Danhua Wu

Applying User Testing Practices on a Wearable Device

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Abstract

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The purpose of this final year project was to find out the usefulness of Kinemata, a wearable device that was created with the intension of assisting an amateur perform physical training without external supervision. The suitability of the device for this purpose has been examined with the help of common user experience design guidelines.

Two user tests were organised with the help of medical experts and sports professionals. Qualitative research methods such as focus group discussion, observation, interviews and a questionnaire were conducted for user tests.

The tests sessions were recorded and analysed. The collected data/information helped to identify the strong and weak aspects of the device. Feedback from participants indicated what the benefits and drawbacks of the Kinemata devices and software are.

The project demonstrates the efficiency of qualitative research methods. The project results influence the further development of the Kinemata wearable. The results will be used by a development team to improve the next version of the device and software.

Keywords	wearable devices, user experience, qualitative research method

Contents

1 Introduction

Modern technology is able to provide numerous benefits for the human life. Technological devices are getting so deep into human everyday lives that one can only imagine what advancements would/will be available in the near future. Wearable devices are one of the most interactive enhancements currently available. Interaction happens even when people are not aware of it. For example, heart rate, location, calories and sleep time are being recorded 24 hours per day for future use.

Researchers from Aalto University in Finland have developed a prototype of a device capable of detecting human limb position, acceleration, and pitch tracking. During early stages of the project, research help was needed and I volunteered to develop and apply user tests for the device in practice. The goal of this thesis is to analyse the usefulness and necessity of the device in the current state, and provide feedback that will be used for future improvement. The analysis is based on testing that was performed with the help of medical experts and sports professionals, who have participated in the testing.

2 Wearable Devices

Humans have always attempted to improve the functionality of their bodies. Natural ways of improving capabilities are exercising, dieting, and paying attention to health. Artificially, humans have been augmenting themselves with, for instance, tattoos, piercings and jewellery. In recent years, people with disabilities have been provided with high-tech gadgets that help them solve everyday tasks otherwise impossible for them. While in the future augmentation might be implemented directly into the body, today people use devices that can be worn. These are called wearable devices.

A wearable devices have been around for a while now. An example is the wrist watch. Only hundred years ago, watches were carried around in the pocket, or on the neck, and required two hands to open them and check the time. In the 19th century, a German military officer invented a way to strap the watch on the wrist. [1,5.]

Starting from the 1980s, people started wearing all kind of devices, from video recorders and cameras to TVs and radios. Most of the devices were clunky and massive at that time. [1,228.]

Since the beginning of 2000, wearable devices started to become smaller while their functionality increased. The first fitness trackers were able to count the amount of steps a user takes. Sport companies such as Nike embedded fitness sensors into their clothes and shoes, thus simplifying the process of using the wearable devices. At the moment of writing, the Vandrico Inc. wearable database includes 433 wearable devices available for purchase. [2.]

Companies such Fitbit started to appear, concentrating only on wearable devices. In the beginning of 2010, wearable devices stopped being exotic and became a mass product [3]. It became clear that if one wants to succeed in sports without a trainer, a wearable device is something that can help.

2.1 Examples of Wearable Device in Use

Fitness Wearable Tracker

Fitness trackers are popular wearable devices nowadays [2]. With Fitness trackers, it is easier to record one's fitness and health details. Fitness trackers use syncing technology to connect with mobile devices. Users' activity and sleep reports are illustrated through mobile applications. During the day, fitness trackers track various functions of the body.

Autonomous functions such as the ones listed below, do not need active user interface interaction:

- Activity
- Calories burned
- Heartrate
- Steps
- Distance
- Sleep time
- Time (clock)

Functions were the user has to perform interactions with the interface including the following:

- Calories intake
- Alarm clock
- Goal setting
- Reminders

The average battery life of a fitness tracker is 8 days, however, Xiaomi Mi Band can last up to 30 days. Most of the fitness trackers in the market are made with water-resistant material. This feature brings convenience for users while showering, sweating and other unplanned weather situation. [2;3.]

Medical Wearable Devices

Heart diseases have turned into one of the highest case leading to premature death in the whole world. As reported by World Health Organization, it has been predicted that heart disease rate might reach to 23.3% worldwide by the year 2030. However, patients' medication would be more accuracy with the health statement monitoring. [4,1.]

The first monitoring devices were wired to the patient, transmitting heart rate and other vital information to a monitor nearby [4,2]. With the development of wireless technology and especially Bluetooth, the only problem that remained was powering the device. Nowadays battery capacity is enough to power wearable device for more than a week, which is a great improvement for continuing the development of medical wearables.

An example of technological advancement in the medical field is a wrist blood pressure monitor manufactured by Omron Healthcare Company at CES 2016. It is called "Project Zero" and it is currently the smallest, lightest, and quietest blood pressure monitor. It is the size of the regular wristwatch. The device is able to take measurements of the blood pressure, record physical activity, and track sleeping data. It has wireless connectivity option, which allows reviewing previous results on the phone or computer. [5.]

The Zephyr performance system offers various products for collecting heart rate and R-R data. Collected data is important for discovering early stage of diseases, for instance, hypotension, hypertension, and arrhythmia. Transmitted data are sent through Bluetooth, and received by devices. Consumer also needs a mobile application in order to access all kind of data that has been recorded. The application is supported by main mobile platforms such as, iOS, Android, Windows. [6.]

The example of Omron Healthcare and Zephryr show how easy and simple it is to use wearable devices. While sensors get smaller and require less energy than before, healthcare solutions get more discreet and less noticeable.

Wearable Tracking Devices for Children

There are two kind of main technologies in the market that are used to trace the location of children. Simple radio waves are great in use of monitoring children’s locations in short distance. A signal will be sent to a parent’s phone through Bluetooth, such technology is perfect for the moment in the grocery store when a patient turns around to find their child out of their sight. [7.]

With the development of the GPS technology, it has become an easy task to keep tracking on children’s whereabouts with one’s mobile devices. Besides the real-time location services, some of the newer wearable devices offer geo-fencing safe zone settings, which will inform the guardian immediately once the kids are out of the safe zone which the guardian settled. Heart rate and ambient temperature information received by the guardian will prevent heat stroke happens. [7.]

Like the main function of the fitness tracker, wearable devices for children also have the activity tracking sensor built in. It is great information for parents to know how active the child is. One of these products is introduced by PAXIE safe family wearable [8]. These kinds of wearable devices meet the parent's needs concerning their children's safety, keep the worries away.

2.2 Human-Computer Interaction

Computers are becoming an essential part of people's everyday life, not only limited by work or hobby. This level of involvement directs the design and evaluation towards user experience. Interaction design should not only improve usability for the product, but also set goals for user experience — make experience motivating, enjoyable, and satisfactory [9]. Interaction design teams usually are combined of people with different backgrounds and views, which makes the design process more complex, but combine multiple opinions [10,39].

Human-computer interactions have developed a strong link between design and usability in the last fifteen years. With the introduction of new devices, old methodologies like direct manipulation do not work [11]. Computers are no longer bulky desktop PCs that are used only for complicated job related tasks. They are becoming everyday items, part of the human environment, and part of the human in the form of wearables.

Human-computer interaction is concentrated on designing products, rather than experiences resulting from interaction with product. In order to design experiences one should mainly concentrate effort on a product's interaction and functionality, since a product and its experiences are closely related. Uncomplicated products have a tendency of delivering poor experiences. [12,49.]

Talia Lavie and Noam Tractinsky have defined five quality dimensions important for user experience:

- Classical aesthetics
- Expressive aesthetics

- Usability
- Pleasurable interaction
- Service quality [13,49.]

Example attributes for these quality dimensions are “clean design”, “original design”, “easy to use”, “feel pleasure”, and “can count on site” respectively. [13.] Most of the dimensions are product-oriented, while pleasurable interaction is more experience-oriented. [13,49.]

Human-computer interaction research began with the goal of learning human behaviour in the work environment. In the centre of the analysis was the human and his/her behaviour [14]. It became a key task of usability testing. Products were described as something that should stimulate the user, provide new experiences, and allow user to learn new things. At the same time the product should be pleasing to the user. These aspects create a multidimensional model of the product, which allows getting better understanding of the design. [14,93.]

Another aspect that was discovered to affect the user experience was the ability for the user to choose personalized user interfaces. Depending on the product’s purpose (“work” versus “leisure”) and time restrictions (“social” versus “time pressure”) the product may have a greater or lesser impact on the user’s choice and valuation. [14,93.]

Researchers of Human-computer interactions have been always setting the goal to design user interfaces that will avoid the user to face frustration and dissatisfaction. User experience has been based on the human perspective, rather than the functionalities perspective. It has focused on delivering positive experiences to the user joy, fun, and pride.

Some of the user experience researchers such as Kim and Moon [15], Desmet and Hekkert [16], and Hassenzahl [17] have based their research on the emotion analysis:

- Consequences (what kind of emotions come after using the product)
- Past (the emotions that come from previous experiences of using the same or similar kinds of products)

Since the source of particular emotions might be difficult to pinpoint, the task of designing a product that will give predictable response is a difficult task. The proposed solution was to create the context for emotion rather than the emotion itself. The context would be assembled with variations effects for creating affective responses. The responses, though, are dependent on the users' goal. Tracking the way emotions affect judgement and decision-making, both immediately and long-term, is essential for successful user experience. [14,94.]

2.3 Research methods for investigating user experience

"Obser-view" Observation & Interview

Linda Kragelund has written an article in which she discusses the ability of interviews incorporate reflection and lead to mutual learning [18]. Mellanie Rollans provides instructions and guidelines on how to record qualitative observation data on the example of the 4D&4R observational tool that was developed for this purpose [19]. The researchers mentioned above recommend combining observation with an interview, therefore gathering both inside and outside perspectives [20].

In her work, Linda Kragelund has stated that she used the semi-structured interview and observation approach at first [18]. However, testers have expressed their will to provide feedback in the form of the interview after being observed, providing comments on their behaviour while being observed. This way, both the researcher and participants understood better observations made earlier. [19.]

In the linked observation and interview, the data recorded provides insider and outsider perspectives. The approach that Kragelund offered allows getting intersubjective perspectives and gives extra transparency to the research. Kragelund called this approach "obser-view". [20.]

Kragelund defines the new approach as more direct, since the participants are playing essential role in the process of constructing data, by directly contributing. The "obser-view" approach means that after observational data was collected, the data should be immediately discussed between researchers and observants. It helps to get better understanding of a tester's behaviour for both the tester and researcher. [20.]

Audiovisual recording of the event and participant's interaction is beneficial for the quality of data recording. It is beneficial for the researcher in the long run, since it would simplify the task of the explanation and justification of data accuracy and integrity. [20.]

Questionnaire

Qualitative responses to the questionnaire are able to justify and clarify the quantitative responses [21]. In order to guarantee the accuracy, genuineness, and commitment of the tester, one should design a questionnaire keeping its specifications in mind. Questionnaire specifications include [21]:

- Length
- Format
- Sequence
- Wording
- Question types:
    - Classification
    - Behavioural
    - Knowledge
    - Perception

Question responses could be in closed, open, or mixed format. Sarantakos has defined closed questions as simple for analysis and difficult for constructing. At the same time he points out that open questions are easier to construct than analyse. [21.]

Open questions offer possibility for unique and spontaneous answer. Free form responses allow the user to share personal experiences, opinions, and understanding on the topic. [22.]

Both types of questions are essential for the research. Responses that are generated by closed questions are easily summarized and clearly presented, while answers from the open questions add depth and meaning to the results in general.

As mentioned before, there are five basic types of questions: classification, behavioural, knowledge, perception and feelings. Classification questions are created in order to classify a person in relation to others and for supporting information that may predict the main effects revealed from behavioural, knowledge, perception or feeling questions. [23;24.]

Focus group interviews

Focus group interviews have a group of individuals gathered to discuss a topic that has been introduced by a facilitator. The facilitator is defining the topic of discussion and the main key-points, without taking part the discussion itself. The discussion is being held in an informal manner, and the facilitator does not “interview” participants. He/she guides and directs the discussion. Another task of the facilitator is to ensure that every participant of the focus group participates in the discussion. The ability of the facilitator to be there as a passive listener, meanwhile leading the direction of the discussion flow and posing important questions, is essential. [25,177.]

The focus group session is recorded for further analysis. After the meeting is over, transcribed data out of the recording is being analysed using content or thematic analysis. The focus group members are typically assembled from different social layers, making group to have variety of distinctive individuals. The method emphasises the importance of the focus group facilitator to be able to run effective discussion that would have all the necessary information for further analysis. [25,178.]

The focus group interviews are conducted more as “everyday talk” rather than “interview”. Thus, the participants feel more relaxed and participate more dynamically when they feel that other members are in the same position as they are. Another reason for using the focus groups is the ability to save time. Performing an interview with each member of the focus group would be time consuming. Furthermore, being alone in an interview is more stressful than participating in a group discussion. These factors may lead to unexpected answers, and people might have trouble expressing thoughts clearly. [25,180.]

3 Kinemata

Memorising and repeating someone else's movements in exercising might be a challenging task, especially when there is no one around who could point on the obvious mistakes observable from the outside. Kinemata is designed to overcome these limitations by assisting in performing accurate motions (see figure 1). Kinemata is constantly sending signals to the user as tactile and visual responses to the user's movements.

Figure 1. Current version of Kinemata.

Kinemata has been designed and developed by the Learning Environments research group of Aalto University department of School of Arts, Design and Architecture. The main designers and developers have been Jana Pejoska and Johannes Neumeier.

Kinemata is meant to be a self-learning tool and to be used in tandem with an instructor. As a self-learning tool the user should perform reference movement recording and then use that recording to master the movement. For the latter one, the instructor could perform movement while wearing Kinemata and record that movement. Later the learner can compare that recording as comparable to his/her own movements.

Kinemata can be used not only as a sports learning tool, but as an artistic performance tool. Movement can be translated to sound or visual response while performing, or it can be controlled remotely.

The first version of Kinemata had handcrafted casing. The bottom part was created from the wood, using a conventional drill. A metal buckle was added for the straps that attached the device to the user. The top part of the casing was maser cut from acryl, then glued together in order to form a thicker casing. Both parts were connected using glue and screws. The device was polished with sandpaper in order to make the surface smooth and create an organic feeling (see figure 2).

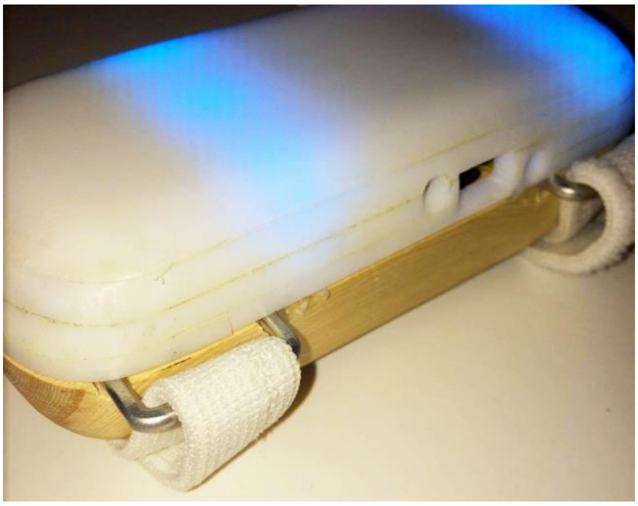

Figure 2. Previous version of Kinemata.

As the project went along, a new version of Kinemata was built. The second iteration of the device had a fully 3D printed protection case instead of wood and acrylic. The top and bottom part of Kinemata v2 were printed as pieces of a puzzle, fitting each other on the edges Therefore no glue was used for connection. Metal buckle parts were removed as well – the new version has a single wide rubber strap going through the device, which simplifies putting onto the user. Kinemata v2 was made more than twice thinner and 100 grams lighter than v1. A custom designed printed circuit board was developed specifically for this device.

The components for the circuit buird have not changed with the second iteration of the device. Several LEDs have been installed on the circuit board inside the casing. Both the acrylic and the 3D printed case are transparent enough to see the light through it. However they are matte enough so nothing else could be seen through them. This way device gets more professional, almost “commercial” look. One of the LEDs is used for showing Bluetooth connection status, when the connection is enabled and the device is successfully connected. Whenever there is no light, the connection between Kinemata and the computer is lost. Kinemata v1 had six additional LEDs that were changing colours depending on the angle and position of the device. The LEDs were able to change light colour between six colors, depending on the sensor readings. In the later version six LEDs were replaced by a single LED in the middle of device. The new LED is capable of showing 12 colours, therefore reacting to smaller sensor iterations.

The current version of Kinemata has a battery that lasts less than an hour without charging. Designers were primarily focusing on the functionality of the device Therefore, the problem of battery capacity has not been taken into consideration.

The Kinemata software was designed specifically for measuring, monitoring and recording data. The software records at 60 frames per second which is precise enough to record every quick movement of the device. The data from the device or devices are shown in the software simultaneously as sensors on the device generate it. The Kinemata software provides flexibility to the user, and user can choose which data would be shown in real time and which data will be recorded (see figure 3.).

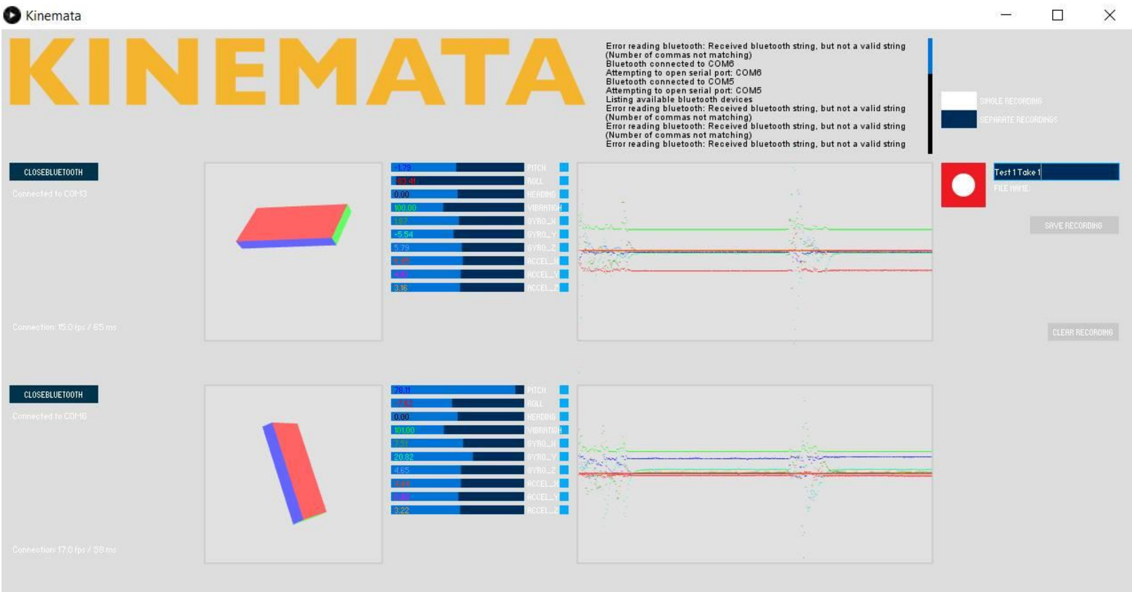

Figure 3. Kinemata software.

On the right side of the large “KINEMATA” heading, there is a dynamic notification box is located. The information about connectivity and Bluetooth status, as well as showing debugging information will be updated. As mentioned before, Kinemata devices could be used in a pair, or singularly. The button on the right of the notification box is able to switch between double-single mode recordings.

The Bluetooth device selector is located on the left side of the Kinemata software window. Before using the software, the device (or devices) should be paired with the computer's Bluetooth adapter. When searching for Bluetooth devices, the Kinemata v1 device has a Bluetooth module name starting from "CA", while the newer device has a name starting with "DE". After pairing is done, the Bluetooth device selector should be refreshed with the "refresh" button which would appear next to the selector. After the list has been refreshed, the correct device should be selected for one or both lists. After the connection has been established, the Bluetooth light on the Kinemata device would stop blinking. In order to ensure that the connection is working, one should shake device around. Shaking of the device is a recommended procedure every time the device is connected, as it resets sensor extremes. If the connection is successful, the 3D modeled cuboid, on the right from the Bluetooth selector, will repeat the rotation of the actual device. If the cuboid is completely static and does not move, wrong Bluetooth has been selected, or the connection is lost.

On the right side of the 3D model of the cuboid, the list of data is updated in real time and available for recording. The user can manage which data will be displayed and recorded by disabling and enabling tickboxes next to data names. Disableable tickboxes for data recordings are:

- PITCH
- ROLL
- HEADING
- VIBRATION
- GYRO_X
- GYRO_Y
- GYRO_Z
- ACCEL_X
- ACCEL_Y
- ACCEL_Z

In the above list, GYRO stands for gyroscope and ACCEL stands for acceleration. A gyroscope measures angular velocity of the sensor. Acceleration evaluates the rate of the change of the velocity of the Kinemata sensor. On the left side of the tickbox, the names of the current values are displayed on top of colour bars that are dynamically showing graphical representation of the current values. On the right side of the data list, there is a graph, which shows graphically the data changes in the real time.

On the right side of the Kinemata software window, there is a recording button. The red button with a white circle in the middle represents the classical “Record” button from traditional video cameras. When recording, the button will change to red with a white square in the middle, which represents “Stop” button. The user interface allows the user to name the file for the recording. However, final recording name takes a form of user defined name together with the current date and time as in “kinemata-2016-2-24_13-34-31-TesterA Leg abdb back left leg take 1-track-2”. The “track-2” shows that recording is done from the second connected device located in the bottom of the Kinemata software. The data is being recorded and saved in the form of comma separated value file format (.CSV). Data is being stored in the folder “recordings” which is same folder where the Kinemata software is located. Collected data could be used for movement correction, analysis, and self-learning.

4 Investigation Aim, Process, Method and Data Gathered

4.1 Aim and Process

The aim of following tests is to test device in different environment with different groups of people. Groups are conducted of both male and female participants. Most if the participants were aware of the Kinemata performance capabilities before testing

Test 1. Physical therapy test.

1. Participants

Three participants were recruited by a coordinator from Well-being and Therapy Services at Helsinki Metropolia University of Applied Sciences. Two participants had previous knowledge of physical therapy (see table 1). The third participant was service worker in the same institution. However he had no previous experience with any of physical therapy exercises. All the names of the participants have been changed to nick names.

Table 1. Participant's information in physical therapy test.

Name	**Gender**	**Age range**	**Occupation**
Ana	Female	25-34	Student (Physical therapy)
Linda	Female	18-24	Student (Physical therapy)
Tom	Male	35-44	Employee (Service)

2. Tasks

Five exercises were selected by a physiotherapy professional (see figure 4):

- Exercise number one: biceps curls
- Exercise number two: breaststroke swimming hand and arm positioning
- Exercise number three: leg abduction
- Exercise number four: deadbug abdominal exercise
- Exercise number five: “bird and dog” exercise

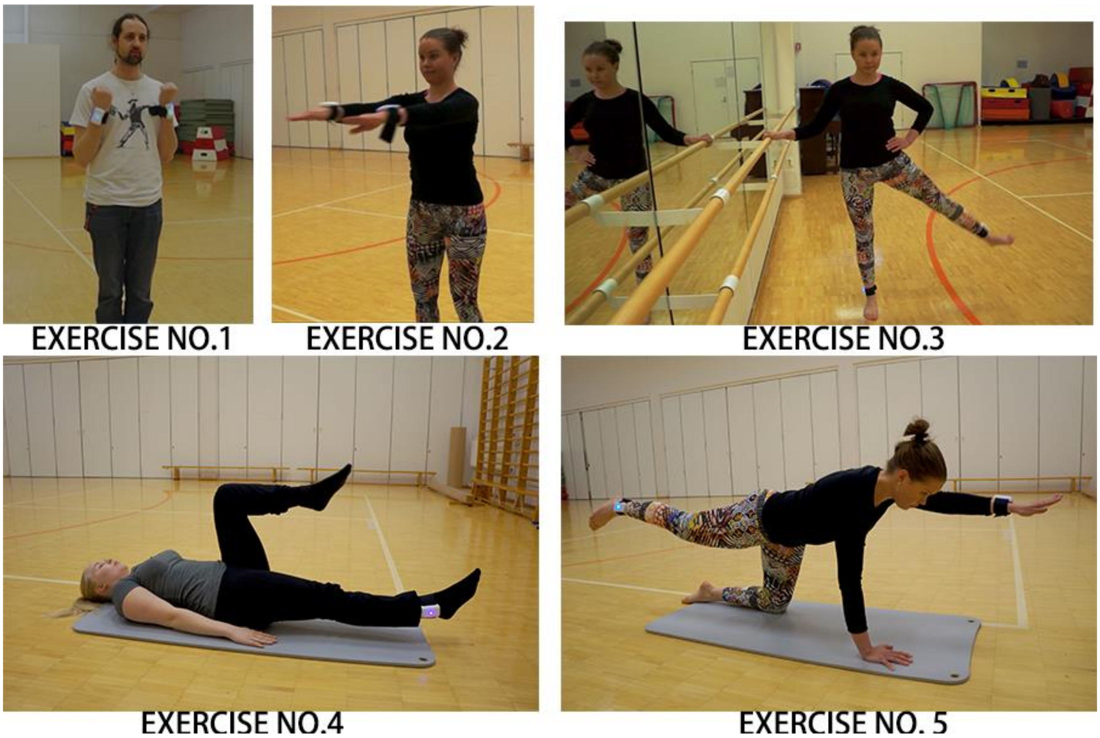

Figure 4. Physical therapy exercises.

The exercises mentioned above could be divided into two groups: dynamic exercises and complex static exercises. Dynamic exercises are exercises that are being performed during workout warmup. These exercises are meant to warm up the muscles without overstretching them. Static exercises performed opposite of dynamic ones - the muscles of the body should be contracted during the exercises while the body performs little to no movement.

Biceps curls, breaststroke swimming hand and arm positioning, and leg abduction exercise are dynamic exercises while dead bug abdominal exercises and the “bird and dog” exercise are complex static exercises.

The Positia Metropolia Sport Hall was chosen as the location of the test. It is an indoor hall which is isolated from outside visitors and which offers a quiet warm space for testing purposes. The place allowed performing tests with no distraction and no additional complications.

The participants were informed of and instructed on the basic functions of the Kinemata device before the testing was conducted. The testers tried wearing the device before the testing session. The participants have gave provided permission to be video recorded during the testing.

First, the test exercises were performed by one of the participant who had previous knowledge of physical therapy, followed by the second participant familiar with physical therapy. During the exercises, the participants who were not being recorded at the moment, were able to observe the performance of the participant who was recorded. Both physical therapy students were able to perform exercises without interference or any additional instructions. Each of the exercises was performed three times.

The third participant was instructed by the physical therapy students on how to perform the exercise correctly. He was able to perform the exercises on second and third try without additional instructions or extra help. All of the participants were interviewed after the testing and they were asked to fill in a questionnaire after the interview. The questionnaire had basic questions about physical therapy level of comfort and general impression of the Kinemata device.

Test 2. Archery test.

1. Participants

For the archery test four participants were chosen: three of the participants had close to no experience of the archery, while last one was an international level professional archer (see table 2). However, all of the testers indicated that they have been performing physical exercises on a regular basis. All the names of the participants have been changed to nick names.

Table 2. Participant’s information in Archery test.

Name	Gender	Age range	Occupation
Lily	Female	18-24	Student (Business Management)
Jack	Male	25-34	Employee (Computer Science)
Ben	Male	25-34	Employee (Computer Science)
Leo	Male		Sports

2. Task

Testing was conducted in the Archery Club Wilhelm Tell Helsinki sports center which provided all the necessary equipment necessary for safe and successful testing (such as bows, arrows, and protective gear.). The instructor working at the archery club instructed everyone on how to use bow correctly and made sure exercise would be performed accurately. Several professional archers were practising in the archery club and one of them kindly agreed to participate in the testing process. Each of the participants performed several shots before the testing in order to get familiar with the equipment.

Drawing a bow is not a complicated task. However drawing a bow correctly requires skill. The bow is being hold in the less dominant hand (left hand for right-handed person, right hand for a left-handed person). The archer pushes the bow in the direction of the target with an extended arm, while holding it statically. The dominant hand holds the bowstring and extends it enough to the back, so the palm would be close to the face. [25,151.] This is done while standing sideways to the target, as it shown in figure 5.

Figure 5. Beginner testing Kinemata while performing archery.

As one can see in figure 5, the standing position is requiring the archer to hold his/her hands in a straight line. Performing a shot in this position increases accuracy of the shooter while releasing extra tension from the back muscles [25,152]. This is where Kinemata's position sensors might be useful. Since there are two devices tracking both hands, Kinemata could track that arms are in the perfect position. Kinemata should be used by an amateur who would like to learn archery (see figure 5.). Visual notifications would allow a coach to observe if the person is standing correctly and a tactile response would allow the amateur to feel how well he/she is performing without looking at the device.

While Kinemata is useful for posture, it would be even more helpful for aiming and shooting. The difference between having a correct posture and actually aiming at the target is that the archer changes his/her focus from the correct body positioning towards the aiming. While trying to aim closer to the center of the target, one might unconsciously move slightly therefore making aiming more difficult [25]. Since it takes time to perfect both aiming and posture at the same time, Kinemata might help with that. While a person can change focus from the correct body positioning to aiming, Kinemata would still track proper posture position and would inform the user in case it has changed.

Figure 6. Professional archer, standing with the bow ready to shoot.

A professional archer, see in figure 6, who has perfected the posture and aiming skills, still has moments when they take a shot and miss greatly. It might be a matter of milliseconds between the moment when the bowstring was released and arrow left the bow, where shooter failed. While it is problematic to pinpoint exactly the moment when it went wrong, Kinemata was able to provide information on the slightest movements over short periods of time.

The testers were aware of Kinemata capabilities before the test and had seen how it performed. After wearing the device each of the participant made three shots while data was recorded by Kinemata and while being video recorded (see figure 5). Shootings were supervised by the instructor and were performed properly. The same way as with the previous test, the participants were interviewed after the testing and they filled in the same questionnaire.

4.2 Methods and data

Focus Group

There were two focus groups with four participants in each group in the beginning of the user test.

The first group consisted of one personal fitness trainer and three of his customers. The participants knew each other. The testing was located in Forever Matinkylä Espoo gym which was participants' usual workout and sports events place. The Second group consisted of one physical therapy professional, two physical therapy students, and one physical therapy client. Discussion was conducted in an office room in Vanha Viertotie campus of Helsinki Metropolia University of Applied Sciences. After the participants were told about how Kinemata devices work and what kind of information can be acquired from Kinemata software, the participants started the discussion.

The discussion was held in the casual "everyday talk" form instead of an "interview". All of the participants were exchanging their opinions with each other, including the test designer. The discussion began with the usage of Kinemata. ´Some participants concentrated their focus on one of Kinemata's functions, such as, vibration. The participants pointed out that with the tactile function, Kinemata could be used for yoga performance, steady exercises during gym workout, and archery performance. The latter one was selected to be one of the test tasks. The other participants requested to see how Kinemata can help in the action movement. One of the participants is a football player. He advised that Kinemata might be useful in football training, such as dynamic warm up exercises before a football match.

As discussion continued, the participants expressed different thoughts on the expectations towards Kinemata devices. By the time the focus group discussion was conducted, the first version of Kinemata was in use, as shown in figure 2. Some of the participants adored the wooden part of the case. As these participants explained, wooden material brought an organic and close-to-nature feeling to them. However, it also increased the weight of the device which added extra weight while performing the exercises. The participants admitted that if the device was too heavy, it would stop them when it would come to purchasing a wearable device.

Interestingly, some of the participants were delighted about the coloured light function of the Kinemata device. They claimed that the colourful light displayed on the device would add an additional playful effect while performing some repetitive exercises. Meanwhile, participants noted that young people might enjoy having a device with bright and colourful lights as part of the fashion style of the wearer. On the other hand, one of the participants argued that light might negatively affect concentration of the user. For example, for a person who would like to have a session of very calm and relaxing yoga, light can be distracting.

Observation & Interview

As chapter 2.3 pointed out, recorded audiovisual data of the event and the participant's interaction is valuable for future research. Even though the testing process has been recorded, notes were taken down at the same time as the interaction was happening. These notes became valuable when generating custom questions for the participants.

Physical therapy test participants showed great interest towards Kinemata devices during the first time they were requested to wear them on the wrist. Participants were moving arms around performing random movements, in order to experience the vibration and light colour changes. They noted that the vibration sensor makes sound during vibration that is easily distinguishable.

In order to let participants see how the colour changes on the Kinemata devices, all the physical therapy participants were requested to perform all five exercises in front of a mirror which allowed them to see their whole body movement. It is worth mentioning that for some exercises such as leg abduction, the participants were instructed to look straight forward during the whole exercise in order to keep the correct form.

During some dynamic exercises (see figure 4, exercise No.1 and No. 2), some of the participants were showing easily observable confusion during the movement. A question related to this action was asked after the exercises were performed. The participants explained that they spotted red colour light displayed on the devices was mistaken as the alert for them that they might have performed exercise incorrectly.

It was clearly observed that for all the amateur participants it took longer to aim at the target with Kinemata worn on their wrist, compared to aiming without Kinemata worn on their wrist. However, the duration of the aiming time did not change for the professional archer in the same conditions. Most of the participants glanced at the Kinemata device during the aiming process.

The interview process happened shortly after shooting. During the interview some of the amateur participants admitted that with Kinemata devices worn, they spent longer time to aim because the feeling of the vibration on their wrists, especially on the dominant hand, made them realize that they were not ready to shoot. Most of the participants did not acknowledge that they glanced at the devices while performing archery. Nonetheless, all the amateur participants pointed out that they have attention to devices while performing and the devices caused distraction and distress in the performing process.

The professional archer, on the other hand, argued that there was no trouble for him to keep his dominant hand steady. Thus the device was not useful for him on his dominant hand. However, the Kinemata device improved the steadiness for less dominant hand, as he informed during the interview.

Questionnaire

A mixed questionnaire which consisted of both open and closed questions was delivered to each participant except the professional archer due to personal request of the last one. Questionnaires were sent through Email after interview was conducted. The questionnaire contained eight questions as shown in appendix 1. Each of the participants filled in and submitted the questionnaire within a day.

Three questions requested basic information about the participants—age range, gender and occupation. These questions were followed by rating questions (asking the participant to grade aspects of the device on a scale from “dissatisfied” to “satisfied”). The articipants were asked to give their opinion on the level of satisfaction of the comfortableness, physical size, vibration and lights of Kinemata devices. Next, the overall level of satisfaction was rated by participants. Last but not the least, suggestions for improvement for Kinemata were requested. It was an open question. Seven out of eight questions were closed questions.

During the interview process all of the necessary topic questions were asked face to face. This is the reason why the questionnaire had only a single open question. It was considered to be a waste of time for the participants to answer exactly the same questions during the interview and in written form.

5 Analysis and Results

Interview

None of the participants were native English language speakers. Some of the quotes from the participants might be grammatically incorrect. However, text was not corrected in this thesis, for the sake of the research.

Many of the participants have mentioned that even though they had previous experiences with several types of wearables that already exist in the market, a movement learning wearable device like Kinemata provided them with a new unique experience:

“I have polar activity band I use when I workout. Heart rate, how long I have been working out. Nothing like this can track movement.” (female, 18-24)

“If I am doing more specific sports that I need to learn some sort of new movement, if I get injured, I need to learn something new back again, then Kinemata will be good device.” (female, 18-24)

Most of the participants suggested that the physical dimensions could be smaller. Other than the size of the device, there was no complains related to comfortability from the participants:

“It felt good on wrist and ankle. If it’s possible to get even just half the size it would be more not so noticeable, it would be easier to use and forget about it, and then can really easily track the movement. It bothers a little bit, because it’s big. Though the band is comfortable. Maybe thinner.” (female, 18-24)

“It could be smaller, it definitely could be smaller. The size is the thing kind of weird. It’s the one thing to make you feel you are wearing it.” (female, 18-24)

The users noted that the tactile way of communication between device and participant was better than the visual one:

“I think the light is nice. If it’s in my wrist, then help to understand the movement, not ankle.”

"I feel like it's somehow hard to get it connected to the movement. Little bit confusing if I try to concentrate on the lights."(female, 25-34)

"Vibration came really quickly as soon as you moved. So it was really on point." (female, 18-24)

Tactical response for the movement was particularly helpful for yoga or workout exercises when the person was required to look straight ahead of him/her while performing movement. The ability to get evaluation of the movement without looking at the device was helpful:

"The abdominal movement, when I was lying on my back trying to keep my legs in 90 degrees to be sure the other leg is staying still, it gives really good feedback for you, like you might be moving without this but when you have it, and you are like. Oh no I moved my other leg and I am not supposed to do it." (female, 18-24)

"Because it has the vibration, so I want like start moving my arms oh it's vibrating and now it's not." (female,18-24)

"First of all. I know I am wearing it even though I am not thinking about it much. But it's there and also the vibrations. That make me think that when it stops when I have stopped. So that makes me think yeah what I am doing next."(female, 18-24)

One of the original goals of Kinemata was to motivate participants to perform exercises better and more precise, Participants has mixed thoughts about motivational purpose of Kinemata:

"This is really good reminder in movements when you are not supposed to use something because it gives you the right away feedback that 'oh, you just used it, and you are not supposed to move for example your arm or your leg'." (female, 18-24)

"I think this would be good for maybe for neurology patients." (female, 25-34)

"It depends on the person, because to learn something you knew, you need to have a purpose to learn it, but this is a good way to learn it. So I don't know if it exactly is the motivation to learn it, because I feel like you need to have another motivation first." (female,18-24)

Questionnaire

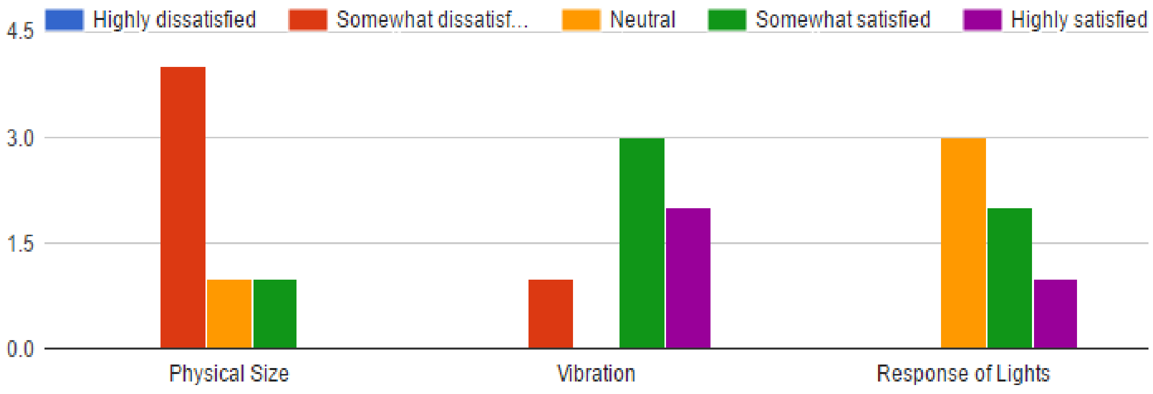

Figure 7. Rating three main functions of Kinemata devices.

As figure 7 illustrates, four out of six participants were dissatisfied with the Kinemata devices' physical size, while none of them was satisfied with the physical size. Five out of six participants chose either "somewhat satisfied" or "highly satisfied" with the vibration function of Kinemata. These results clearly indicate that vibration met the Kinemata's designer's expectations. Half of the participants had a "neutral" attitude while another half has "above satisfaction" selected for the light response feature.

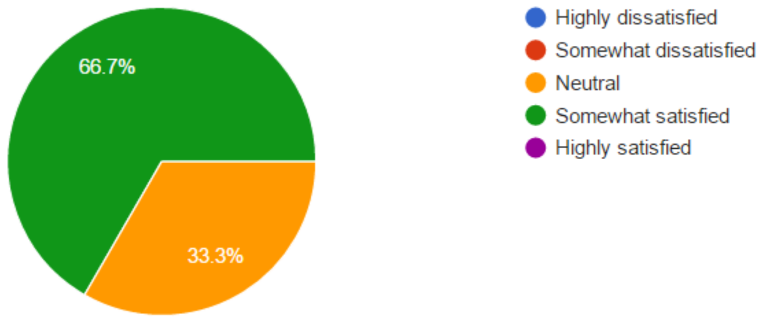

Figure 8. Rating of overall level of satisfaction with Kinemata devices.

As can be seen in figure 8, four participants (or 66.7 %) rated "somewhat satisfied" regarding to the overall level of satisfaction with Kinemata devices' use.

Data Collected with Kinemata Software

There were 42 files of data collected from two test tasks. One of the data files was selected and mapped as figure 9 which shows vibration information from participant A's and B's left hand Kinemata device. The horizontal axis represents time, and the vertical axis represents the vibration value.

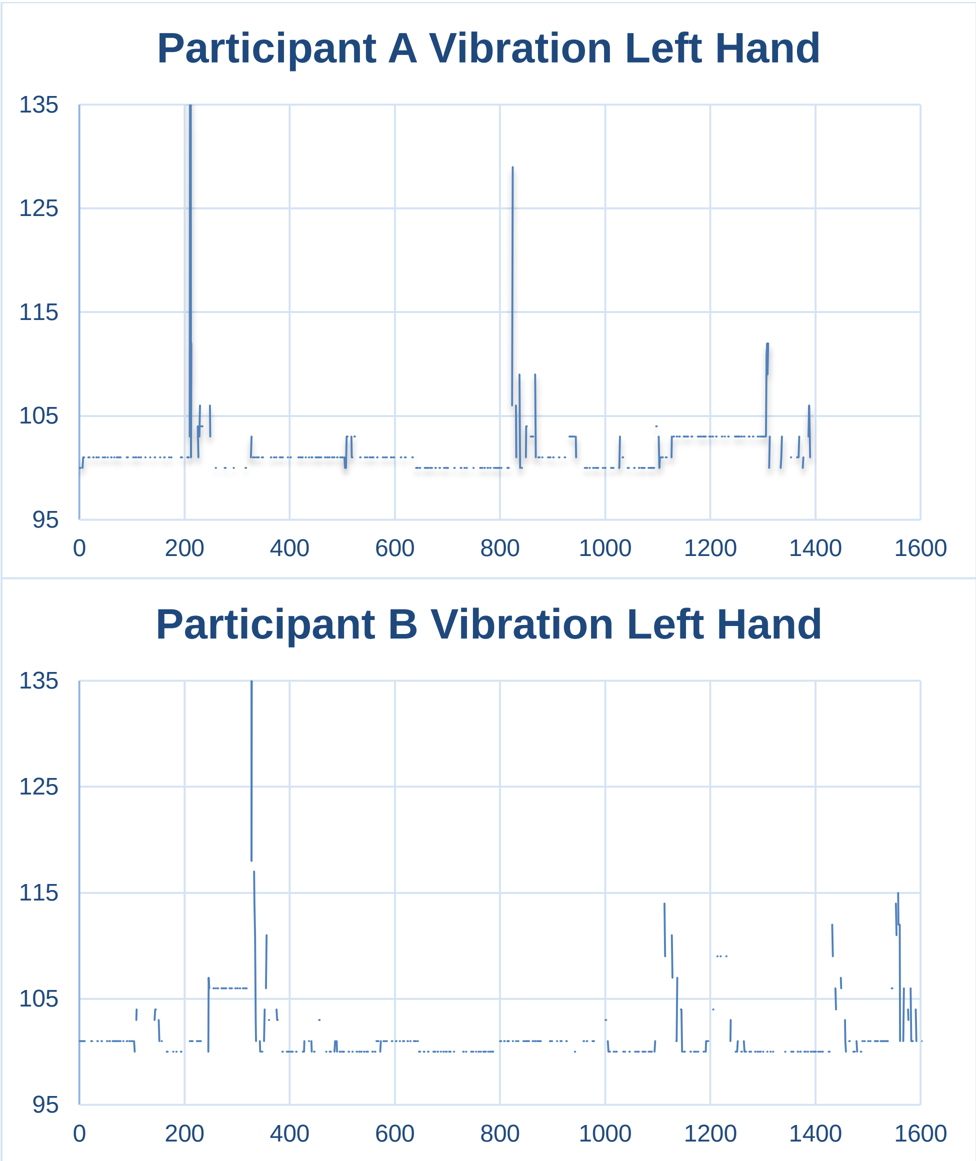

Figure 9. Left hand vibration data collected from the participant A (top) and participant B bottom) in archery performance.

Peaks in the graph show time when the participants raised the bow after shooting an arrow. Three arrows were shot during this task. Data between these three peaks represent the aiming process. This information indicates the stableness of the participant's left hand which held the bow.

It can clearly be seen in the chart that aiming for the first time takes longer than for the second and third time. Participant B's left hand was more stable compared to participant A's left hand. It is visible in figure 9, where participant B's data line is more stable and levelled.

The mapped graph was showed to one of the archery participants for feedback (see figure 9). The participant mentioned that he was surprised that the device was able to record all the movements including slight vibrations. Even though the project contributor thought he had quite steady hands on the last aming, it is still shown in the graph that the participant has space for improvement. However, the participant suggested that the visualisation can be improved. For example, it is not clear at which point the device was stable.

All of the data recorded during the testing process was saved for further analysis. That includes data recordings from Kinemata devices (.CSV files) as well as video recordings of the exercises. All these data will become available for device developers at the end of the testing-analysis process.

6 Discussion

The idea of testing in an archery club was gained from one of the focus group discussions. The focus group meetings were conducted with the purpose of coming up with solutions similar to this one. The different exercises picked for the physical therapy test were also the result of the focus group discussion.

The focus group meetings were conducted with four people which is less than recommended by focus group guidelines. Also, focus group meetings were not video or audio recorded and were not available for future review. However, notes were taken during every focus group meeting.

Both interview and test observation generated high amounts of data. The main suggestions based on these recordings are related to physical specifications of the device. The first suggestion was related to the vibration of the device. The participants were interested in having more obvious different levels of vibration, which would give more detailed response from the device. Having different levels of vibrations to get more detailed information about the movement accuracy is on the list of recommendations for the next version of the device.

The second suggestion was related to the size of the device. Most of the participants expressed a negative attitude towards size and dimensions of the current version of the device. Even though the second version of Kinemata has reduced more than half of the size compared to the first version, most of the participants were still not feeling comfortable with wearing it for longer periods of time. If the size of the Kinemata device could be reduced to match the size of a regular wristwatch, it might bring higher level of satisfaction.

The current way of recording data is storing recordings in .CSV files. Comma separated value data are not easily understandable by a person who is not familiar with the way gyroscopes work. In order to make the Kinemata software more appealing for the user, an easier understanding application could be developed. Data could be represented in visual form like graphs or 2D/3D models. This way more people would be able to interact with the software without previous training. Additionally, it is easier for a user to compare visualised values than a list of numbers.

Unfortunately, Kinemata also has inherited some negative aspects common for all of the wearables. One of the issues is the lack of a stable Bluetooth connection. In case of the wearable that could store data in its memory for later analysis, connection problem is not very critical issue. However, Kinemata is relying on Bluetooth connection to send data to a computer in real time. This means that signal interruptions would result into irretrievable data loss. This happened with one of the participants during the archery test, which caused unnecessary frustration. After a short delay, recording was conducted, with no interruptions this time.

Another issue inherited from other devices by Kinemata is the battery life. Even though the designer of Kinemata was not setting a goal to equip the device with a long lasting battery, it is worth mentioning this aspect of the device. During the tests, some of the participants have encountered unexpected behaviour of the device—random vibration patterns and light blinking out of the ordinary. The creator of the device has instructed that it might happen when battery is running out of “juice”. However, since device is lacking any battery level indications, it is unrespectable every time the device battery runs out. During the testing it has happened several times. Testing was conducted, and the average lifespan of Kinemata was about one hour time, which is an extremely low result for the wearable device.

All of the tests were conducted in different environments and all of the locations for testing had bright artificial light. It has been noted that the participants were not always able to see the light indication on the Kinemata device.

Most of the wearables enable interacting with them using tactile sensors or physical buttons. The Kinemata device has a single button for switching it on and off. All other interactions with the device, like recording motion or exercise data should be done through the Kinemata software application.

Everything above conducts, that even though the Kinemata device is able to provide unique learning experience for physical exercises, it has a lot of drawbacks at the current state of the device. Since it is just the second iteration of the prototype of the device it still requires an experienced person with previous training to use it. Even though most of the participants did not have annoying or irritating moments, they would have received poor user experience if there had not been a person who conducted the testing process.

7 Conclusion

The goal of the project was to understand how Kinemata would be used in practice at the current state of development and to generate guidelines for future development of the device. The data for the guidelines was collected using user experience practices.

Through the theoretical knowledge of HCI, I considered the product's functions to design the test tasks, to design a better experience, for a better result. It was expected to get both positive and negative feedback in order to improve the Kinemata devices and software.

The "obser-view" method I adopted based on the qualitative research method has crucial value for my test. I observed the whole process and then made changes to the interview question relatively, in order to be ready for the interview session. I followed guideline recommendations to video record the whole performance, which helped me to get all the missed out details after the task was done, in order to improve the analysis.

The product was originally described as something that should stimulate the user to exercise more extensively, provide new experiences, and allow the user to learn new things. The results indicated that using Kinemata can help an amateur to learn new movement more accurately. However, at the current state the device requires prior training and should be used with experienced user assistance.

After all the data was collected, a list of recommendations and improvements was created, and the list was presented to the Kinemata development team together with all the data collected during the project. This data influences future development of the Kinemata device and defines the direction for the project to develop to.

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Post questionnaire

Customer Feedback

We would love to hear your thoughts or feedback on how we can improve your experience!

*Required

What is your age? *

- Less than 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55 and over
- I prefer not to say

What is your gender? *

- Female
- Male

What is your occupation? *

- Student
- Employee
- Unemployed
- Freelancer
- Other:
-

If you are a student, please write down your major.

In your opinion, in which field Kinemata can be used and be helpful? *

- Sports
- Performing arts
- Physical therapy
- Other:

- ○

How comfortable do you feel when you wear Kinemata? *

- ○ Very comfortable
- ○ Somewhat comfortable
- ○ Neutral
- ○ Somewhat uncomfortable
- ○ Very Uncomfortable

How do you rate the following? *

	Highly dissatisfied	Somewhat dissatisfied	Neutral	Somewhat satisfied	Highly satisfied
Physical Size					
Vibration					
Response of Lights					

Overall level of satisfaction with Kinemata *

- ○ Highly dissatisfied
- ○ Somewhat dissatisfied
- ○ Neutral
- ○ Somewhat satisfied
- ○ Highly satisfied

Do you have any suggestions for improvement? *

Name *

Email

SUBMIT