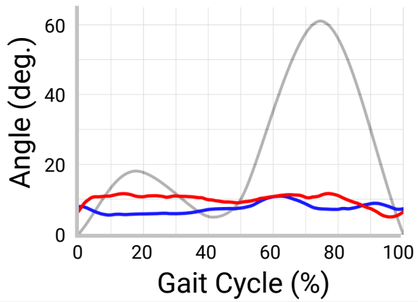
Ankle | Knee | Hip | Trunk

Left Right Normal

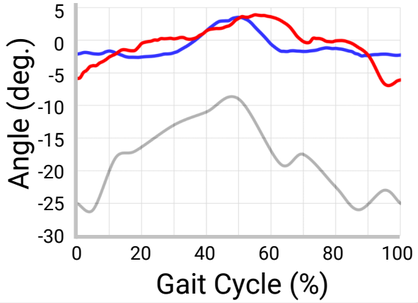
Abduction (+) / Adduction (-)

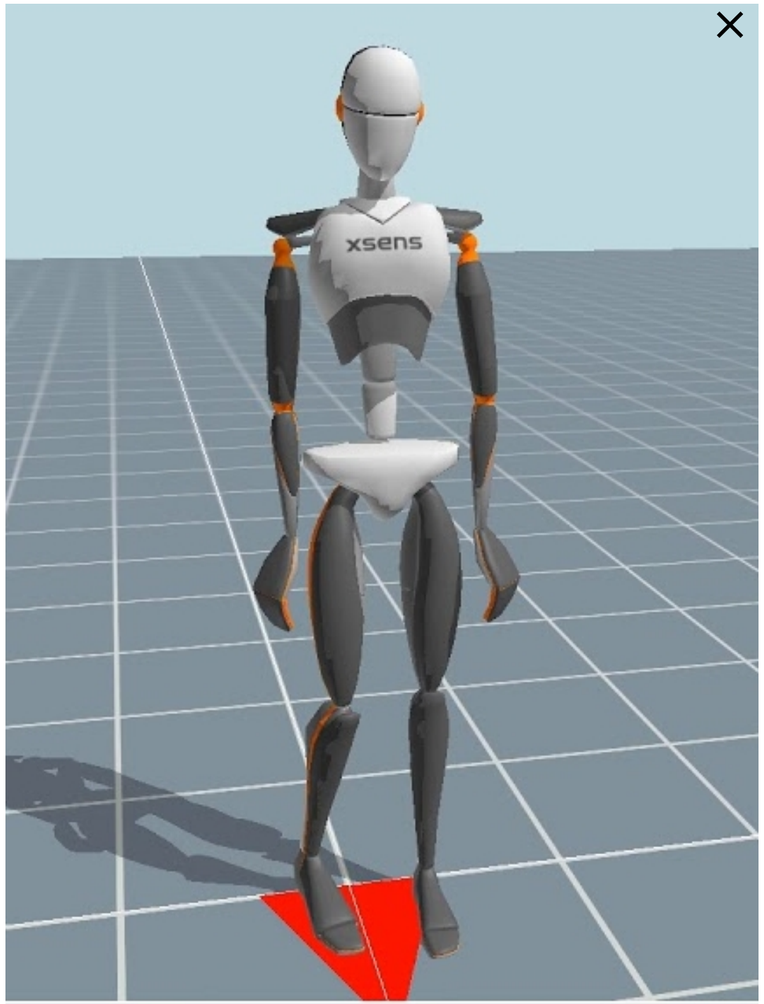


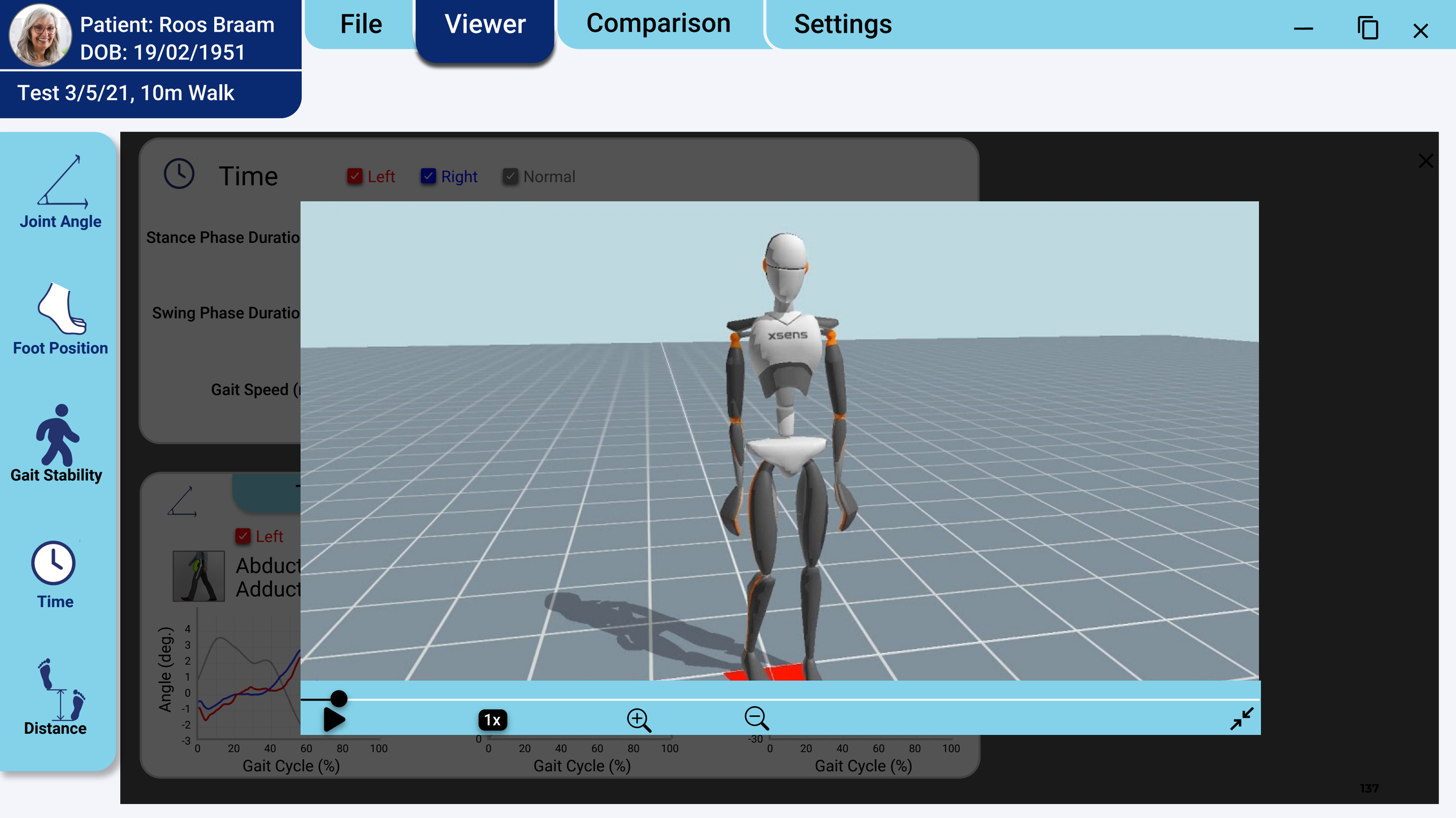
Flexion (+) / Extension (-)



Int(+)/External(-) Rotation





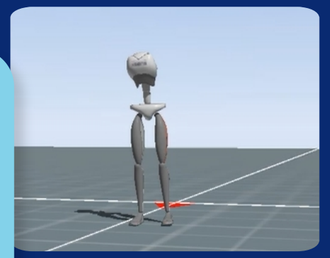

Patient: Roos Braam
DOB: 19/02/1951
Test 3/5/21, 10m Walk
File
Viewer
Comparison
Settings
Joint Angle
Foot Position
Gait Stability
Time
Distance
Time
Left
Right
Normal
Stance Phase Duratio
Swing Phase Duratio
Gait Speed (
xsens
Left
Abduct
Adduct
Angle (deg.)
4
3
2
1
0
-1
-2
-3
0 20 40 60 80 100
Gait Cycle (%)
1x
0 20 40 60 80 100
Gait Cycle (%)
-30
0 20 40 60 80 100
Gait Cycle (%)
137

Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

Test 3/5/21, 10m Walk



+ Add Test

+ Add Test

Joint Angles
- [x] Trunk
- [x] Hip
- [x] Knee
- [x] Ankle

Foot Position
- [x] Clearance in Swing
- [x] Foot Orientation in Stance & Swing

Gait Stability
- [x] Gait Width
- [x] Position of Center of Mass (CoM)
- [x] Extrapolated Center of Mass (XCoM)

Time
- [x] Gait Speed
- [x] Stance Phase Duration
- [x] Swing Phase Duration

Distance
- [x] Step Length
- [x] Stride Length
- [x] Distance Walked

Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

Joint Angle

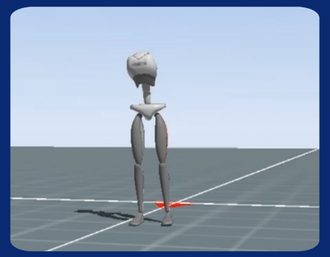
Foot Position

Gait Stability

Time

Distance

Test 3/5/21, 10m Walk



+ Add Test

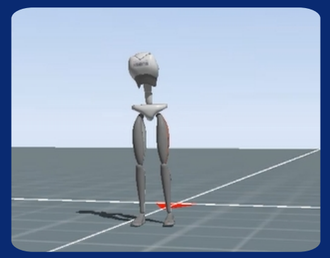
+ Add Test

Patient: Roos Braam
DOB: 19/02/1951

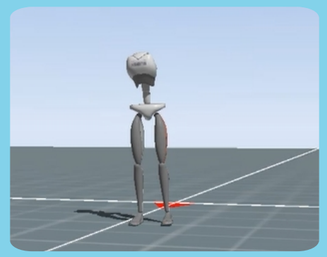
Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

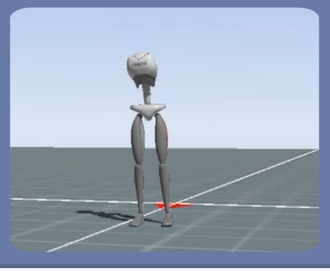
Test 3/5/21, 10m Walk



Test 28/4/21, Brace



Test 26/4/21, 20m Walk



Joint Angle

Foot Position

Gait Stability

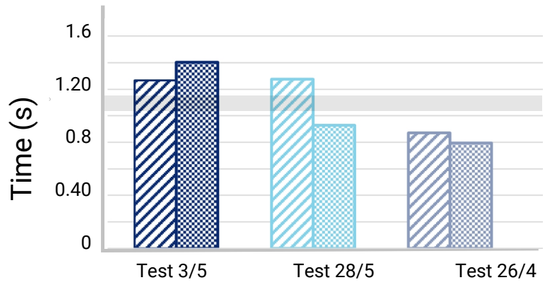
Time

Distance

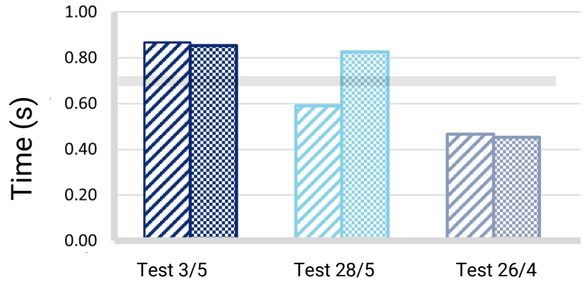
Time

Left ☑ Right ☑ Normal

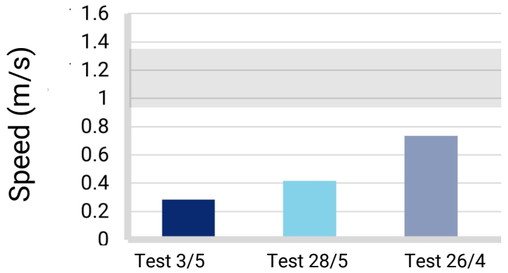
Stance Phase Duration



Swing Phase Duration



Gait Speed

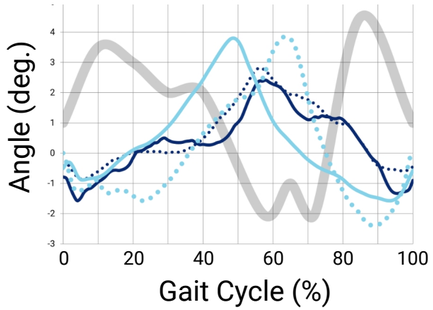


Joint Angle

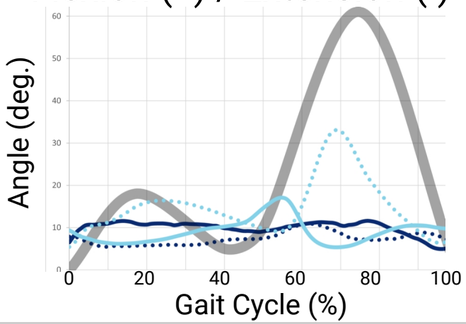
Trunk | Hip | Knee | Ankle

Left — ☑ Right ····· ☑ Normal

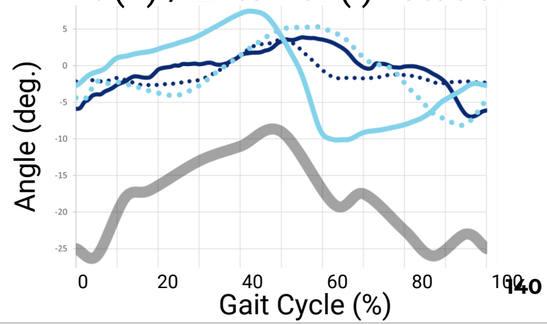
Abduction (+)/ Adduction (-)



Flexion (+) / Extension (-)



Int (+) / External (-)Rotation



Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

Viewer

- Joint Angle
- Distance
- Foot Position
- Gait Stability
- Time

Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

Viewer

- Joint Angle
- Distance
- Foot Position
- Gait Stability
- Time

Time

Gait Speed

- Data: 2.20
- Data + Standard Deviation: 2.2 ± 0.6
- Data + Minimum & Maximum: 2.20, Min. 1.33, Max. 4.75
- Average Plot
- Scatter Plot

Stance Phase Duration

- Data: 2.20
- Data + Standard Deviation: 2.2 ± 0.6
- Data + Minimum & Maximum: 2.20, Min. 1.33, Max. 4.75
- Average Plot
- Scatter Plot

Swing Phase Duration

- Data: 2.20
- Data + Standard Deviation: 2.2 ± 0.6
- Data + Minimum & Maximum: 2.20, Min. 1.33, Max. 4.75
- Average Plot
- Scatter Plot

Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

Viewer

- Joint Angle
- Distance
- Foot Position
- Gait Stability
- Time

Time

Gait Speed

- 2.20 — Data
- 2.2 ± 0.6 — Data + Standard Deviation
- 2.20, Min. 1.33, Max. 4.75 — Data + Minimum & Maximum
- Average Plot
- Scatter Plot

Stance Phase Duration

- 2.20 — Data
- 2.2 ± 0.6 — Data + Standard Deviation
- 2.20, Min. 1.33, Max. 4.75 — Data + Minimum & Maximum
- Average Plot
- Scatter Plot

Swing Phase Duration

- 2.20 — Data
- 2.2 ± 0.6 — Data + Standard Deviation
- 2.20, Min. 1.33, Max. 4.75 — Data + Minimum & Maximum
- Average Plot
- Scatter Plot

Viewer

- Joint Angle
- Distance
- Foot Position
- Gait Stability
- Time

Gait Stability

Clearance in Swing

- 2.20 — Data
- 2.2 ± 0.6 — Data + Standard Deviation
- 2.20, Min. 1.33, Max. 4.75 — Data + Minimum & Maximum
- 0% 50% 100% — Average Over Gait Cycle
- 0% 50% 100% — Every Step Over Gait Cycle
- 0s 20s 40s 60s — Over Time

Foot Orientation in Stance & Swing Phases

- 2.20 — Data
- 2.2 ± 0.6 — Data + Standard Deviation
- 2.20, Min. 1.33, Max. 4.75 — Data + Minimum & Maximum
- 0% 50% 100% — Average Over Gait Cycle
- 0% 50% 100% — Every Step Over Gait Cycle
- 0s 20s 40s 60s — Over Time

Patient: Roos Braam
DOB: 19/02/1951

Test 3/5/21, 10m Walk

File | Viewer | Comparison | Settings

- New
- Open
- Open Recent ▶
- Save
- Save As
- Print
- Share
- Logout

Viewer

- Joint Angle
- Distance
- Foot Position
- Gait Stability
- Time

Gait Stability

ance in
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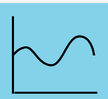
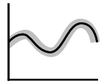
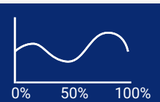
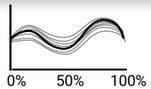
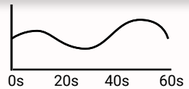
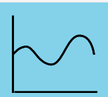
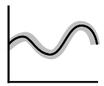
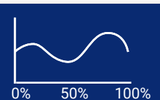
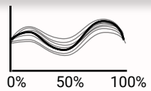
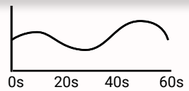
	 2.20 Data	 2.2 ± 0.6 Data + Standard Deviation	 2.20 Min. 1.33 Max. 4.75 Data + Minimum & Maximum
	 0% 50% 100% Average Over Gait Cycle	 0% 50% 100% Every Step Over Gait Cycle	 0s 20s 40s 60s Over Time
Foot Orientation in Stance & Swing Phases	 2.20 Data	 2.2 ± 0.6 Data + Standard Deviation	 2.20 Min. 1.33 Max. 4.75 Data + Minimum & Maximum
	 0% 50% 100% Average Over Gait Cycle	 0% 50% 100% Every Step Over Gait Cycle	 0s 20s 40s 60s Over Time

Appendix DD. Evaluation of Final Design Interview Questions

Prototype Tasks

1. Login
2. Open Test
3. Data Visualization Selection
    3.1. Find Viewer
    3.2. Select which parameters to view
    3.3. Select what categories to view at this time
4. Comparison Between Tests
    4.1. Find Comparison
    4.2. Add Tests
    4.3. Change parameters and features
5. Settings
    5.1. Find Settings
    5.2. Click on Time
    5.3. Change type of data and visualization
6. Done Viewing Data
    6.1. Click Logout

Evaluating Layout

• What do you like and what can be improved?

• Does it require additional instructions?

• Is it clear?

• How easy it is to understand and operate?

Evaluating Visualizations

• How easy is it to understand?

• How intuitive is it to interpret? Can you understand without additional instructions?

• Are the visualizations objective?

• Can they be viewed quickly time efficiently?

• Comparison Visualizations

o For comparison bar graphs, do you want all lefts together and all rights together or want it grouped by test?

o Is comparing three tests enough?

o The gait variation is not there. Do you miss it?

o Does left and right changing from viewer to comparison confuse you?

Clinical Eye vs. Gait Vision

The same questions were asked for the clinical eye and gait vision evaluation

• Can you spot the differences between the gaits easily?

• How objective is it?

• Is it intuitive to understand?

• Is it time-efficient?

• What parameters were you looking at when evaluating the gait? What parameters are you making your decision on?

• For interface, did you take the avatar video or visualizations into consideration more?

• What brace would you recommend and why?

Added Value

• Do you see this system adding any benefit to gait assessment? If so, where?

• If this product was offered in the next year would you want to use it?

• Do you think this would be of added benefit in trying to explain things to patients?

• How do you think this product can be used in 5 years in health care? What do you envision being done with the product?

Clinical Eye

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I can easily identify the difference between gaits	○	◉	○	○	○
2. I can objectively evaluate the gaits.	○	◉	○	○	○
3. I can interpret the gait time efficiently	○	◉	○	○	○
4. From the gait evaluation, I can recommend a brace to implement	○	◉	○	○	○

Gait Assessment

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I can easily identify the difference between gaits	○	◉	○	○	○
2. I can objectively evaluate the gaits.	○	◉	○	○	○
3. I can interpret the gait time efficiently	○	◉	○	○	○
4. From the gait evaluation, I can recommend a brace to implement	○	◉	○	○	○

Appendix EE. Final Design Evaluation - Interface Layout Questionnaire

Visual Aesthetics of Interface

	Strongly Disagree	*Disagree*	*Neither Agree nor Disagree*	*Agree*	*Strongly Agree*
1. The layout appears too dense.	①	②	③	④	⑤
2. The layout is easy to grasp.	①	②	③	④	⑤
3. The layout appears well structured.	①	②	③	④	⑤
4. The site appears patchy.	①	②	③	④	⑤
5. Everything goes together on this site.	①	②	③	④	⑤
6. The design is uninteresting.	①	②	③	④	⑤
7. The layout is inventive.	①	②	③	④	⑤
8. The design appears uninspired.	①	②	③	④	⑤
9. The layout appears dynamic.	①	②	③	④	⑤
10. The layout is pleasantly varied.	①	②	③	④	⑤
11. The color composition is attractive.	①	②	③	④	⑤
12. The colors do **not** match.	①	②	③	④	⑤
13. The choice of colors is botched.	①	②	③	④	⑤
14. The colors are appealing.	①	②	③	④	⑤
15. The layout appears professionally designed.	①	②	③	④	⑤
16. The layout is not up-to-date.	①	②	③	④	⑤
17. The site is designed with care.	①	②	③	④	⑤
18. The design of the site lacks a concept.	①	②	③	④	⑤

System Usability Scale

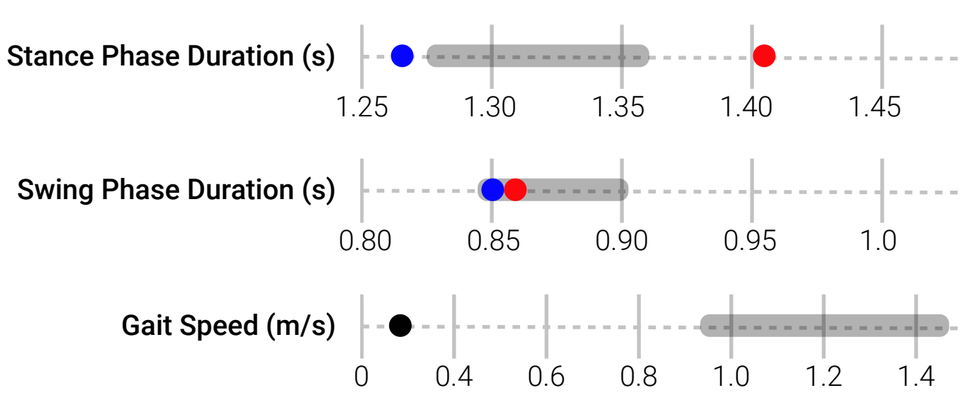
For each of the following statements, please mark one box that best describes your reactions to the interface today.

		Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1.	I think that I would like to use the interface frequently.	1	2	3	4	5
2.	I found the interface unnecessarily complex.	1	2	3	4	5
3.	I thought the interface was easy to use.	1	2	3	4	5
4.	I think that I would need the support of a technical person to be able to use the interface.	1	2	3	4	5
5.	I found the various functions in the interface were well integrated.	1	2	3	4	5
6.	I thought there was too much inconsistency in the interface.	1	2	3	4	5
7.	I would imagine that most people would learn to use the interface very quickly.	1	2	3	4	5
8.	I found the interface very cumbersome (awkward) to use.	1	2	3	4	5
9.	I felt very confident using the interface.	1	2	3	4	5
10.	I needed to learn a lot of things before I could get going with the interface.	1	2	3	4	5

Appendix FF. Final Design Evaluation - Interface Visualizations

Time

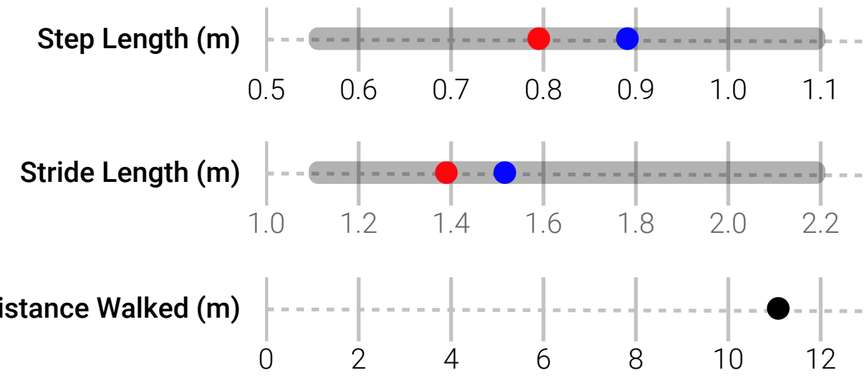
Left Right Normal



	Left	Right	Normal
Stance Phase Duration (s)	1.27 s 59.35 %	1.40 s 62.20 %	1.28 - 1.35 s 60 %
Swing Phase Duration (s)	0.87 s 40.65%	0.85 s 37.80%	0.85 - 0.90 s 40 %
Gait Speed (m/s)	0.28 m/s		0.94 - 1.43 m/s

Distance

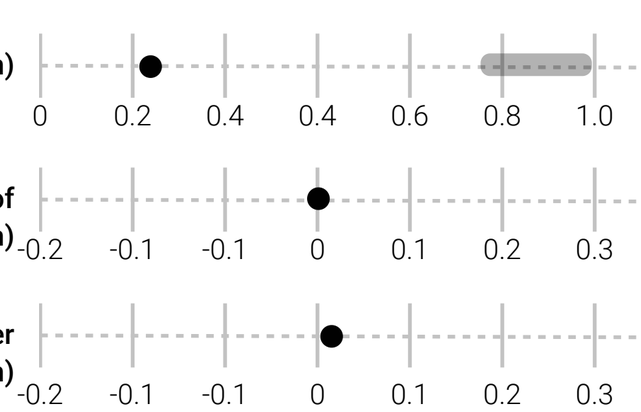
Left Right Normal



	Left	Right	Normal
Step Length (m)	0.90 m	0.80 m	0.56 - 1.10 m
Stride Length (m)	1.52 m	1.39 m	1.12 - 2.20 m
Distance Walked (m)	11.01 m		

Gait Stability

Normal

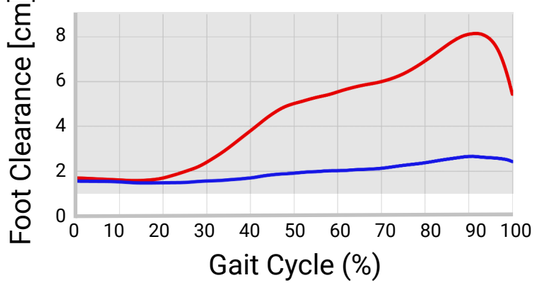


	Average	Normal
Gait Width (m)	0.90 m	0.77 - 0.96 m
Position Center of Mass (CoM) (m)	0.0m	
Extrapolated Center of Mass (XCoM) (m)	0.01 m	

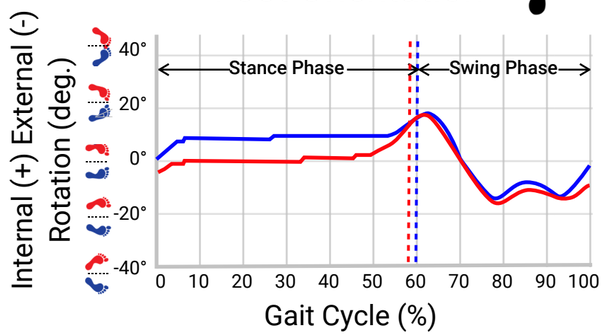
Foot Positioning

☑ Left ☑ Right ☑ Normal

Foot Clearance



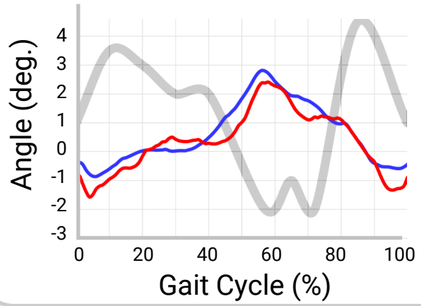
Foot Orientation



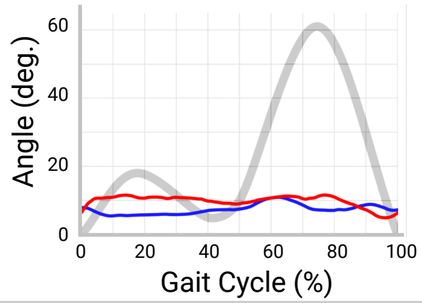
Knee

☑ Left ☑ Right ☑ Normal

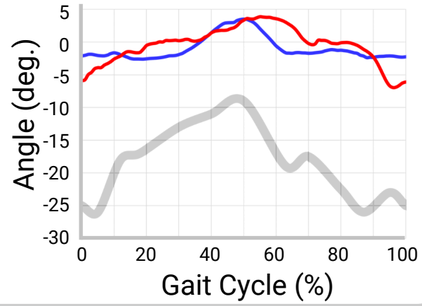
Abduction (+) / Adduction (-)



Flexion (+) / Extension (-)



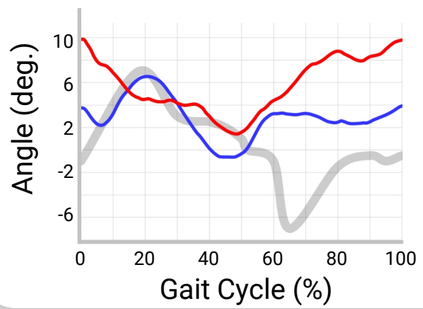
Int(+)/External(-) Rotation



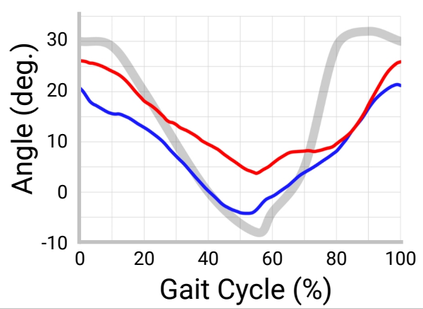
Hip

☑ Left ☑ Right ☑ Normal

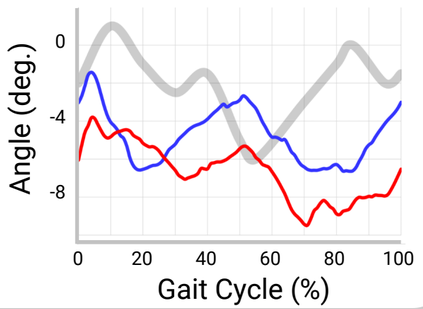
Abduction (+) / Adduction (-)



Flexion (+) / Extension (-)



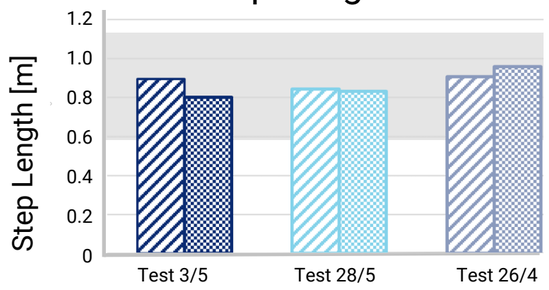
Int(+)/External(-) Rotation



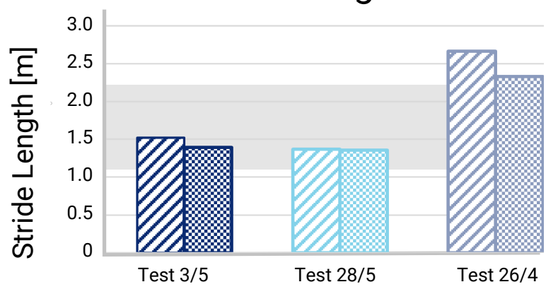
Distance

Left ▨ Right ▩ Normal

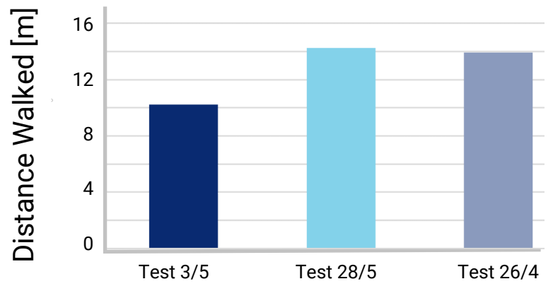
Step Length



Stride Length



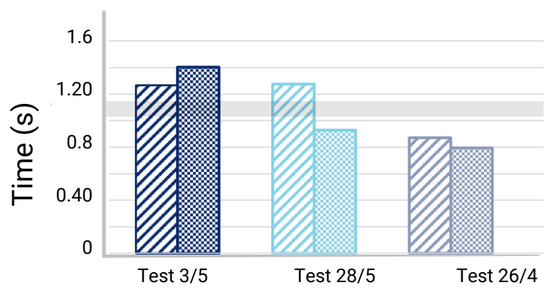
Distance Walked



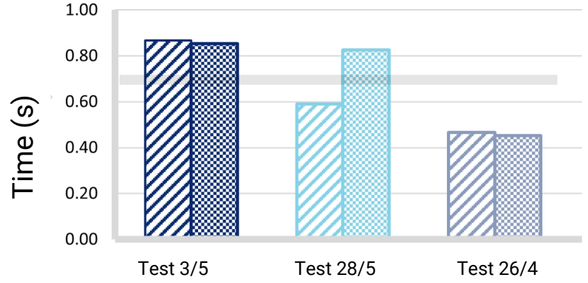
Time

Left ▨ Right ▩ Normal

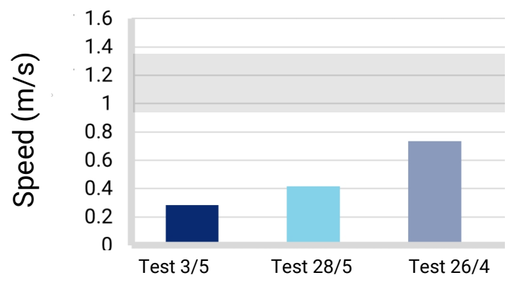
Stance Phase Duration



Swing Phase Duration

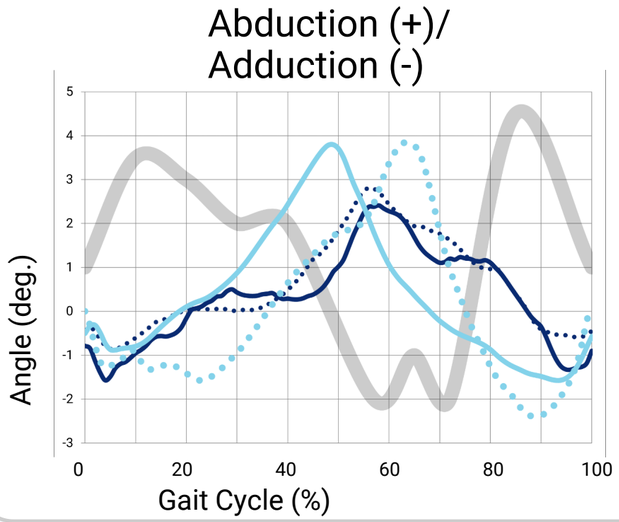


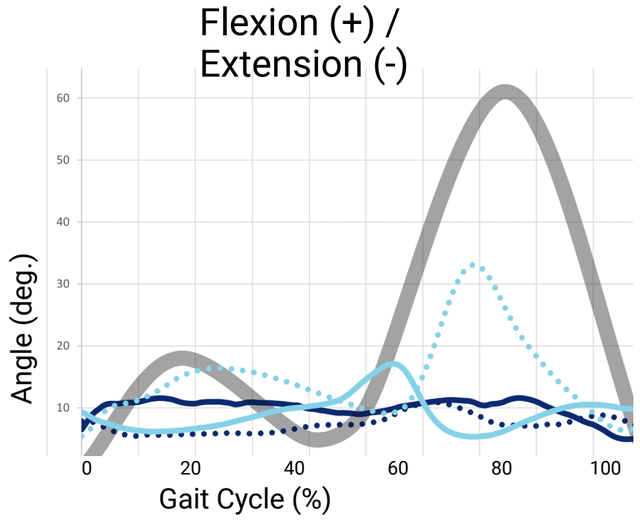
Gait Speed

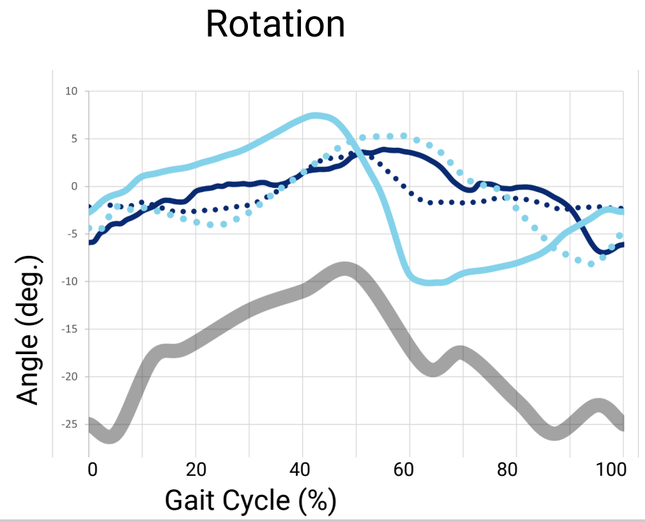


Knee

Left ▨ Right ▩



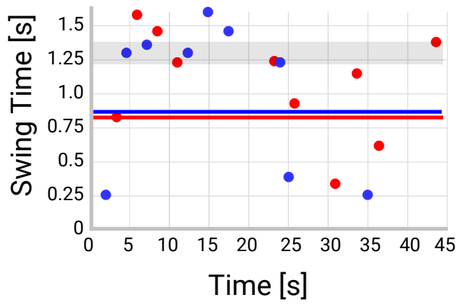




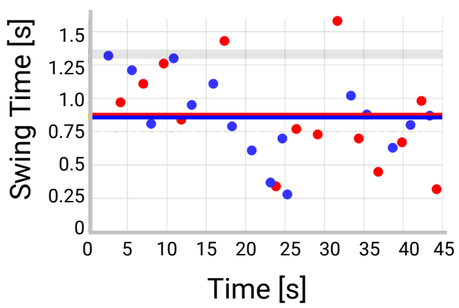
Time

Left Right Normal Average

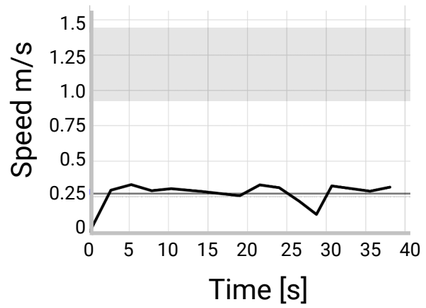
Stance Phase Duration



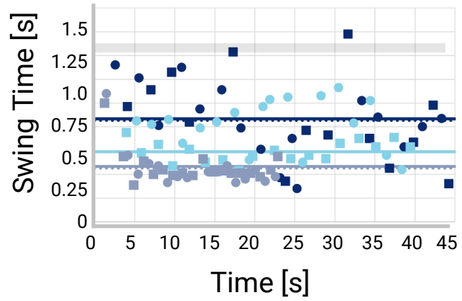
Swing Phase Duration



Gait Speed



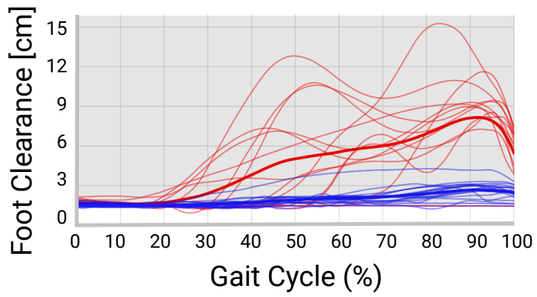
Swing Phase Duration



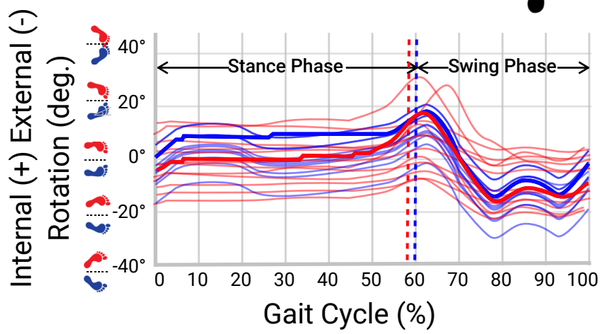
Foot Positioning

Left Right Normal

Foot Clearance



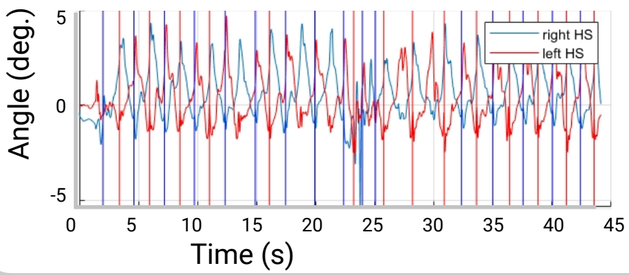
Foot Orientation



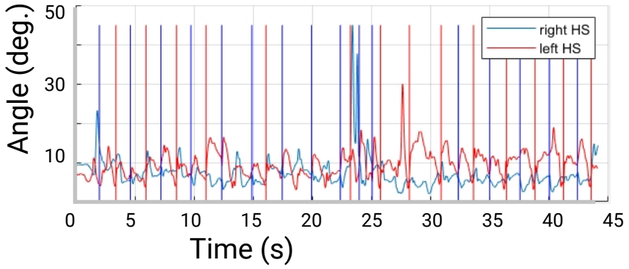
Knee

Left Right Normal

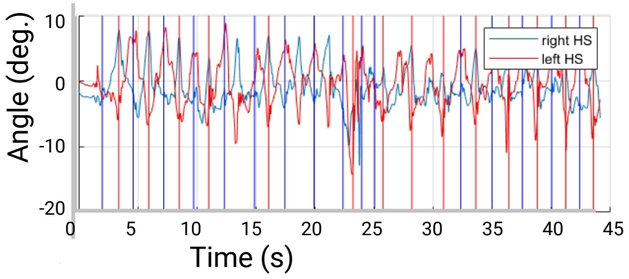
Abduction (+) / Adduction (-)



Flexion (+) / Extension (-)



Int(+)/External(-) Rotation

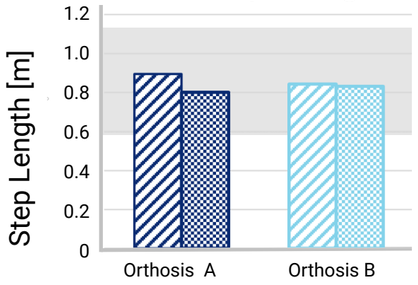


Appendix GG. Final Design Evaluation - Orthoses Comparison Visualizations

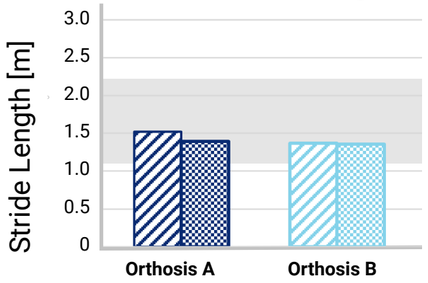
Distance

Left ▨ Right ▩

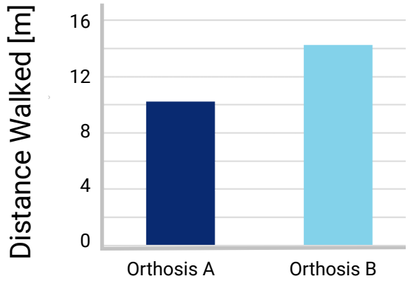
Step Length



Stride Length



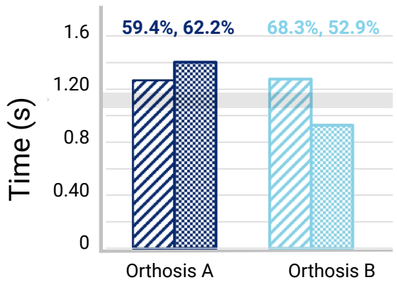
Distance Walked



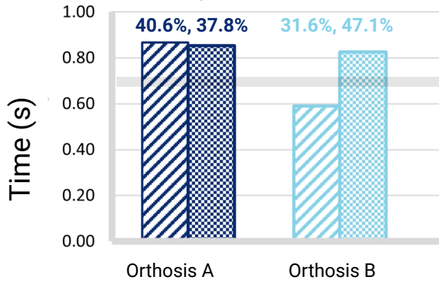
Time

Left ▨ Right ▩

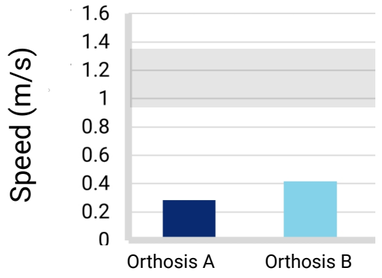
Stance Phase Duration



Swing Phase Duration

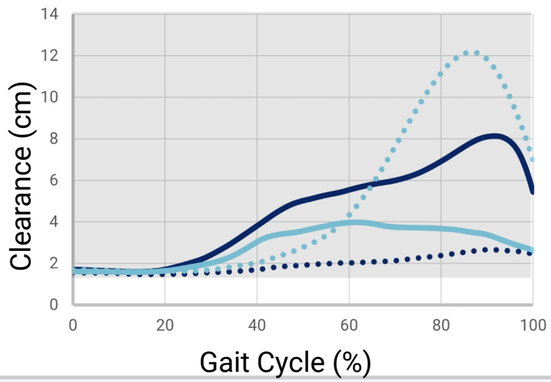


Gait Speed



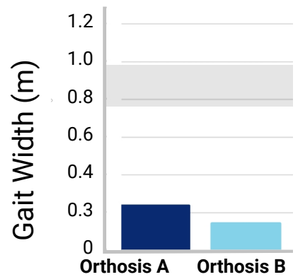
Clearance in Swing

Left — Right ····· Normal ■



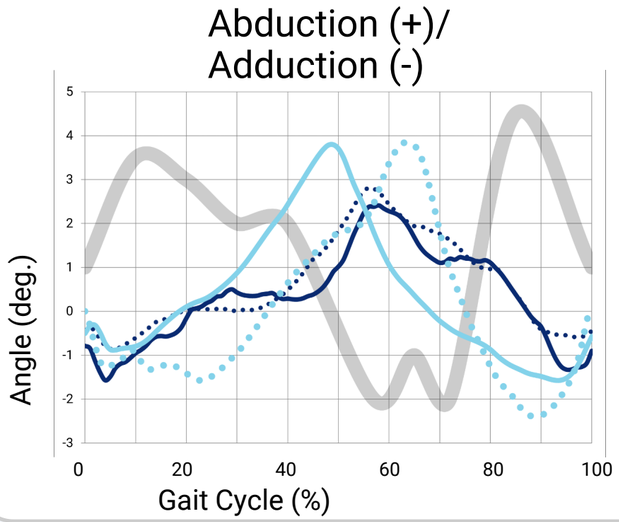
Gait Stability - Gait Width

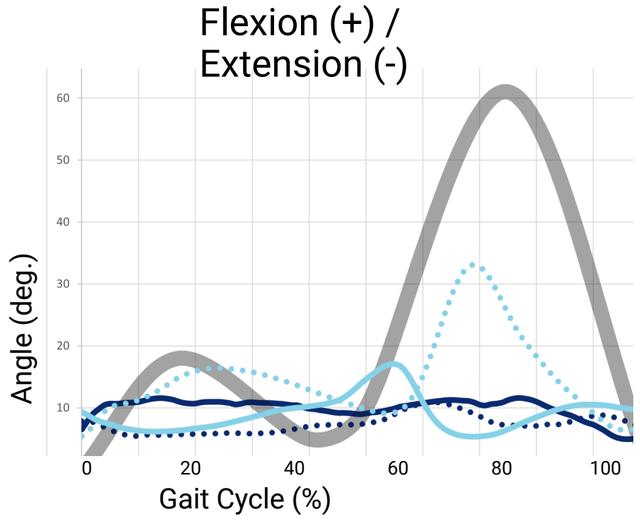
Normal ■

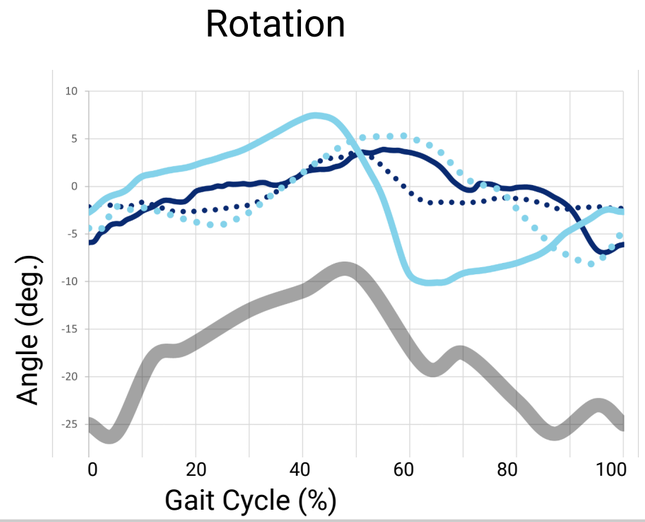


Knee

Left ▨ Right ▩







Appendix HH. Implementation - Behavioral Change Model

A

Specifying the Target Behaviour

-**Target behaviour**: To get clinicians to adapt to using system

-**Who needs to perform the behaviour**: Physiotherapists & Physicians

-What do they need to do differently to achieve the desired change: Use system in addition to clinical eye

-When do they need to do it?: When selecting orthosis

-Where do they need to do it?: On hospital premises

-How often do they need to do it?: When selecting orthosis

-With whom do they need to do it?: Alone

Capability-Opportunity-Motivation Behaviour Model

Most Important to change: Reflective motivation, Psychological Capability, Physical Opportunity

Medium Important: Automatic Motivation, Social opportunity

Least Important / Minimal to no change needed: Physical capability

COM-B Components	What need to happen for the target behaviour to occur	Is there a need for change
Physical capability	Have the physical skills to be able to put sensors on patient and operate digital interface	No change needs as clinicians have these skills
Psychological Capability	Know how to operate system	Minimal change needed as they know how to operate a computer and interface is easy to use
	Know how to interpret graphs	Change needed as most clinicians know what the parameters mean, but do not know how to interpret the graphs
Physical opportunity	Have access to system	Change needed as currently gait assessment system is located in a difficult to access location
Social opportunity	Clinicians talk to each other about using system and their experience	No change needed as they already discuss with each other tools they are using
Reflective motivation	Believing that there is added benefit to using the system (more objective, able to see detailed results, etc.)	Change needed as they are used to using clinical eye and are not as willing to abandon this way
Automatic motivation	Have established routines of when clinicians want to make a decision about something (Such as selecting orthosis) then they use the system	Change needed to establish routine

Behavioural diagnosis of the relevant COM-B	Psychological capability, physical opportunity, reflective motivation, and automatic motivation

BCW Intervention Functions

		Intervention Functions								
		Education	Persuasion	Incentivi-sation	Coercion	Training	Restriction	Environmental Restructuring	Modelling	Enablement
COM-B Components	Physical Capability					■				
	Psychological Capability	■		■	■	■				■
	Physical Opportunity							■		
	Social Opportunity							■	■	
	Reflective Motivation	■	■						■	
	Automatic Motivation	■	■	■	■				■	

APEASE Criteria

APEASE Criteria: Affordability, Practicality, Effectiveness and cost-effectiveness, Acceptability, Side-effects/safety, and Equity

Candidate Intervention Functions	**Does the intervention function meet the APEASE criteria (affordability, practicability, effectiveness/cost-effectiveness, acceptability, side-effects/ safety, equity) in the context of using the system to select interventions?**
Education	Yes, but need to be conscious of practicability in terms of how much time spent on education as physicians have limited time to spare
Persuasion	Not practicable in this context. / Not relevant
Incentivisation	Not effective as clinicians will not respond to it. Not acceptable by clinicians and Convergence Team
Coercion	Not effective as clinicians will not respond to it. Not acceptable by clinicians and Convergence Team
Training	Yes, but need to be conscious of practicability in terms of how much time spent on education as physicians have limited time to spare
Restriction	Not practicable as there is no ways to restrict in this context

Environmental Restructuring	Yes
Modelling	Yes
Enablement	Yes
Selected Functions	Education, Training, Environmental Restructuring, Modelling, Enablement

Link Between Intervention Functions & Policy Categories

		Intervention Functions				
Policy Categories		Education	Training	Environmental Restructuring	Modelling	Enablement
	Communication/ Marketing					
	Guidelines					
	Fiscal measures					
	Regulation (Policy, Protocol for this project)					
	Legislation					
	Environmental/ Social Planning					
	Service Provision					

Identifying Appropriate Policy Categories

Intervention Functions	**COM-B Component**	**Potentially useful policy categories**	**Does the intervention function meet the APEASE criteria (affordability, practicability, effectiveness/cost-effectiveness, acceptability, side-effects/ safety, equity) in the context of using the system to select interventions?**
Education	Psychological Capability Reflective Motivation Automatic Motivation	Communication / Marketing	Yes
		Guidelines	Yes
		Fiscal Measures	Not accepted by clinicians or Erasmus MC. Also, not affordable by Erasmus MC
		Regulation	Yes, but in terms of practicability may not be implemented until later stages
		Legislation	Not practicable in this context.
		Service Provision	Yes, but need to be conscious of practicability in terms of how much time spent on education as physicians have limited time to spare
Training	Physical Capability Psychological Capability	Communication / Marketing	Yes
		Guidelines	Yes
		Fiscal Measures	Not accepted by clinicians or Erasmus MC. Also, not affordable by Erasmus MC
		Service Provision	Yes, but need to be conscious of practicability in terms of how much time spent on education as physicians have limited time to spare
Environmental Restructuring	Physical Opportunity Social Opportunity	Communication / Marketing	Yes
		Legislation	Not practicable in this context.
		Environmental / Social Planning	Yes
Modelling	Social Opportunity Reflective Motivation Automatic Motivation	Communication / Marketing	Yes
		Environmental / Social Planning	Yes
Enablement	Psychological Capability	Environmental / Social Planning	Yes
		Service Position	Not practicable to have support service with immediate response, but is practicable to have support service that responds within a few days.
Policy Category Selected		Communication/marketing, Guidelines, Regulation, Environmental / Social Planning, Service Provision	

Identify Behaviour Change Techniques

Intervention Functions	**COM-B Component served by intervention functions**	**Policy categories through which BCTs can be delivered**	**Intervention Strategy**	**Mode of Delivery**
Education	Psychological Capability Reflective Motivation Automatic Motivation	Communication / Marketing	Talking at monthly meetings and sending emails to get people to attend classes to learn about gait assessment and training on how to use the system Talking at monthly meetings to get people on board to use the system	Over real time meeting
		Guidelines	Manual / tutorial on how to use the system. Also include how to use it for specific scenarios (selecting interventions, tracking progress, etc.) Informational packet on what the parameters mean and how to interpret the visualizations	Digital or physical copies. Can also be done through videos (in addition, not sole way of delivery) Guidelines can be explained in a meeting, if time allows
		Regulation	Integrate system into protocol clinicians and physicians have to follow. For example, when selecting an orthosis, integrate having to use the system at the beginning of the selection process into the protocol. Or for inpatient rehabilitation, as part of the patient's rehab protocol, every 2 weeks a test is conducted to track their process. Could also be integrated when departments are restructuring their protocols and processes / how they do things. Could also be part of the protocol that every new physiotherapist has to take part in a course to learn about gait assessment and how to use the system. In terms of practicability may not be implemented until later stages	Explain changes to protocol in meeting Written protocol in digital or physical form

		Service Provision	Providing classes to educate clinicians on gait assessment, the benefits of the system, and how and when to use the system. Need to be conscious of practicability in terms of how much time spent on education as physicians have limited time to spare	Meetings in person or online in real time. Alternatively, to accommodate people's schedules could be format of an online class with lectures, written documents, and assignments they complete to test their understanding.
Training	Physical Capability Psychological Capability	Communication / Marketing	Same as Education or See Education	See Education
		Guidelines	Same as Education	See Education
		Service Provision	Providing classes to show them and have them practice how to use the entire system (attaching sensors, calibration, collecting data, etc.). Also to show them how to use the interface. Need to be conscious of practicability in terms of how much time spent on education as physicians have limited time to spare	Preferably in person, real time meeting. Alternatively, to accommodate people's schedules could be format of an online class with lectures and written documents. Then have to do an in person demonstration to a qualified person to prove they can operate the system. These tests could take place at a set time every month or be scheduled individually per person.
Environmental Restructuring	Physical Opportunity Social Opportunity	Communication / Marketing	Encourage clinicians to talk to each other about their experience using the system	Talk about this about at a weekly or monthly meeting. Can also send reminders via email.
		Environmental / Social Planning	Placing the system in such a location that is easy to access by all departments Social planning → As part of every weekly meeting every so often or as part of monthly meetings make it such that people using the system can share their experiences with the group	During training show people where the system is located and how to access it. Take 5 minutes of every monthly meeting or every so often weekly meeting to have people share their experience.
Modelling	Social Opportunity Reflective Motivation Automatic Motivation	Communication / Marketing	Encourage clinicians to talk to each other about their experience using the system Start by recruiting a small number of clinicians to train and use the system. They can then serve as models when expand	Talk about this about at a weekly or monthly meeting. Can also send reminders via email. Can publish a list of people who use the system and are willing to talk about it and then people can contact them for more info, Recruit via email and in person conversations.

		Guidelines	Provide examples of the added benefit of using the system Provide examples of how to use the system to evaluate orthosis	Rather than talking about it, show examples through videos or written/graphic documents. Can be done through real time meetings or through videos/online lectures. Can also be done through a print or digital document.
		Environmental / Social Planning	Social planning → as part of every weekly meeting every so often or as part of monthly meetings make it such that people using the system can share their experiences with the group	Talk about this about at a weekly or monthly meeting. Can be done through a monthly email where updates on the system are shared and testimonials from clinicians are included
Enablement	Psychological Capability	Environmental / Social Planning	Make it easy to find out who to contact if they have a problem and for them to contact them to be easy Having a meeting once a month where clinicians can come and have their questions answered. Can also be done quickly at an already existing meeting or a non-mandatory, open meeting that occurs for an hour every other week when anyone can join at anytime during that hour (like office hours).	In manual include contact details of point person. In the interface include contract details of point person Have a form liked in the interface that they fill out if they have issues or have questions Questions can be answered quickly at an already existing meeting or a non-mandatory, open meeting that occurs for an hour every other week when anyone can join at anytime during that hour (like office hours
		Service Position	Help support/person / support services / point person that they can contact when they have a problem/difficulty using the system or interpreting the results. Not practicable to have support service with immediate response, but is practicable to have support service that responds within a few days.	Contact support through email or phone (which is listed in the manual and interface) Fill out a form in the interface when have a question or problem.

Appendix II. Implementation - Interface Technology Implementation Plan

Interface Technology

Horizons	Horizon 1: 2022		Horizon 2: 2023	Horizon 3: 2025	Horizon 4: 2028	Horizon 5: 2031
	July - September 2021	October - December 2022				
Operating Device	Laptop	Laptop	Laptop & Desktop	Laptop & Desktop	Laptop, Desktop, Tablet	Laptop, Desktop, Tablet, Phone
Technology Set Up	• Algorithms • Xsens System • Application	• Algorithms • Xsens System • Application • Database	• Algorithms • Xsens System • Application • Database	• Algorithms • Xsens System • Application • Database • Security • Plugin	• Algorithms • Xsens System • Application • Database • Security • Plugin • Healthcare Records System	• Algorithms • Xsens System • Application • Database • Security • Plugin • Healthcare Records System • Machine Learning
Interface Capabilities	• View End of Trial • Can select parameter categories but not individual parameters • View Avatar in fixed position	• Can select parameters & parameter categories • Comparison with 2 Tests • Workable Interface without aesthetics	• View Real Time & End of Trial • Workable Interface with aesthetics • Can change settings • Comparison with 3 tests • Rotate Avatar	• Track Patient Progress • Secured login per user • Can change settings • Can print out report • Can send test file	• Separate interface for patients • Can add tests to patient's records	• Provide feedback to aid in interpretation for inexperienced clinicians
Data	• Data	• Data	• Data • Standard Deviation • Minimum & Maximum	• Data • Standard Deviation • Minimum & Maximum	• Data • Standard Deviation • Minimum & Maximum	• Data • Standard Deviation • Minimum & Maximum
Visualizations	• Average Horizontal Plot • Line graph of average over gait cycle	• Scatter Plots • Line graph of every step over gait cycle	• Line graph over time	• No Change	• No Change	• No Change
Features	• Swing & Stance Phase Labels • Avatar in fixed position	• Can turn on/off left, right, & normal	• Can rotate avatar • Avatar progress displayed on graphs • Zoom in/out of graphs	• Can print out report	• Can leave notes on tests in interface	• Provides feedback to guide inexperienced clinician in identifying most pressing issues
Quantity of Technology	• 1 Xsens System • 1 Computer to control Xsens • 1 Computer to view interface results	• 1 Xsens System • 1 Computer to control Xsens • Interface results can be viewed on 1 laptop per department	• 2 Xsens System • 1 Computer per department that can control Xsens • Interface results can be viewed on any laptop	• 5 Xsens Systems • 2 computers per department that can control Xsens • Interface results can be viewed on any laptop • Interface results can be viewed on any tablet	• 3 Xsens systems per location • 2 computers per department that can control Xsens • Interface results can be viewed on any laptop • Interface results can be viewed on any tablet	• 3 Xsens systems per location • 2 computers per department that can control Xsens • Interface results can be viewed on any laptop • Interface results can be viewed on any tablet

Appendix JJ. Implementation - Financial Overview

Horizon	Item	Quanitity		Material Cost		Component Cost	Total Cost
Horizon 1: 2022	Developing Interface	428	hr	€ 50.00	per hour	€ 21,400.00	€ 36,768.00
	Developing Education Plan	120	hr	€ 50.00	per hour	€ 6,000.00	
	Xsens System	1		€ 6,343.00	per system	€ 6,343.00	
	Xsens Software (MVN Analyze)	1		€ 3,025.00	per year	€ 3,025.00	
Horizon 2: 2023	Developing Interface	81	hr	€ 50.00	per hour	€ 4,050.00	€ 8,075.00
	Leading education and training sessions	20	hr	€ 50.00	per hour	€ 1,000.00	
	Xsens Software Subscription (1 year)	1		€ 3,025.00	per year	€ 3,025.00	
Horizon 3: 2025	Developing Interface	86	hr	€ 50.00	per hour	€ 4,300.00	€ 21,718.00
	Leading education and training sessions	40	hr	€ 50.00	per hour	€ 2,000.00	
	Xsens System	1		€ 6,343.00	per system	€ 6,343.00	
	New Xsens Software (MVN Analyze)	2		€ 3,025.00	per year	€ 6,050.00	
	Existing Xsens Software Subscription (1 year)	1		€ 3,025.00	per year	€ 3,025.00	
Horizon 4: 2028	Developing Interface	246	hr	€ 50.00	per hour	€ 12,300.00	€ 63,529.00
	Developing Patient Interface	249	hr	€ 50.00	per hour	€ 12,450.00	
	Leading education and training sessions	40	hr	€ 50.00	per hour	€ 2,000.00	
	Xsens System	3		€ 6,343.00	per system	€ 19,029.00	
	Data Processing Software Development	355		€ 50.00	per hour	€ 17,750.00	
Horizon 5: 2031	Developing Interfaces	240	hr	€ 50.00	per hour	€ 12,000.00	€ 43,715.00
	Xsens System	5		€ 6,343.00	per system	€ 31,715.00	

The hours to develop the interfaces was calculated using adc calculator (https://www.appdevelopmentcost.com/).