Usability-study and acceptance analysis of VivaBack´s eCoach in comparison to the personal feedback-coaching

Master Thesis

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by
Niklas Stockreiter, BSc
171808

First advisor: FH-Prof. Romana Bichler, PT MAS
Second advisor: Valentin Rosegger, BSc

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Declaration

I declare that I have developed and written the enclosed Master Thesis completely by myself, and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. This work was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.

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Preface

„Es ist nicht genug, zu wissen, man muss auch anwenden. Es ist nicht genug, zu wollen, man muss auch tun.“
J.W. von Goethe

Whether through physical activity, daily work or for other reasons, many people complained of back pain at least once in their lives – so did I a few years ago. As part of my second bachelor thesis, I dealt with the topic of health problems in the workplace in radiologic technology. I quickly realized that the daily work has an influence on the personal health and that back pain and discomfort especially in this profession occur very often.

With this background knowledge I researched for possible topics for my master thesis. Fortunately, I was able to establish contact with a young ambitious company and thus write my master thesis in cooperation with the company VivaBack. At this point I would like to thank Valentin Rosegger, representing the company VivaBack, for the pleasant and successful cooperation.

I would also like to thank my supervisor, FH-Prof. Romana Bichler, PT MAS, who supported me considerably during the whole process.

Thanks also to my fellow students who became friends, for the crazy, funny and instructive time during this Master degree programme.

Last but not least, I would like to thank my family and my partner, who accompanied me during my studies, motivated me and above all believed in me.

Abstract

Background: Back pain is an omnipresent global problem. The problem is the incidence of back complaints and back pain, especially chronic lower back pain, the difficulty and obscurity of diagnosis and the resulting unnecessary radiological imaging procedures and other treatments.

Aim: The aim of this paper is to give an overview of the general topic and to present a possible new approach for dealing with the problem of back pain, using the sensor-based system by VivaBack. Further the major goal is to compare the two existing feedback methods presented – face-to-face coaching and automated eCoach – and to determine the usability of the eCoach with the help of two groups of participants and two different questionnaires.

Method: A literature search was performed in order to give an overview of the prevailing problem. Additionally, 20 back posture measurements were performed on 20 participants with the VivaBack sensor-based system. By two online questionnaires, both groups were asked about the transfer of knowledge, the acceptance of the given feedback method and the usability of the eCoach.

Results: The results are the presentation of the acquired data on the basis of questionnaires and the resulting comparison of both feedback methods, as well as a first usability test for the eCoach. If the results of the individual questions are compared between the two groups, it can be seen that the face-to-face feedback was always rated better than the eCoach. If an average value across all 10 questions is used as comparison value, the face-to-face feedback results in a lower mean value of 1.94, which is better, while the eCoach achieves a higher mean value of 3.09, which is worse. The SUS score for the evaluation of usability is between 75 and 80.5 on a scale of 0 (bad) to 100 (excellent) and can therefore be evaluated as a solid good system.

Conclusion: It is stated that the eCoach at its current stage of development cannot achieve the same effect in terms of knowledge transfer and is subjectively less accepted by the participants than face-to-face feedback. Therefore, the eCoach currently cannot replace the feedback via physiotherapist. With regard to usability and a SUS score of at least 75 to 80.5, it could be concluded that the participants were satisfied with the usability and that the eCoach is a solidly good system. At the current stage of development, the eCoach can be at least offered as a supporting feature to access the evaluated data and content of the feedback from home.

Kurzfassung

Hintergrund: Rückenschmerzen sind ein allgegenwärtiges globales Problem. Das Problem ist die Häufigkeit von Rückenbeschwerden und Rückenschmerzen, insbesondere chronischen Kreuzschmerzen, die Schwierigkeit und Unklarheit der Diagnose und die daraus resultierenden unnötigen radiologischen Bildgebungsverfahren und weiteren Behandlungen.

Ziel: Ziel dieser Arbeit ist es, einen Überblick über das allgemeine Thema zu geben und einen möglichen neuen Ansatz zur Behandlung des Problems der Rückenschmerzen mit dem sensorbasierten System von VivaBack zu präsentieren. Hauptziel ist, die beiden vorgestellten Feedback-Methoden – face-to-face Coaching und eCoach – mit Hilfe von zwei Teilnehmergruppen und zwei verschiedenen Fragebögen zu vergleichen und die Usability des eCoach zu ermitteln.

Methodik: Zuerst wurde eine Literaturrecherche wurde durchgeführt, um einen Überblick über das vorherrschende Problem zu geben. Anschließend wurden 20 Rückenhaltungsmessungen an 20 Teilnehmern mit dem sensorbasierten System von VivaBack durchgeführt und Feedback auf zwei verschiedene Varianten gegeben. Mittels Online-Fragebögen wurden beide Gruppen nach dem Wissenstransfer, der Akzeptanz der gegebenen Feedback-Methode und der Usability des eCoach gefragt.

Ergebnisse: Ergebnisse sind die Präsentation der gewonnenen Daten auf Basis von Fragebögen und der daraus resultierende Vergleich beider Feedbackverfahren sowie ein erster Usability-Test für den eCoach. Vergleicht man die Ergebnisse der einzelnen Fragen zwischen den beiden Gruppen, so zeigt sich, dass das persönliche Feedback immer besser bewertet wurde als der eCoach. Wird als Vergleichswert ein Mittelwert über alle 10 Fragen verwendet, ergibt sich aus dem persönlichen Feedback ein niedrigerer Mittelwert von 1,94, was wiederum besser ist, während der eCoach einen höheren Mittelwert von 3,09 erreicht, was wiederum schlechter ist. Der SUS-Score für die Bewertung der Usability liegt zwischen 75 und 80,5 auf einer Skala von 0 (schlecht) bis 100 (exzellent) und kann daher als solides gutes System bewertet werden.

Schlussfolgerung: Es kann gesagt werden, dass der eCoach in seinem aktuellen Entwicklungsstand nicht den gleichen Effekt hinsichtlich Wissenstransfer erzielen kann und subjektiv weniger von den Teilnehmern akzeptiert wird als ein persönliches Feedback. Daher kann der eCoach derzeit das Feedback durch den Physiotherapeuten nicht ersetzen. Hinsichtlich der Usability wird ein SUS-score von immerhin 75 bis 80,5 erzielt woraus sich schließen lässt, dass der eCoach als solides gutes System bewertet werden kann. Im aktuellen Entwicklungsstand kann der eCoach zumindest als unterstützende Funktion angeboten werden, um von zu Hause aus auf die ausgewerteten Daten und Inhalte des Feedbacks zugreifen zu können.

Table of Content

1 Introduction

In everyday life our body is exposed to various health burdens. But do you know about the danger of sitting for your personal health?

> *"Sitting is more dangerous than smoking, kills more people than HIV and is more treacherous than parachuting. We are sitting ourselves to death."* *[Dr. J. Levine] [1]*

But not only sitting represents a potential health risk. Different professions require different working postures. Physically strenuous postures such as knee bends or kneeling are often unavoidable. The multifactorial load, due to untypical body positions, can stress the soft tissue (e.g. intervertebral discs) statically too strongly and lead to an early herniated disc due to degeneration of the intervertebral discs in the long run. [2]

In general, a musculoskeletal disorder including occupational risk factors, anatomical, socioeconomic and psychological interaction lead to the term of low back pain (LBP) which is varying in pain and disability degrees. [3]

1.1 Problem

Discomfort and pain in the area of the lower back are very common in the western population. Although within the progress of modern medicine and high-resolution imaging like the magnetic resonance imaging (MRI), back pain is still a problem. For about 85% of all back pain reasons there are no standardized examination protocols or effective practical therapies. That the whole problem with back pain is unsolved show numbers that back pain is the most expensive disease in industrial countries (for e.g. the costs are about 15-20 billion Euro per year alone in Germany). [4]

Unless a specific cause is suspected, the European guidelines for the management of chronic nonspecific low back pain (CLBP) do not recommend computed-tomography (CT) scans, magnetic-resonance-imaging (MRI) or radiographic imaging (X-ray), bone scanning or facet nerve blocking for the

diagnosis of nonspecific CLBP. Further they recommend for e.g. pharmacological treatments with weak opioids for the short-term use to relief the pain or conservative treatments like cognitive behavioural therapy, multidisciplinary (bio-psycho-social) treatment or supervised exercise therapy. [5]

Evidence based treatment schemes suggest physical exercises in combination with education to effectively prevent lower back pain. Shoe-soles, back-belts or other interventions are not effective enough to work preventive. [6]

The market for mobile health-apps and his potential is known for a long time and increasing continuously. Companies research and develop consecutively new apps in diverse areas and fields. [7] In this context the World Health Organisation (WHO) defined the term “mHealth” as new horizon for health supported by mobile technologies. [8]

VivaBack is an Austrian company that developed a wearable sensor system for monitoring the back posture during a day of work. The aim of VivaBack is on the one hand to identify unilateral stress, visualize your back posture and to give a professional feedback, and on the other hand to support your health especially the health of your back and raise awareness. Currently they give feedback in the framework of personal coaching, discussing the outcome of the monitoring, defining goals and working on strategies to improve your back health.

To make the next step, VivaBack is working on an automated feedback system. During the development of a product / prototype there are some concerns referring to the usability. Therefore, a usability-study is mandatory to develop and work target-orientated for optimal user-machine-interface. [9]

For a long time, I have been interested in the field of health promotion. My second bachelor thesis also dealt with ergonomics in the workplace, especially with diseases of the musculoskeletal system and health promotion.

This paper deals with the problem of musculoskeletal pain, LBP, CLBP, the current approach to solving this problem and shows VivaBack´s method for possible preventive approaches regarding the above described topic.

1.2 Pivotal Question

The central questions of this paper are:

- Q1: Will the automated eCoach be better or less accepted by participants than the personal feedback?
- Q2: Is it possible to replace the personal feedback with the automated eCoach?
- Q3: Is it possible that the eCoach can achieve a SUS score of at least 80 or more in a usability test?

1.3 Aim

The aim of this work is to give the reader an overview of the problems of chronic back pain, poor posture in everyday life and the resulting strain on the musculoskeletal system. In addition, a comparison of both feedback methods of VivaBack and an acceptance analysis of the automated eCoach will be made. The usability test should also provide information about the usability of the eCoach.

1.4 Method

To give a scientific answer to the questions of research a comparison between the state-of-the-art feedback method and the possible automated eCoach will be performed. Acquired data will be analysed, compared and visualised. Further an evaluation of a usability test will be performed.

On the one hand a literature search and on the other hand a randomized pilot-study with two randomized groups of 10 students per group from the master program Digital Healthcare 2017 will be performed. Participants of group A will get their feedback via the personal, current state of the art feedback coaching by one of VivaBack's employees and Participants of group B will get their feedback via VivaBack's automated feedback-prototype (eCoach). To compare the outcome of two randomized groups referencing effectiveness and coaching, and to answer the questions of research the participants have to answer a survey after getting their results. Additionally, a survey-supported usability-study will be performed with participants of group B.

1.5 Structure of the Thesis

This paper has six chapters (Figure 1). At the beginning an overview of the structure of this work is given. Chapter number two deals with the theoretical background and with the current state of the art, describes the basics of back problems, defines technical terms and explains how VivaBack´s sensor system works. Chapter three then describes the requirements and methodology and its evaluation methods. The fourth chapter presents the results of the acquired data, compares both feedback methods and answers the research questions. The discussion – chapter five – describes the limitations and strengths of this paper and contains the interpretation of the results. Finally, the conclusion – chapter six – summarises the work and especially the results again, shows which conclusions can be drawn from it and presents further research questions.

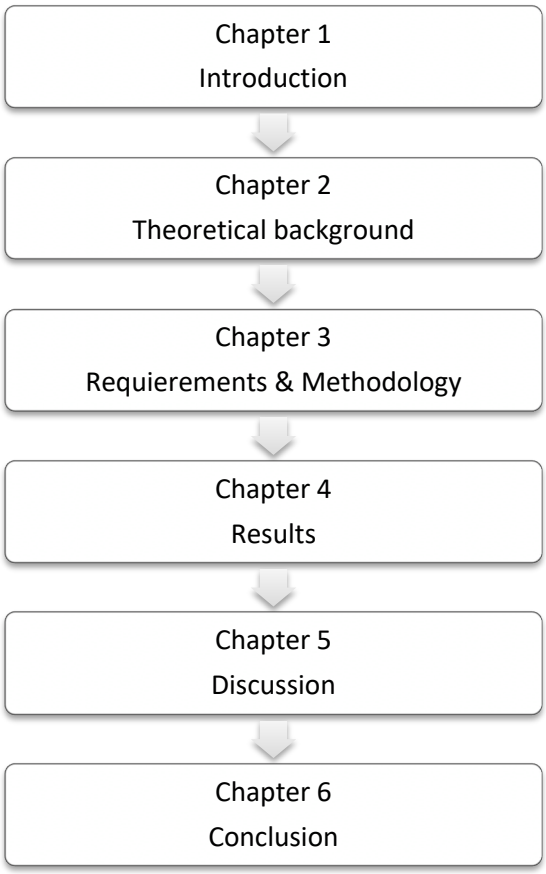

Figure 1: Structure of the thesis

2 Theoretical Background

"CLBP is not a clinical entity and diagnosis, but rather a symptom in patients with very different stages of impairment, disability and chronicity." [5]

The following chapter gives an overview of the basic problem of back pain and how widespread this problem is. Especially unspecific lower back pain and the possible consequences are outlined. Not only medical aspects are discussed but also socio-economic effects are presented. In addition, some causes of back pain and the challenge of diagnosis will be addressed. Last but not least, occupational medical aspects, prevention and the role of VivaBack's sensor-based system in this are described.

2.1 Backpain as a widespread symptom

The frustrating term "non-specific" LBP comes from the fact that about 80% of patients complain about pain in the spine, especially in the lower spine, for no obvious reason. Only in about 20% of cases can the examining physician find a cause and make a more specific diagnosis. This is partially due to the lack of accurate methods for clinical and imaging examinations regarding this particular case. [10]

A study by Kjaer Et. al shows that the correlation between back pain and a disease of the spine is only conditionally connected and has not yet been sufficiently researched. In their cross-sectional cohort study of a non-specific population group, they tried to explain the connection between "abnormal" MRI findings in lumbar spine examinations and lower back pain. They came to the conclusion that most degenerative intervertebral discs - "abnormalities" apart from intervertebral disc protrusion - are only moderately related to lower back pain. [11]

According to Statistik Austria, in a health survey of the Austrian population in 2014, chronic back pain was most frequently mentioned in a list of 17 different diseases. With about 1.8 million people, which corresponds to 24% of the Austrian population, almost a quarter of all Austrians suffer from chronic back pain. It was around 23% of men and 26% of women. Also striking was the increase in complaints with increasing age. Causes leading to the frequency of these

complaints are manifold and often different clinical pictures occur in combination with other complaints. Neck pain or obesity are often mentioned in connection with back pain. [12]

According to the WHO, chronic lower back pain in particular is now not anymore just a common health problem in western countries. In recent decades, incidence has also increased in low and middle-income countries. The fact that CLBP is now in the inglorious Top 10 of high-risk diseases and injuries is shown by the WHO Global Burden of Disease Study (GBD) from 2010. CLBP even ranks ahead of HIV, chronic obstructive pulmonary disease (COPD), tuberculosis, lung cancer and others in regard to the disability-adjusted life years (DALYs). [13]

As a systemic analysis of the GBD Study 2017 showed, in 1990 the first three ranked diseases for years lived with disability (YLD) were lower back pain, headache and dietary iron deficiency. In 2017, the most common diseases for both sexes were still lower back pain, headache and depressive disorders. [14]

Various studies have already shown the immense costs caused by back pain every year. It has been shown that this does not only apply to Austria or Europe. Also in the United States of America chronic back pain, and the further treatment or therapy approaches causes costs in the millions. [15]

2.2 Effects and negative consequences of chronic back pain

Chronic back pain not only increases the risk of psychological disorders such as depression, dissatisfaction or somatisation, but also affects economic and financial aspects for employers. For example, through increased absenteeism, sick leave or reduced work performance and productivity. [16]

A controlled study by Atkinson Et. al investigated the prevalence and risk of psychiatric disorders in men with CLBP. The results show that at least one psychiatric disorder, such as anxiety, drug abuse and depression, occurred in 81.4% of test subject´s lifetime history. At the same time, the frequency of alcohol abuse in their lifetime was higher in the group of test subjects with CLBP (64.9%) than in the control group (38.8%). In conclusion, it could be stated that the reporting of depressive episodes - also in combination with anxiety states - was most frequently made by the test subjects with CLBP during the study. [17]

Vice versa, increased workload, inadequate feedback, lack of support from work colleagues, monotonous work processes and some others have long been known as psycho-social risk factors for causing back pain. [18]

Pfingsten also writes in his paper that the connection between back pain and certain conditions at the workplace was seen as a cause earlier. He points out that bio-social factors such as a lack of job satisfaction also have a significant influence on back pain. [19] Longitudinal studies have shown that - although an increased risk of occurrence of back pain prevails among workers with strain due to lifting or long walk and standing – there is no validity only on a simple biomechanical level with regard to long-lasting constant body positions such as sitting and the occurrence of chronic back pain. [20]

But physical complaints, especially head-, neck- or back pain, lead to reduced performance and productivity at the workplace. Data from America show just how much sickness-related reduced productivity during working hours also has an impact on costs. According to a 2003 study by Stewart Et. al, the cost of pain-related reduced productivity among employees was approximately $61.2 billion. [21] In addition to the increasing incidence of chronic back pain, the number of surgical procedures has also increased rapidly in the last 10 to 15 years. This shows that preventive measures have had no effect to date. [22]

2.3 Challenge of diagnosis

Although there are European guidelines for the diagnosis of CLBP, they are not always applied in reality. In these guidelines there is a clear concept for diagnosis.

First of all, an exact patient anamnesis and clinical-physical examination should be performed. Here, the use of a triage system is recommended to exclude specific spinal pathologies and nerve root pain. Furthermore, it is expressly pointed out that radiological imaging is not recommended as long as there is no specific hint for certain diseases. Only in the case of radicular symptoms is magnetic resonance imaging indicated for further clarification. However, in order to find a more accurate cause for CLBP, it is recommended that psychological status, workload and other psychosocial factors be assessed. [5]

The difficulty of finding the cause and diagnosis of lower back pain lies both in the area of clinical diagnostics and imaging examinations. By limiting the significance of clinical examinations, radiological imaging examinations are often ordered. But even these do not allow precise conclusions to be drawn about the pain picture of patients in the most cases. [23]

It has already been investigated - also using magnetic resonance imaging - that the relationship between lower back pain and the prevalence of abnormalities in the spinal cord is not significant. [24] The risk of a disc prolapse or narrowing of the spinal canal increases with age and is often detected by digital imaging. However, these pathologies are not always the cause of the pain. Even though surgery rarely leads to pain relief, the above-mentioned pathologies are often referred as indications for surgical and invasive procedures. [25] Even in patients who suffer from unspecific chronic back pain for longer than six weeks, but who are still not urgently suspected of having a serious spinal disease, a radiographic examination should not be carried out due to the lack of benefit. Although patients undergoing radiological imaging are more satisfied with their treatment, it is important to find a way to give patients a sense of satisfaction without having to undergo a radiological examination.[26]

As mentioned above, the CLBP treatment approach should not start with radiological imaging but should follow a conservative approach. Creating awareness for one's own body, especially the back - as a functional and supporting apparatus, education and a multimodal approach are highly recommended. In order to relieve severe pain, the use of NSAIDs (non-steroidal antirheumatic drugs) is also mentioned for short-term treatment. Operative interventions are only recommended if the patient has been suffering from CLBP for more than 2 years and the previous conservative, multimodal therapy approaches have not been successful. [5]

The problem with specific description of lower back pain and the subsequent diagnosis, treatment and course of the disease can also be identified by reviewing the current literature. There is an inconclusion due to the different choice of outcome parameters within the different studies. For example, studies describe that 80 - 90% of test subjects with LBP are back at work after 6 weeks. However, the relief of pain is not reported here. [27]–[29] Other studies in turn show that - contrary to the mistaken belief that 90% of LBP patients recover within a month - these patients have stopped consulting their doctor. [30]

2.4 Occupational Medicine & Prevention

By occupational medicine is meant the subject that is active in preventive medicine. As a general rule, doctors in this field try to prevent the occurrence of pain at work and thus make health-promoting aspects possible. Ergonomically designed workplaces, which focus on the worker and his needs, are intended to create the right degree of strain on the musculoskeletal system. [31]

This involves evaluating the burden of work tasks and activities, work organisation, work environment, organisational climate and others. [32] However, this subchapter does not deal with this in more detail.

According to the current guidelines of the Medizinische Fachgesellschaft e.V. AWMF (Nationale VersorgungsLeitlinie Nicht-spezifischer Kreuzschmerz), the frequency of CLBP should be reduced through the targeted use of ergonomic interventions at the workplace. The aim is to create a certain level of awareness - for back strain and at the same time to protect the back - at the workplace. [33]

The aim here is on the one hand to support the companies with occupational medicine in order to create the most ergonomic working environment possible, and on the other hand to convey the message that targeted training and compensatory movements are necessary to solve the entire problem. Even if not everyone always wants to hear this. [31] To sum up, to develop a multimodal approach on the part of employers in order to be able to prevent the LBP syndrome in employees, caused by the manifold bio-psycho-social stress factors, is necessary. [18] Work-related stress peaks in the spine can be regarded as risks for back pain, even if the results of various studies vary in their outcome and often see other factors as causes. [34]

2.5 The role of VivaBack's sensor system

As described above, the causes of back pain are diverse and are often triggered by several factors (bio-psycho-social level). In order to investigate at least one area that may be a possible cause of back pain and to find solutions, VivaBack deals with individual back posture at the workplace.

The founders of the company VivaBack have developed a concept based on a sensor system that records the back posture during a working day. By attaching an acceleration sensor to the thigh, it is possible to determine how long the person has been sitting, walking or standing. The other two sensors are position sensors. One is attached to the sternum (about two centimetres below the Incisura jugularis), while the other is attached to a point on the lower back, between the left and right spina iliaca superior posterior (height of the third to fifth lumbar vertebrae). This makes it possible to determine the flexion and extension of the back during the measurement period. By creating an individual motion profile, unilateral stress can be identified, and suitable measures initiated. To demonstrate the implementation of this method, let me illustrate this with a short example scenario.

In the following (Table 1) a way is sketched – which in reality – mostly the patients with back pain have to follow and at the same time the use of VivaBack's sensor system can be demonstrated:

State of the art procedure	Possible procedure with VivaBack
↓ Occurrence of lower back pain	↓ Occurrence of lower back pain
↓ Visit to the general practitioner	↓ Visit to the general practitioner
↓ Prescription and intake of NSAIDs	↓ Analysis of the back posture during a certain period of time by VivaBack's Sensor System
↓ X-Ray	↓ Creating a motion profile
↓ Possible result - not necessarily related to the complaint	↓ Individual counselling, awareness raising, focusing on activity, self-management & education to improve the own health
↓ Possible MRI for further clarification	↓ If necessary – X-Ray and further clarification
↓ Physiotherapy, therapeutic gymnastics, interventional procedures, etc.	

Table 1: Possible influence of the sensor system on the treatment process

VivaBack's goal is to find a new method for dealing with back strain and possible pain. This technology with its further actions can not only be used for prevention but can also adapt the treatment process for existing back pain. On the one hand, unnecessary radiological digital imaging, which often lead to unnecessary interventional procedures, should be avoided. On the other hand, an understanding for the own health of the back and the connection between sitting, walking and standing should be created through targeted awareness creation. This enables people to be actively involved in their own way of improving back problems. Another goal of VivaBack is to transform everyday postures into valuable resources for someone's own back health. This is where VivaBack steps in with personalized strategies for a balanced and dynamic movement profile - based on the individual data.

2.6 Purpose of Feedback & Usability

Generally speaking, feedback is when specific information is provided by an agent (e.g. an expert - in this case a physiotherapist or sports scientist) related to someone's personal performance or actions. [35] This means that it is a process of circular feedback between at least two persons or systems with the aim of controlling or modulating behaviour. The effectiveness and acceptance of feedback also depend on factors such as the source of the feedback (sender - e.g. judgement), the recipient of the feedback (e.g. younger recipients use feedback more than older recipients), the content of the feedback (positive feedback is more accepted than negative), or the assessment of the feedback by comparison. [36]

VivaBack offers group feedback or feedback through face-to-face coaching, depending on the possibility. Feedback in the group differs from the individual feedback in several ways. While in individual feedback the actual focus is only on a single person and their strengths and weaknesses, in group feedback the group norms are more focused. Through the feedback, on the one hand the goal of creating awareness is pursued, and on the other hand the goal of motivation. Motivation can be distinguished between intrinsic motivation and extrinsic motivation. Intrinsic motivation ("coming from the inside") is often associated with curiosity, incentive or the expectation of success and willingness to make an effort. In extrinsic motivation we speak of positive reinforcement (reward) and negative reinforcement (compulsion). The advantage of intrinsic motivation lies in the fact that it not only works as long as the reward or compulsion works, but that it usually continues to work without external influences. [37]

VivaBack tries to inspire the recipients to intrinsic motivation through feedback, and thereby (by awakening interest in their own health) to achieve the goal of creating awareness and active involvement for personal health.

In order to make the leap from a prototype to a production-ready product, a usability test is often used during ongoing product development.

The so-called SUS (System Usability Scale) was created in 1996 by John Brooke. SUS is still one of the most frequently used methods to test the usability of systems. Based on 10 questions with given answers, a score can be calculated, and the usability can be evaluated. SUS is based on the Likert scale with a five-step scale from "strongly agree" to "strongly disagree". The aim of this scale is to evaluate the overall system with a single number. To calculate the score all points of each question are added. For each question a score from 0 to 4 is possible. It should be noted that in questions 1, 3, 5, 7 and 9 the score is obtained by calculating the scale position minus 1. In questions 2, 4, 6, 8 and 10, it is necessary to calculate

5 minus the scale position. The sum of these scores is then multiplied by 2.5 to give the total system usability value. The SUS score can generally be between 0 and 100. [38]

When interpreting the total number of points, there are different approaches and classifications. To make the result easier to interpret, the obtained SUS score is regarded as a value. This value is described by an adjective. [39] Over the last few years, there have been various variants for the interpretation of the SUS which differ slightly in their limit values for classification. In general, however, the default values for most classifications are similar or equal. [40]

Therefore, a simplified version of the SUS score interpretation was created in this paper (Table 2).

Value	Adjective
100	Perfect System
> 80	Good to excellent system
> 60 – 80	Marginal to good system
< 60	Reference to considerable usability problems

Table 2: Interpretation of the SUS-score

2.7 Sensor Systems

Nowadays, terms such as "sensor", "sensor systems" or "sensor technology" are frequently used, read or heard. But what exactly are sensors, and what are they developed and used for?

The term sensor is still relatively new and not clearly defined. Alternative terms such as transducers or measurement recorders are still used. However, a sensor can be described as the primary element in a measurement chain that converts a variable input value into a suitable measurement signal. A sensor is thus an electronic component provided with connecting wires through which electrical signals are conducted into and out of the component. [41]

For some time now, calibrated acceleration sensors (accelerometers) have been used for continuous measurements of position and acceleration, i.e. body position and movement. Already in 1998, a study was carried out which determined the

frequency and duration of tremor in Parkinson's patients by means of accelerometry. [42]

An equally important type of sensor that is used in medicine and especially in occupational medicine science is the position sensor or inclinometer. The principle of this sensor is based on the detection of the angle of the perceived axis and a reference vector like gravitation or the magnetic field of the earth. [43], [44]

The already existing use of various monitoring systems is also shown by a study from 2012. Martin Et al. developed a prototype for a real-time monitoring system using Microsoft Kinect to provide employees with increased stress from lifting and carrying a training opportunity for correct lifting and carrying of heavy objects. [45]

Already in 2004 Gallagher Et al. wrote about the importance of real-time tracking of posture in humans. Although the possibility of such motion tracking by using camera labs has existed for some time, a local presence is required during the measurement period. In order to track postures as easily as possible, it is necessary to use small, light and mobile tracking systems that can be easily attached to people and where the recorded data can be stored locally or wirelessly. [46]

Although there are already individual gadgets that record a partial posture of the back such as “Upright Go” or “Lumo Lift”, a new and more precise form of posture tracking is made possible by the sensor system and the special algorithm of VivaBack. The first two mentioned products provide real-time haptic feedback through vibration alarms. However, the simple sensor systems result in very inaccurate measurements and posture profiles cannot be created as with VivaBack. Both products are supported by corresponding apps that visualize and graphically display data on the one hand but cannot recommend any further individual steps on the other. In addition, only the posture of the upper back or the cervical spine is monitored. In the case of "Upright Go", the device is attached at the height of the seventh cervical vertebra and then calibrated via the device control. "Lumo Lift" is attached to clothing (preferably under the clavicle) and then calibrated. Here, too, the tracking is more for the upper back area. As you can read in the device description of the manufacturer, "Lumo Lift" serves not only as a posture tracker but also as an activity tracker.

This is where the VivaBack sensor system stands out from existing products on the market. The comfortable portable system, which consists of an acceleration sensor and 2 position sensors, which (at the moment) lead via cable to the control element, enable monitoring of the back posture over an entire working day. This opportunity in combination with the follow-up personal coaching with professional

coaches currently makes VivaBack a unique provider in this field and can in the long run lead to a significant improvement in one's own health and especially one's back health.

In the following chapters, the operating principle of VivaBack is explained in more detail. The sensor system and the steps that finally enable accurate data acquisition are described. The different feedback methods and the different types of feedback are also described. The collected data are then analysed and presented.

3 Requirements & Methodology

This chapter describes the methodology and requirements, study design, investigation enforcement, questionnaires and the study population in detail. To answer the defined question of research and to achieve the formulated goals of the work, a descriptive explorative study design was chosen. Further, an online survey was created, answered by the participants and the results were evaluated. The participants were questioned about knowledge transfer, acceptance of the feedback method and further about the usability of VivaBack's automated eCoach.

3.1 Research Questions

The first question deals with the comparison of the effectiveness of knowledge transfer, consultation and acceptance of personal feedback with the automated eCoach. The aim is to determine whether one of the two feedback methods has better or worse outcome on the above-mentioned cases.

- Q1: Will the automated eCoach be better or less accepted by the participants than the personal feedback?

The second question is to investigate whether, in the opinion of the participants, it is possible for the eCoach to replace the human feedback coach, with the same knowledge transfer, consultation and acceptance.

- Q2: Is it possible to replace the personal feedback with the automated eCoach?

The third question is about the usability of the eCoach. Since the eCoach is still in the prototype stage, it is important for the developers to get feedback to take action or make changes before release.

- Q3: Is it possible that the eCoach can achieve a SUS score of at least 80 or more in a usability test?

3.2 Study Design

To get from zero to the final results of the evaluation, the following four main steps were carried out.

Firstly, a literature review was performed to give an overview of the topic and the problem, especially the problem with diagnosis, treatment of chronic lower back pain (CLBP) - general diseases of the musculoskeletal system – costs and the possible negative effect on the whole human body. This was executed between beginning of December 2018 and the end of February 2019.

Secondly, the sensor-based measurements were performed over a period of 4 to 8 hours per participant. The subsequent evaluation provided information on the back posture within the framework of the feedback-coaching. Fellow Students of the master program Digital Healthcare were selected as participants.

Thirdly, an online questionnaire was created and distributed after the feedback-coaching. Each participant was invited to complete the questionnaire following the consultation. The general survey was in the style of the already existing long-time-questionnaire by VivaBack. Participants of the Group with the automated (eCoach) feedback were invited to complete a second – extra – survey referring to the usability of VivaBack's eCoach.

Both questionnaires contained 10 questions each. The questionnaire on acceptance, knowledge transfer and counselling were identical for both groups. Only participants in the group with the eCoach received a questionnaire on usability. The development of the questionnaires took place between January and end of February 2019.

The online surveys were open between 23.3.2019 and 14.4.2019. The participation in the survey was voluntary and completely anonymous.

Fourthly, the study design – consisting of descriptive and explorative method – was chosen. By this method evaluation and results can be represented graphically better, and interrelationships can be explained more easily.

3.3 Investigation enforcement

In order to carry out the investigation, it was divided into 2 main steps. The first step dealt with the monitoring of the participants, the measurement and acquisition of the data. The feedback was carried out by an employee of the company VivaBack and was therefore not a self-imposed step of my empirical procedure.

The second part dealt with the creation of an online questionnaire, the subsequent evaluation and data preparation or rather visualization for the outcome of the comparison.

A more detailed explanation of both steps is explained below.

3.3.1 Monitoring, measurement and data-acquisition

In order to obtain a significant number of measurement data, the measurements were taken on a presence unit day at the St. Pölten University of Applied Sciences. The aim was to simulate a day in the office or workplace.

Each participant was given a declaration of agreement before the start of the measurement and was asked to sign it. After approval, the sensors were attached.

An employee of the company VivaBack supported the attaching of the sensors to the participants. The sensor system is attached on three different body positions and has to be calibrated before recording starts.

The first sensor is positioned at the left or right thigh. As you can see (Figure 2[1]) the second is then attached to the sternum (about two centimetres under the Incisura jugularis) while the third one is placed on the lower back (at a point between the left and the right spina iliaca posterior superior – around the third to fifth lumbar vertebrae). The sensors are threaded under the clothing and remain under the clothes during the entire measuring period.

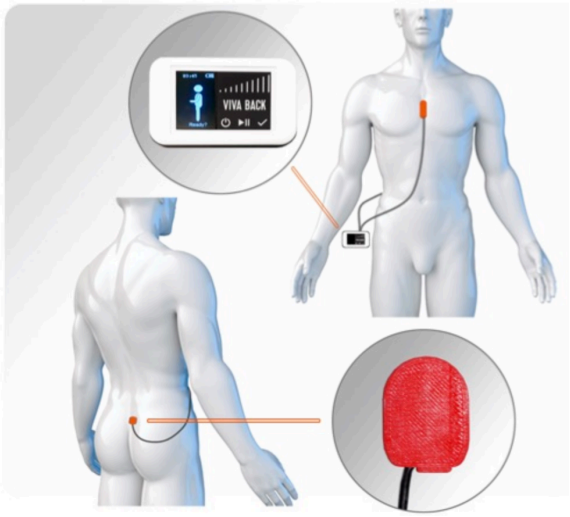

Figure 2: Representation of the sensor positions

Once the sensors are attached, the range of motion is determined. For the neutral position (Figure 3) the participant is asked to stand straight with heels, pelvis and shoulders as contact points to the wall. Here it is important not to stand "unnaturally" upright. I.e. the shoulders must not be pulled back purposely, or the

[1] Source: www.vivaback.com

head must not be held uprighter than usual. This neutral position should be kept as natural as possible. Ideally, this can be carried out leaning against a wall. In order to determine the extent of flexion, the participant is asked to step away from the wall and bend forward with its legs stretched as far as mobility allows (Figure 4). Finally, the maximum extension is defined (Figure 5). The participant is asked to put the hands on the hips and to bend back as far as possible with legs stretched and without toppling over.

During each individual calibration, the position must be held for a few seconds. The most important thing here is that the posture held corresponds to the actual mobility of the participant (stretched legs, etc.).

Figure 3: Neutral position

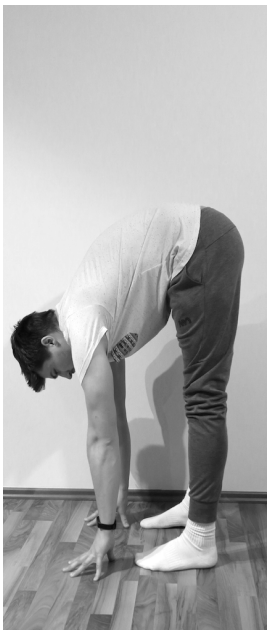

Figure 4: Position for flexion

Figure 5: Position for extension

The cables with which the sensors are connected lead to a small rectangular box, which stores the acquired data by the integrated technology and at the same time serves as a control and operating element with push buttons and a display for navigation and operation. This element is placed to the waistband of the trousers, belt etc. by means of a small carrying bag so that it is hardly noticeable.

Figure 6: Control element

The entire sensor system including the control element (Figure 6[2]) remains fixed during the whole measuring period. After the measurement has been completed, the participants remove the attached sensors from their body and return the devices to the test leader.

Afterwards, the instruments are checked for any errors or damage. If the data recording was successful, employees of VivaBack analyse the data, process any measurement inaccuracies and create the individual feedback.

3.3.2 Survey methodology

After feedback has been received, the online questionnaires were sent to the participants. Participants of group A received an online questionnaire for the evaluation of knowledge transfer, consultation and acceptance of personal feedback. Participants of group B received the identical questionnaire and additionally a second questionnaire, which should give information about the usability of the eCoach.

A more detailed description of the two online questionnaires and the tools used is given in Chapter 3.5.

3.4 The 2 methods of feedback

After evaluation, data preparation and creation of the individual feedback-data for each participant, different feedback methods were used. A distinction was made between personal feedback-coaching within the framework of a 30-minute

[2] Source: Valentin Rosegger, VivaBack

individual discussion and the so-called eCoach. The more detailed description of the two feedback methods is explained below.

3.4.1 Personal Feedback-Coaching

In the following week after data recording, participants of group A completed their personal 30-minute feedback-coaching with a physiotherapist or sports scientist. In this consultation the coach tries to explain the content and purpose of the sensor measurement and how the participants can and should benefit from it.

First, the diagram (Diagram 1) is discussed that provides information on how long the participants have sat, stood or walked during the measurement period.

Then the curve of the diagram over the entire measurement period is explained in a short form – a detailed explanation follows afterwards. Here the neutral position and the amplitude spikes are briefly discussed.

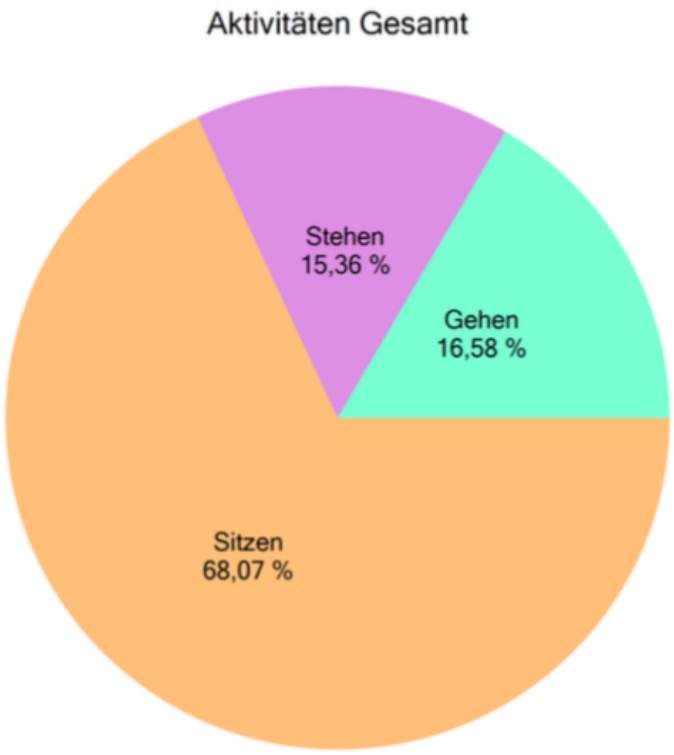

Diagram 1: Total activity

As a third step, the different position groups and the so-called range of motion are explained (Figure 7). The range of motion is divided into range 1 - from max. forward (extreme forward), to light forward to neutral, while range 2 is divided from

neutral to max. backward. As an alternative to the terms mentioned, professional terms such as max. flexion (max. forward), flexion (light forward) and extension (max. backward) are also used for the explanation.

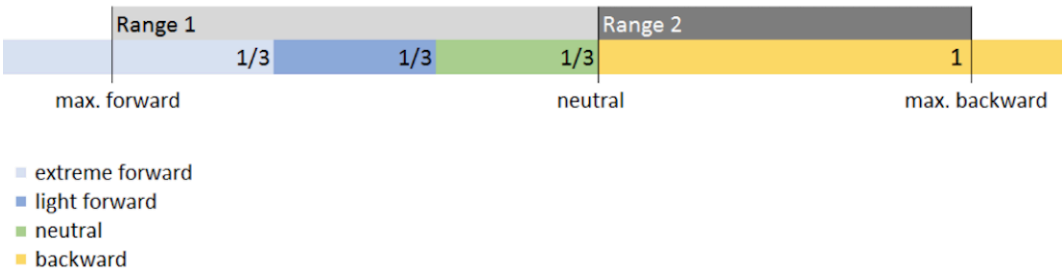

Figure 7: Range of motion

In addition, the position groups show how long (what percentage of the total time), and in which position a person was during the measurement (Diagram 2). Here, unilateral posture profiles can be unambiguously identified and presented in a way that is easy to understand.

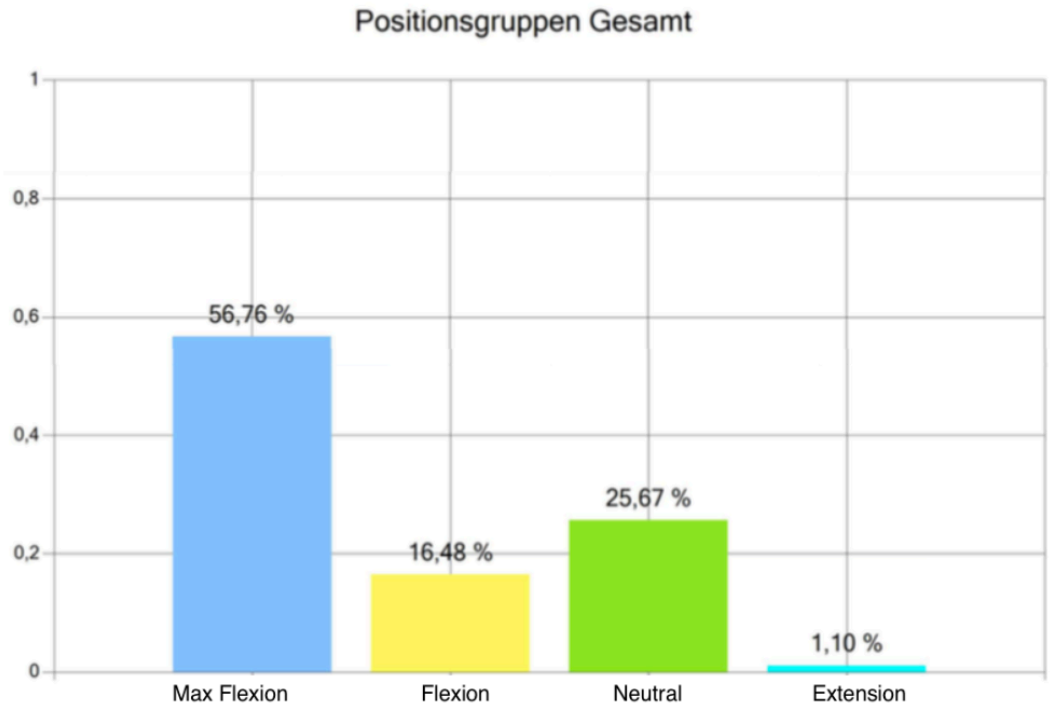

Diagram 2: Total position groups

The various position groups are then divided among the activities. This means that it is shown how the person's posture changes explicitly during sitting (Diagram 3), walking (Diagram 4) and standing (Diagram 5).

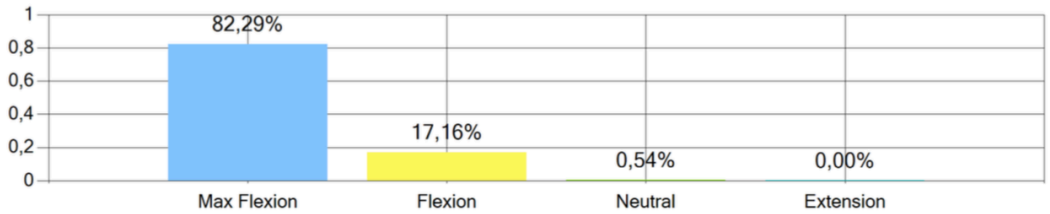

Diagram 3: Percentage during sitting

In order to speak of a balanced back movement profile during sitting, the flexion, neutral and extension areas are added together and should be the same height or the same percentage as the maximum flexion.

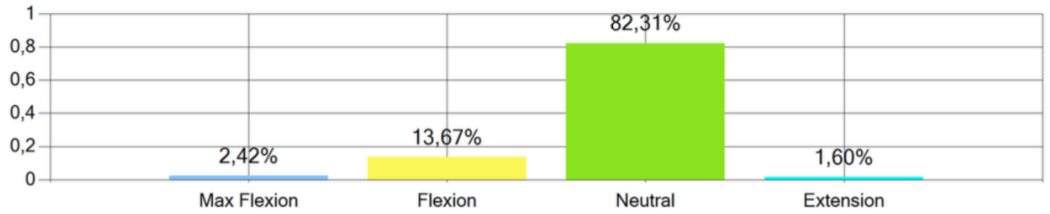

Diagram 4: Percentage during walking

If there are obvious deviations in the neutral position during walking, there can be various reasons for this. Here as well, an attempt is made during the coaching to find the cause of the curve fluctuation with the help of the respondent.

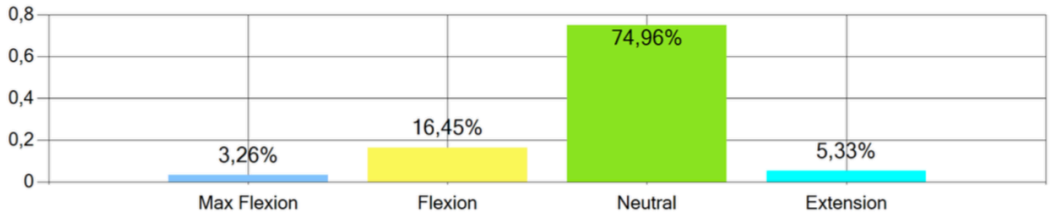

Diagram 5: Percentage during standing

The same applies to standing. If there are any major deviations, an attempt is made to identify possible causes in a conversation between the coach and the respondent.

After explaining the basic terms and understanding the classification of the positions (position groups), the measurement curve over the entire time period (Diagram 6) is analysed and made understandable.

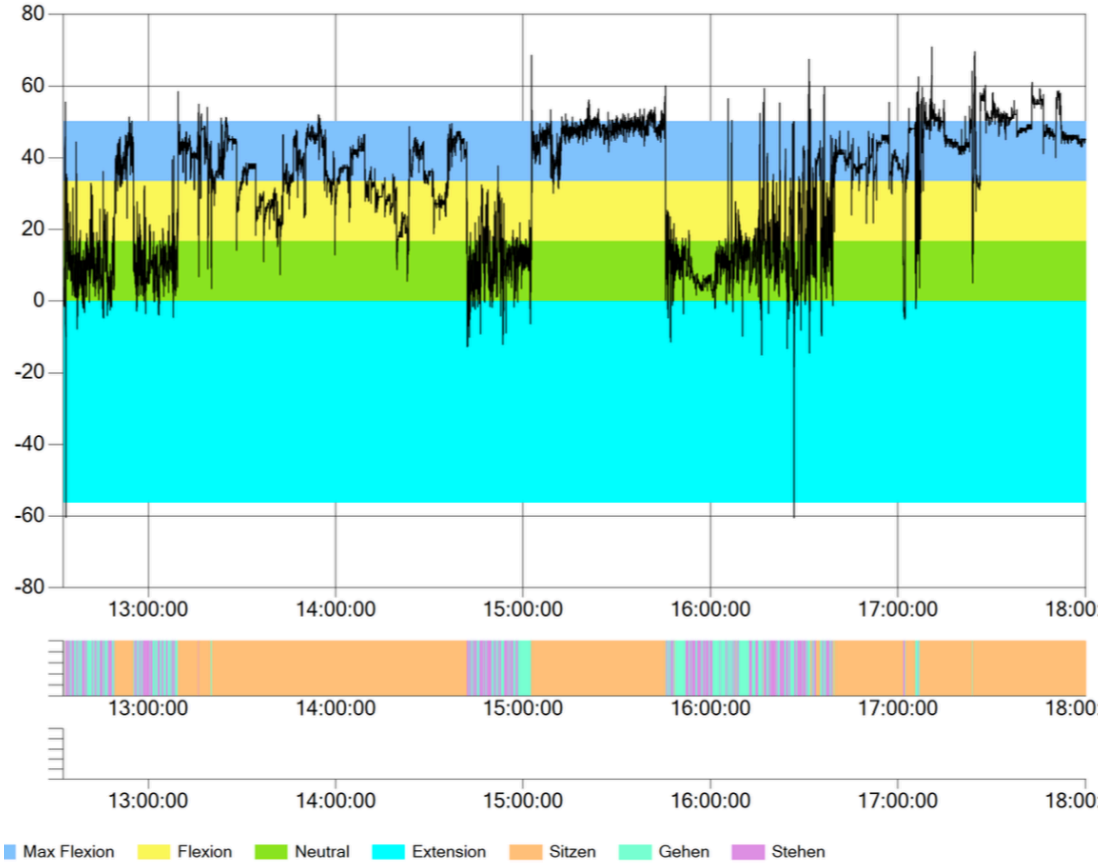

Diagram 6: Measurement curve over the entire time period

As can be seen from the diagram above, the colour-coded representation of the measurement results is used to create an awareness of the personal back movement and back posture. As already mentioned, the back posture can be explained in a temporal context and possible fluctuations due to back movements or unilateral patterns can be identified. To improve understanding, colour codes and position groups are displayed below the graph.

In spite of possible variations in the graphs or the curves, the coach tries to explain to the respondent that there is no wrong posture, but mainly how the person moved during the measurement, and that it is important to move the back in a balanced way.

Depending on the measurement results and the compliance of the respondent, simple steps for compensatory movements or tips and tricks for supporting certain

back postures are already introduced during the discussion of the results - at the latest, however, afterwards.

Especially this part of the consultation becomes coaching. The aim is to create an understanding of how, for example, the tilting of the pelvis affects the back position and how people can support themselves in everyday working life.

For example, the coach shows how the back-bend changes as a person slides all the way back on the chair - up to the backrest and knees bent at a 90° angle while their feet are on the ground. Or it is shown how each person can create a lordosis support from a small pillow, towel or similar. These are just some of the tips, and actions that take place during feedback.

3.4.2 eCoach

After the recorded data was processed an individual link was generated for participants of group B, which lead to the personal evaluation and feedback within the framework of VivaBack´s eCoach. The eCoach, which is still in the prototype stage, was used for the first time in this study.

Feedback from the eCoach pursues the same goal as the personal feedback from a physiotherapist or sports scientist. The feedback is currently only given by a physiotherapist via video and image material. In the context of this feedback method, the data presentation on the website in combination with the videos of the physiotherapist is called eCoach.

Through the use of example videos and further image material - in the form of various graphics - the aim is on the one hand, to present the measurement data in a simple and understandable way, and on the other hand to show tips and tricks for better back posture, back- and compensation movements.

After the welcome text on the website, the eCoach briefly introduces himself (by clicking on the first video) using a video message and gives an overview of the basics of the VivaBack measurement. The interpretation of the recorded data is then explained - again via video. Terms such as "dynamics, activity and position groups" are also explained. The coach also briefly explains what is good for one’s own back, what the current state of research suggests with regard to back posture and how people can help themselves in everyday life. For example, balanced movements of bending, stretching and neutral position of the back are recommended. In addition, it is pointed out that it should be considered to sit, walk and stand alternately during a working day.

The individual recorded data are then displayed in the form of diagrams. In the following, the result of the activity (parts of sitting, walking and standing) is presented (Figure 8). Next to each diagram is an embedded video that explains the content of the displayed data and simplifies interpretation.

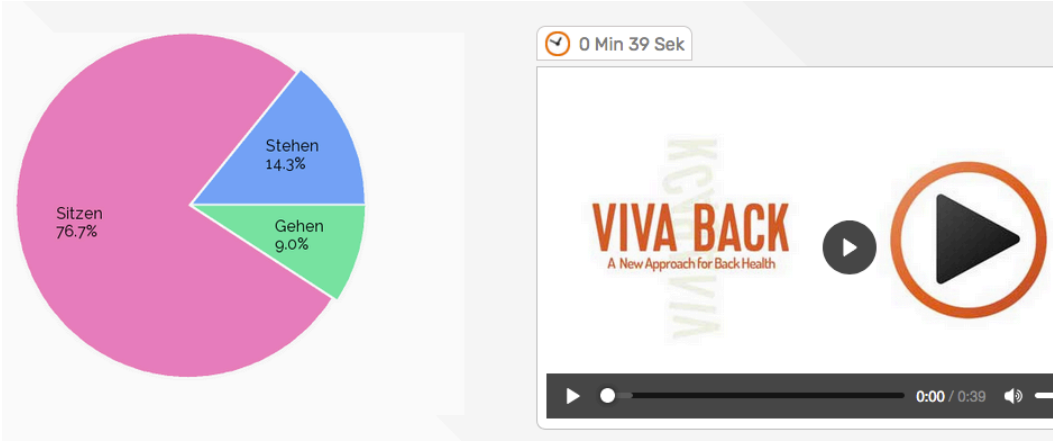

Figure 8: Display of total activity via eCoach

After the results of the total activity have been displayed, the results of the position groups are displayed (Figure 9). Again, depending on the individual profile, a video is embedded to support the interpretation.

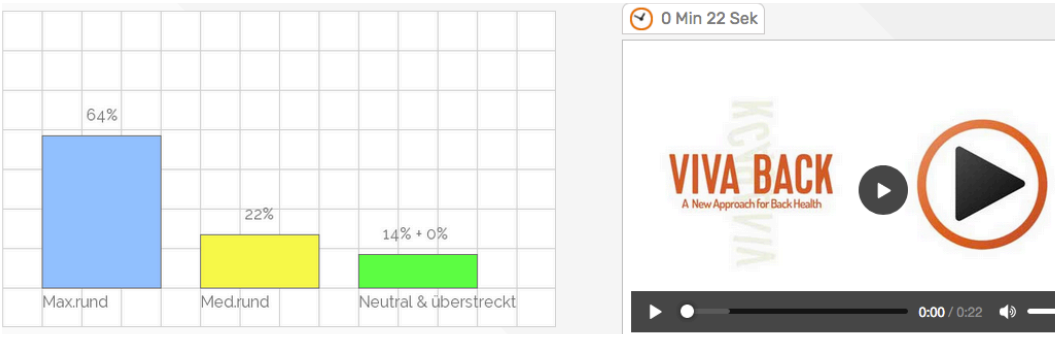

Figure 9: Display of total position groups via eCoach

After the basic results have been analysed, suggestions are made on how to improve personal dynamics, such as how to reduce the amount of sitting, and exercises are presented to show which individual postures the back needs to achieve a balanced posture profile. Depending on how the motion and posture profile is presented, different videos are embedded. In this way, the participant should receive the most adequate advice possible and derive the greatest possible benefit from the eCoach feedback.

3.5 Questionnaire

In order to carry out the evaluation following the feedback rounds, the methodology of the online questionnaire was used.

As Evans and Mathur write, the online questionnaire makes it possible to dispense with intrusive interviews - including their potential sources of error - or telephone surveys, and ensures that the data collected is up-to-date in real time.[47]

Each question had to be answered in order to successfully close the questionnaire and thus be taken into account in the evaluation. Access to the online questionnaires were made available by sending the weblink. It was not possible to interrupt answering the questions and resume them at a later point of time. Both questionnaires were created with the same answer possibilities. For this purpose, the so-called five-stage Likert-Scale was used (Figure 10). This scale can be used to determine the attitude of a respondent to a topic. Here, several evaluative statements are formulated, which the person agrees or disagrees with using a scale. [48]

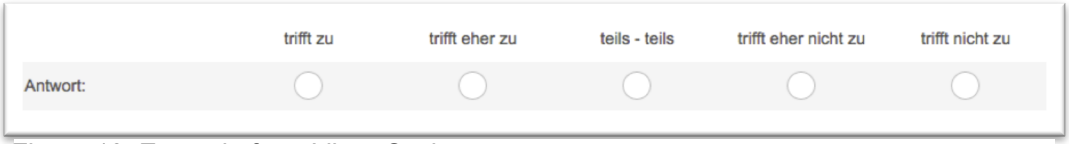

Figure 10: Example for a Likert-Scale

A more detailed descriptions for the creation of the online questionnaires as well as the tools used are described below.

3.5.1 Questionnaire for knowledge transfer, consulting and acceptance

The participants had to answer an online questionnaire, consisting of 10 questions, about three to four weeks after the feedback. In order to evaluate the effectiveness of the feedback methods, the questionnaire was created which focuses on knowledge transfer, counselling and acceptance. The elaboration of the questions was carried out in partnership with the cooperation company and on the basis of an existing internal questionnaire. Further it was created between January and February 2019 and was answered by both test groups. The results were directly compared with each other.

3.5.2 Questionnaire for the usability of the eCoach

In order to successfully develop a product, the goal should always meet the requirements of the user. Usability is the umbrella term for the big picture - for the perfect interaction of hardware, software, menus, etc. - which should already be tested at the development stage of a product ready for series production. [49]

To evaluate the usability of the eCoach, the System Usability Scale (SUS) by John Brooke (1996) was used and modified. [50, S. 189–194]

This usability test contains 5 questions with positively-worded statements and strong agreement to the tested system and 5 negatively-worded statements towards the tested system. To get the most out of the usability test, two of the ten given statements were replaced by self-formulated one. Statement 1 “I think that I would like to use this system frequently” was replaced by “I am satisfied with the eCoach feedback” and statement 7 "I would imagine that most people would learn to use this system very quickly" was replaced by "I have the following suggestions for improving the eCoach / Feedback system”. Here an attempt was made to maintain the balance between the positive and negative suggestive statements. Since these two template-statements do not bring any obvious benefit for the further development and improvement of the eCoach, they were replaced by self-created ones. This enables to determine the general satisfaction - in terms of eCoach feedback - of the participants, and at the same time the participants are given the opportunity to make suggestions for improving the prototype. This exchange of statements was also taken into account in the final calculation of the SUS score. A calculation without a numerical value for Statement 7 and a calculation with an average numerical value of 20 were performed. This leads to two similar results, whose more exact calculation and origin is described in chapter 4.

3.6 Study Population

The study population contained in total 20 participants and was discussed in advance with the cooperation company. The original planned use of the sensor systems for data acquisition would have been in the field of radiology. Due to the physical conditions (especially magnetic fields in the examination room) and the resulting risks for equipment and persons (due to metal parts on the sensors), it was decided to determine a different test group. The final test group therefore consisted of students from the Master Programme Digital Healthcare. There were some general inclusion and exclusion criteria. Participants only had to be Digital Healthcare students. The study population consisted of 8 females (40%) and 12

males (60%) with an age in categorized range between 20 and 60 years. All participants had a certain affinity for technology and a basic understanding of the relationship between digital technologies and healthcare. The inclusion criteria and exclusion criteria are listed below (Table 3).

Inclusion criteria	Students of the Master Programme Digital Healthcare, regardless of age group, gender or place of residence. Approval for study participation and local presence at the University of Applied Science St. Pölten during data acquisition.
Exclusion criteria	Students of programmes other than Digital Healthcare. Absence during measurement or disagreement for study participation.

Table 3: Criteria for study population

In order to ensure the encryption of personal data (name and gender), these were converted into multi-digit codes - consisting of numbers and letters - by an anonymisation run. [51]

3.7 Analysis

In order to answer the research questions, all collected data were then analysed and graphically illustrated using VivaBack´s own software, “Microsoft Excel” and the integrated display possibility within the questionnaire software “Umfrage Online”. A descriptive statistic was created to compare the two feedback methods. Through the SUS, with the predefined evaluation key, the usability of the eCoach was evaluated according to a given scheme. The two self-generated questions - replacing two given questions within the SUS - were treated in the same way as the standard questions in the evaluation and interpretation process of the results.

4 Evaluation Results

This chapter presents the results of the evaluation of the online questionnaires. In order to answer the questions of research and to make a comparison, descriptive statistics is used as method. The acquired data are evaluated and graphically represented.

In total, 20 participants took part in the study. These were divided into two random groups. Participants in Group A received feedback through a personal meeting with a physiotherapist. About two weeks after the feedback, the questionnaire was sent to the participants via email to determine the knowledge transfer and effectiveness of the feedback. A response rate of 100% (10/10 participants) was achieved. One week after data acquisition, participants of Group B received an weblink that led them to their personal eCoach. In addition, another weblink was sent to those participants that led them to the online questionnaire for the usability survey of the eCoach. Due to a measurement error of unknown cause, the evaluation of the personal back posture of one participant could not be adequately prepared and subsequently not included in the evaluation. Therefore, for group B only survey results of 9 out of 10 participants were used for the further procedure. Nevertheless, a response rate of 100% (9/9) was also achieved here in the evaluation of the usability of the eCoach. The link for the online questionnaire regarding knowledge transfer and effectiveness of the eCoach feedback was sent to the participants of group B about two weeks after the feedback. This survey was also answered by 100% of the participants (9/9). Due to the settings of the online questionnaire, each of the ten questions was marked as mandatory and each participant had to answer all ten questions in order to successfully complete the survey. Thus, a proper participation could be achieved.

In the following, the results of the online questionnaires are presented to evaluate the knowledge transfer and the effectiveness of the personal feedback-coaching method. First the evaluation and comparison for the knowledge transfer of group A and group B is presented. This is followed by a presentation of the results of the usability questionnaire.

4.1 Evaluation & comparison of the results of both groups

In this chapter the results of the investigation of this work are presented. Further, based on the results, an answer to the research questions will be made. First, the answers about effectiveness and knowledge transfer of the feedback methods of both groups are compared (in order to be able to answer the research questions) in a more detailed way. The results of the usability study of the eCoach and a detailed answer to the corresponding research question is represented in chapter 4.2.

To make a comparison between group A and group B the questions are stored with a numerical value (Table 4). This numerical value is multiplied by the respective number of participants who chose this answer. After addition of all numbers of answers with the deposited numerical values, the value obtained is divided by the number of participants in order to get a mean value. Both mean values of group A and group B are finally compared and interpreted.

"trifft zu"	"trifft eher zu"	"teils – teils"	"trifft eher nicht zu"	"trifft nicht zu"
1	2	3	4	5

Table 4: Representation of the answer options with the associated numerical values

The following example (Table 5) shows a schematic representation of the process to obtain the mean value.

Num. Value linked to answer options			Group A n=10		Group B n =9
			Number of given answers		
trifft zu (1)			4		1
trifft eher zu (2)			5		0
teils - teils (3)			1		2
trifft eher nicht zu (4)			0		4
trifft nicht zu (5)			0		2
			Total = 17		Total = 33
			17/10 = 1,7		33/9 = 3,6

Table 5: Example for the calculation of the mean value

In order to simplify the interpretation of the results, the mean values of both groups are calculated and compared for each question. The mean values can be between

1.0 (most agreement) and 5.0 (least agreement). Since this survey is about general feedback of the participants, about the existing sensor system, the evaluation and feedback procedure to improve and optimize it, the somewhat small sample size is consciously accepted. Due to the small sample size, no significance level was calculated. The calculated mean values are therefore used to answer and interpret the research questions.

At this point, the different total size of the groups is pointed out once again. Group A had a total size of n=10, whereas Group B had a total size of n=9. This fact must be taken into account when interpreting the results. The results provided below are given as whole numbers and as percentages.

The following diagram shows the number of participants of group A and group B who participated in the questionnaire (Diagram 7):

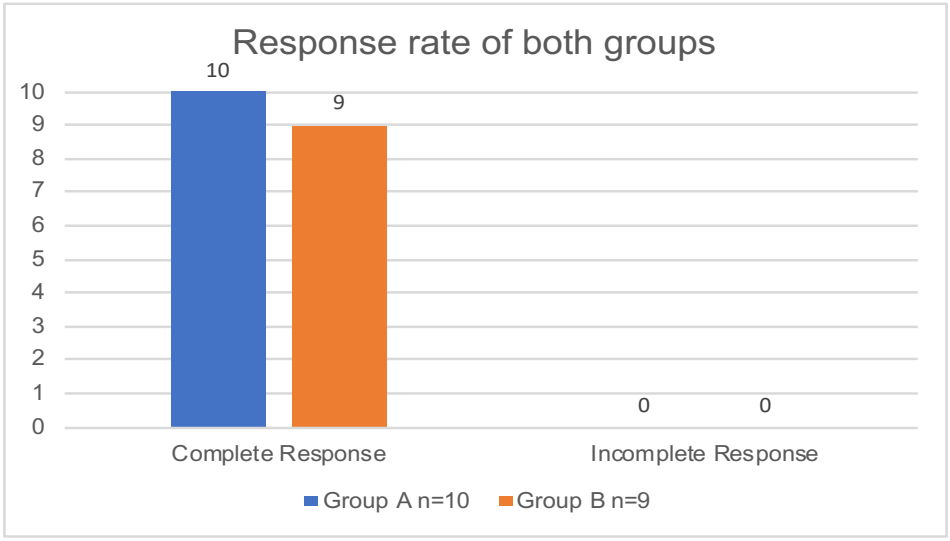

Diagram 7: Response Rate of group A and group B

Question 1: „Sind Sie mit dem persönlichen Feedback zufrieden?“

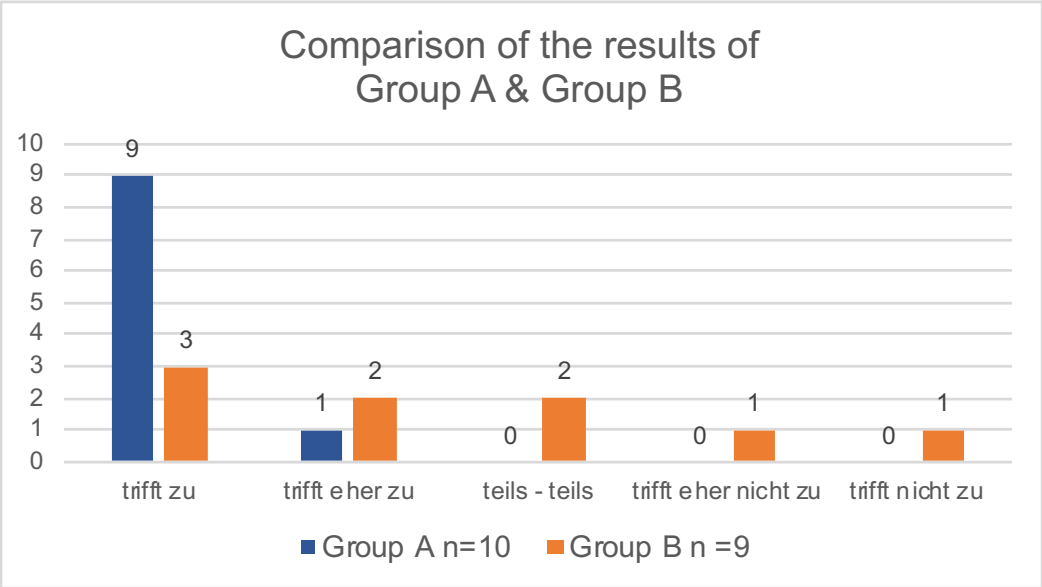

Diagram 8: Question 1 – comparison of the results

As can be seen from the diagram above (Diagram 8), there are clear differences in subjective satisfaction in relation to the feedback received.

From group A, 9 out of 10 participants (90%) answered "trifft zu" and 1 participant (10%) answered with "trifft eher zu".

In Group B, on the other hand, the result is less positive. 3 out of 9 participants (33.3%) gave the answer "trifft zu", 2 participants (22.2%) each chose the answer "trifft eher zu" and "teils – teils". The answer options "trifft eher nicht zu" and "trifft nicht zu" were also chosen by 1 participant each (11.1%).

It can thus be said that participants from group A who received feedback through a personal meeting were clearly more satisfied (average value 1.10) with their feedback than those from group B who received it via the eCoach (average value 2.44).

Question 2: „Durch die VivaBack-Beratung habe ich gelernt, wie ich ausgeglichen sitzen und mich bewegen kann.“

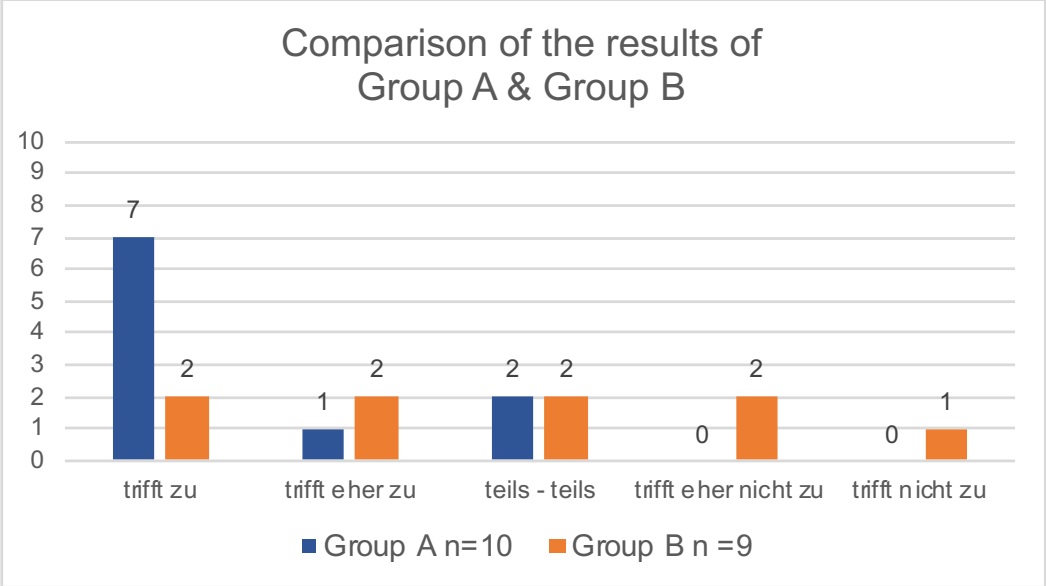

Diagram 9: Question 2 – comparison of the results

When looking Diagram 9 it can be seen that there are noticeable differences in the responses of both groups.

7 of the 10 participants from group A (70%) chose the answer "trifft zu". 1 participant (10%) chose answer "trifft eher zu" and the remaining 2 participants (20%) chose "teils – teils" as answer. None of the participants opted for the answers "trifft eher nicht zu" and "trifft nicht zu".

In Group B, on the other hand, the result again is less positive. In each case 2 participants (22.2%) decided for the answer possibilities "trifft zu", "trifft eher zu", "teils – teils" and "trifft eher nicht zu". Only 1 participant (11.1%) decided for "trifft nicht zu" as answer.

Again, it can be seen that participants who received their face-to-face-feedback could learn more about a balanced movement and sitting behavior. The answers of participants of group B were distributed more or less evenly across the 5 possibilities. Group A therefore scored an average value of 1.50 while group B had an average value of 2.78.

Question 3: „Durch die VivaBack-Beratung habe ich gelernt, wie wichtig es ist, mich regelmäßig zu bewegen, um Rückenschmerzen vorzubeugen.“

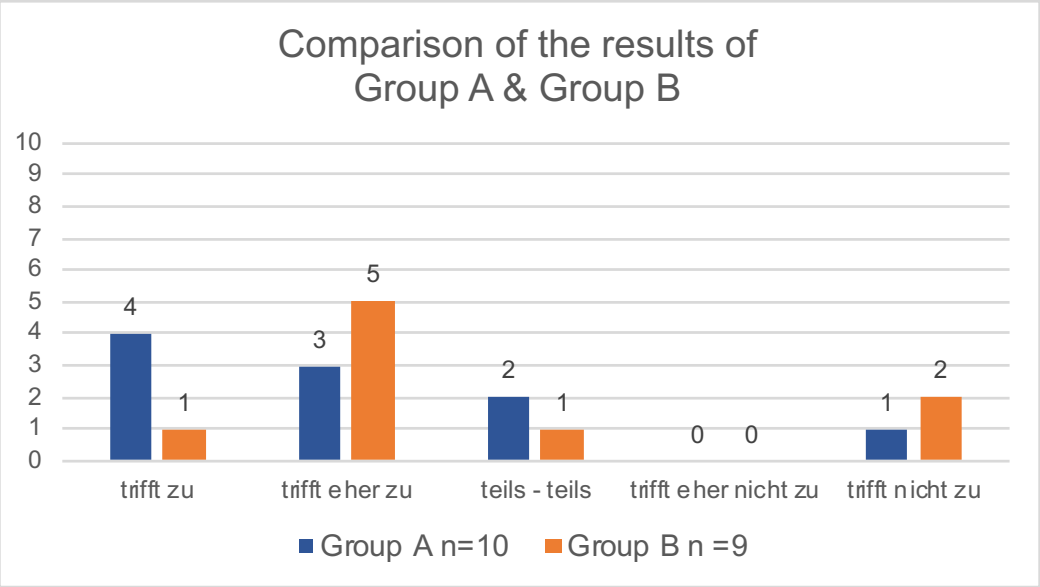

Diagram 10: Question 3 – comparison of the results

When Diagram 10 is considered, it can be seen that there is an overall similarity between the two groups in agreeing to this statement.

With this statement 4 out of 10 participants of group A (40%) gave the answer "trifft zu", 3 participants (30%) opted for "trifft eher zu" and 2 more (20%) decided for "teils – teils". None of the participants chose the answer option "trifft eher nicht zu" and only 1 participant (10%) chose "trifft nicht zu".

In Group B, however, only 1 participant (11.1%) opted for the response option "trifft zu". After all, 5 participants (55.5%) chose "trifft eher zu" as their answer and 1 other participant (11.1%) indicated "teils – teils" as the most accurate answer. No one from this group opted for "trifft eher nicht zu", but 2 participants (22.2%) replied that the answer "trifft nicht zu" was most appropriate for them.

Due to the feedback given by both groups, no clear differences in agreement or disagreement with the given statement can be discerned. The average score for this question was 2.10 for Group A and 2.67 for Group B.

Question 4: „Seit der VivaBack-Beratung gelingt es mir subjektiv besser meinen Rücken regelmäßig zu bewegen.“

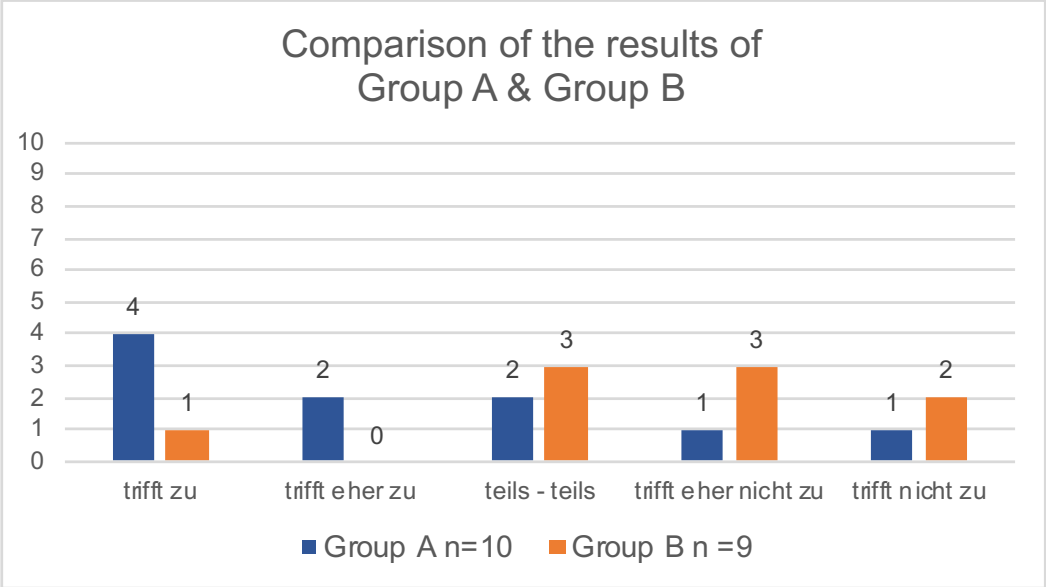

Diagram 11: Question 4 – comparison of the results

If Diagram 11 is examined more closely, an unequal distribution of the response between the two groups can be seen.

For group A, 4 out of 10 participants (40%) chose the answer "trifft zu" while 2 participants (20%) each chose "trifft eher zu" and "teils – teils". 1 other participant (10%) chose "trifft eher nicht zu" as the answer and also 1 participant (10%) gave "trifft nicht zu" as the most accurate statement.

Group B shows that only 1 participant (11.1%) gave the answer "trifft zu" while 3 participants (33.3%) each chose the possibilities "teils – teils" and "trifft eher nicht zu". The remaining 2 participants (22.2%) chose "trifft nicht zu" as their answer and no one from group B chose "trifft eher zu".

This results in different average values for both groups. Group A reaches a value of 2.30 while Group B reaches a value of 3.56.

Question 5: „Seit der VivaBack-Beratung gelingt es mir besser verschiedene Sitzpositionen zu nutzen.“

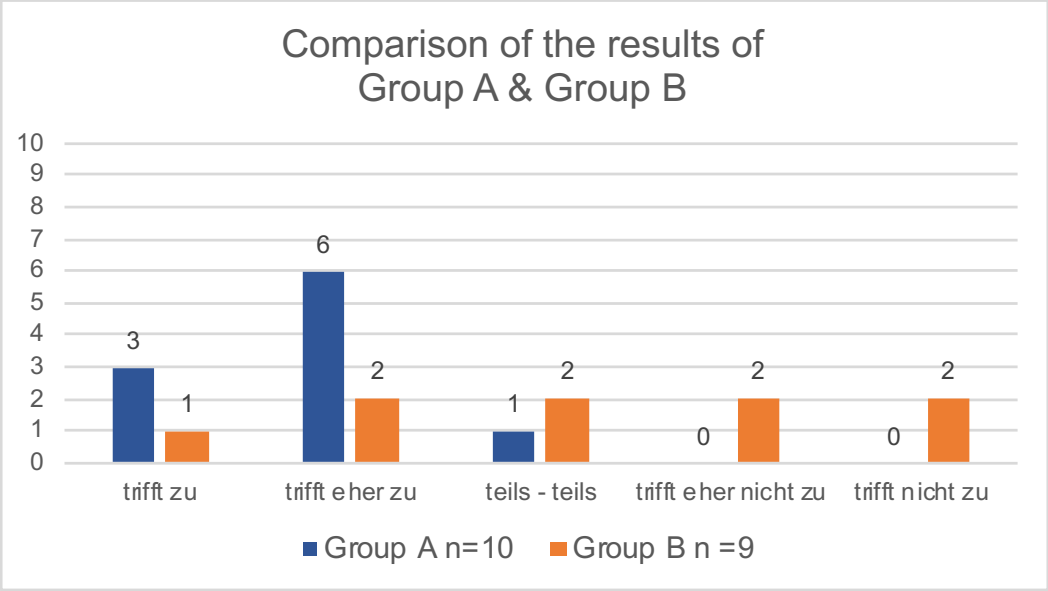

Diagram 12: Question 5 – comparison of the results

Diagram 12 shows that there are significant differences in the delivery of responses between the two groups.

3 of the 10 participants (30%) from group A gave the answer "trifft zu". The predominant majority of 6 out of 10 participants (60%) indicated the answer "trifft eher zu" after all. Only one participant (10%) gave "teils – teils" as an answer. For the two remaining answers "trifft eher nicht zu" and "trifft nicht zu" no one from group A decided.

For group B, the distribution of the answers given is not so one-sided. Only 1 out of 9 participants (11.1%) gave the answer "trifft zu". The remaining 8 answers were distributed 2 times each (22.2%) between "trifft eher zu", "teils – teils", "trifft eher nicht zu" and "trifft nicht zu".

Therefore, it can be deduced that participants from group A (average value 1.80) were subjectively more successful in implementing various seating positions in everyday life than participants from group B (average value 3.22).

Question 6: „Seit der VivaBack-Beratung gelingt es mir subjektiv besser meinen Arbeitsplatz (Bildschirm, Sessel, Tastatur, etc.) auf meine Bedürfnisse anzupassen.“

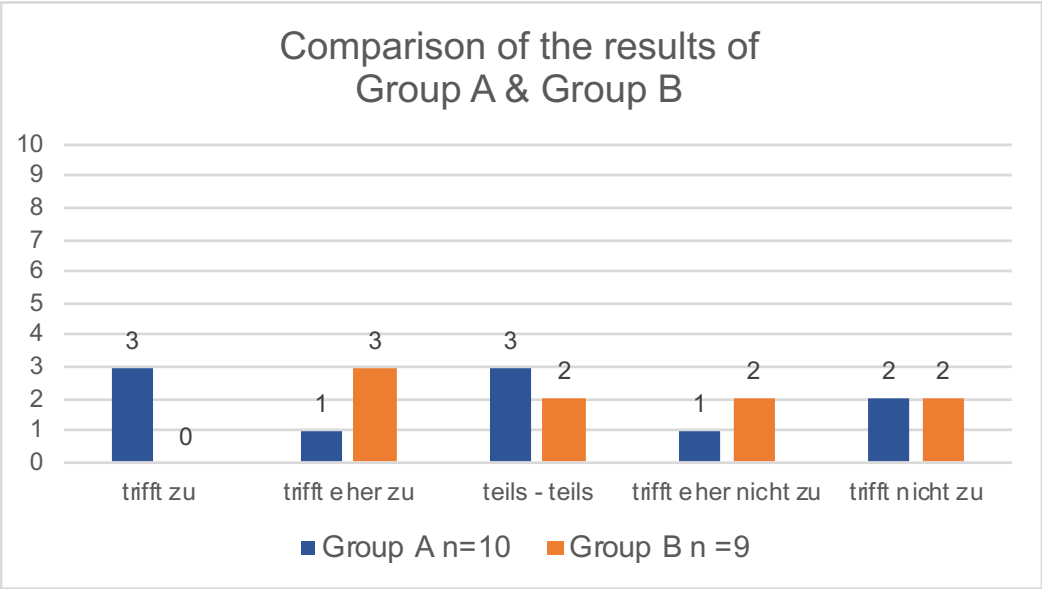

Diagram 13: Question 6 – comparison of the results

If the Diagram 13 is considered, a balanced distribution of the answers given by both groups can be seen at first glance.

It can be seen that 3 out of 10 participants (30%) from group A gave the answer "trifft zu” and also 3 participants (30%) chose "teils – teils" as answer. ". 1 other participant (10%) chose "trifft eher zu" and 1 participant (10%) chose "trifft eher nicht zu". The remaining 2 participants (20%) chose "trifft nicht zu" as the most appropriate answer.

In group B no one chose the answer "trifft zu". At least 3 participants (33.3%) answered "trifft eher zu" and 2 participants each (22.2%) chose "teils – teils", "trifft eher nicht zu" and "trifft nicht zu".

If the average values of both groups are considered a similarity can be observed. Group A scored an average value of 2.88, while group B had a value of 3.33.

Question 7: „Seit meiner VivaBack-Beratung ist mein Wohlbefinden des Rückens subjektiv besser geworden.“

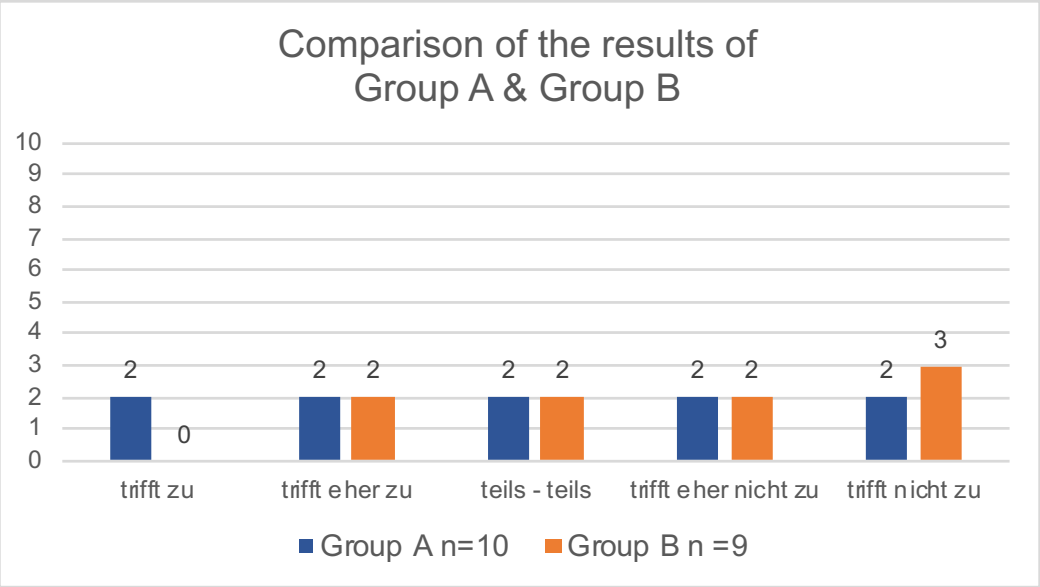

Diagram 14: Question 7 – comparison of the results

As Diagram 14 shows, there is a balanced distribution of the answers within the respective group on the one hand and when direct comparing both groups on the other.

Each of the possible answers "trifft zu", "trifft eher zu”, "teils – teils", "trifft eher nicht zu" and "trifft nicht zu" was chosen by 2 (20%) of the 10 participants of group A.

For group B the result looks similar to group A. The answers "trifft eher zu", "teils – teils" and "trifft eher nicht zu" were chosen by 2 of the 9 participants (22.2%) per answer. 3 out of 9 participants (33.3%) opted for "trifft nicht zu", while nobody voted for "trifft zu".

Looking at the resulting averages, it can be seen that Group A scored a value of 3.00 while Group B had a value of 3.67.

Question 8: „Das Feedback-Verfahren war leicht verständlich und ich konnte neues Wissen zu meiner persönlichen Rückengesundheit erlangen.“

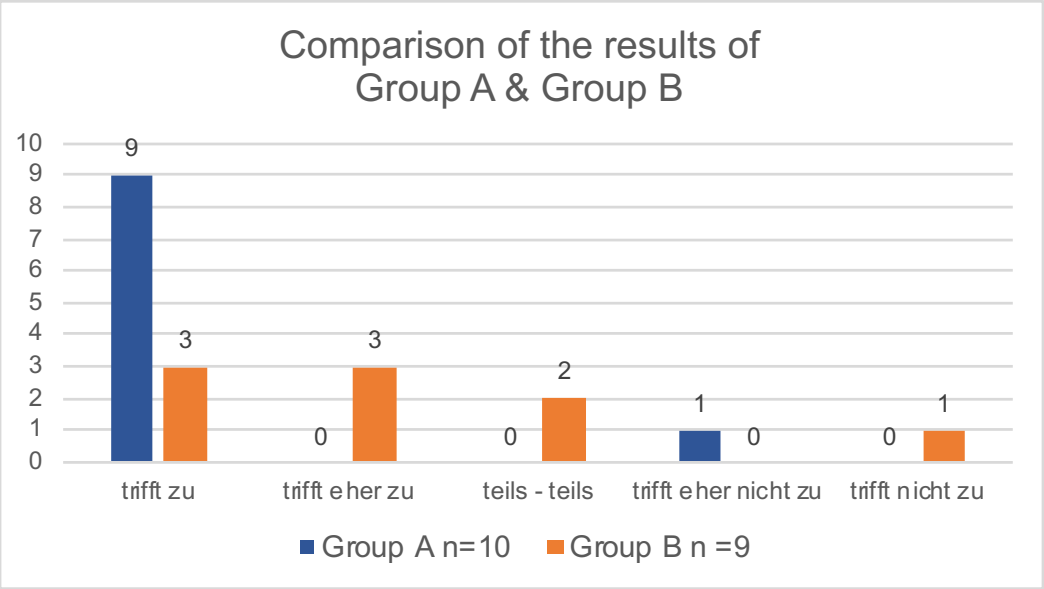

Diagram 15: Question 8 – comparison of the results

The above diagram (Diagram 15) illustrates that there has been a noticeable difference here between the given responses of group A and group B.

Remarkable 9 out of 10 participants from group A - that is 90% - gave "trifft zu" as their answer and therefore full agreement. Only 1 participant (10%) gave "trifft eher nicht zu" as an answer and felt differently.

In group B, the distribution of the answers given was more balanced. 3 of the 9 participants (33.3%) each chose "trifft zu" and "trifft eher zu" as answer and 2 participants (22.2%) chose "teils – teils". Only 1 participant (11.1%) opted for "trifft nicht zu" and nobody gave "trifft eher nicht zu" as an answer.

The average value of both groups also shows that participants from group A with an average value of 1.30 were more satisfied with the feedback than participants from group B, who scored an average value of 2.22.

Question 9: „Die visuelle Datenaufbereitung bzw. Darstellung war übersichtlich und klar.“

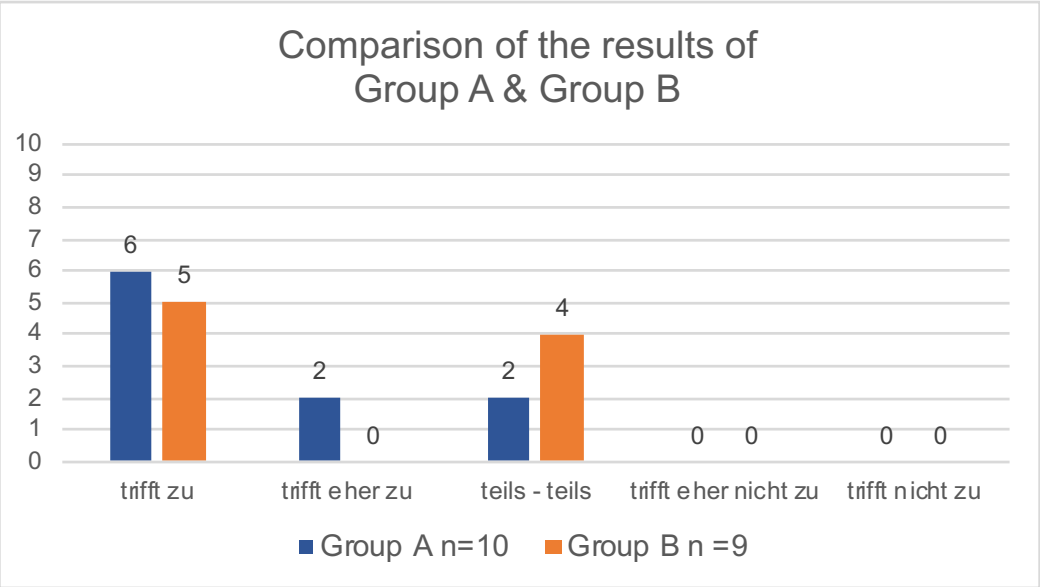

Diagram 16: Question 9 – comparison of the results

The diagram above (Diagram 16) roughly shows that the answers of both groups were similar.

6 of the 10 participants (60%) from group A gave the answer "trifft zu" and were fully satisfied with the visual data preparation and presentation. The remaining 4 participants split up when answering and therefore 2 participants (20%) chose "trifft eher zu" and also 2 participants (20%) chose "teils – teils" as their answer. No one from group A decided for “trifft eher nicht zu” or “trifft nicht zu” as most accurate answer.

In Group B, the 9 responses given were split between two of the five choices. 5 of the 9 participants (55.5%) and thus more than half, gave "trifft zu" as an answer while the remaining 4 participants (44.4%) chose "teils – teils" as the most appropriate answer. None of the participants opted for “trifft eher zu”, “trifft eher nicht zu” or “trifft nicht zu”.

The calculation of the average value shows that participants from group A with 1.60 were slightly more satisfied with the visual data processing and visualization than participants from group B with an average value of 1.89.

Question 10: „Ich würde eine wiederholte Messung zum Langzeitfortschritt meiner persönlichen Rückengesundheit und Körperhaltung durch die Firma VivaBack durchführen.“

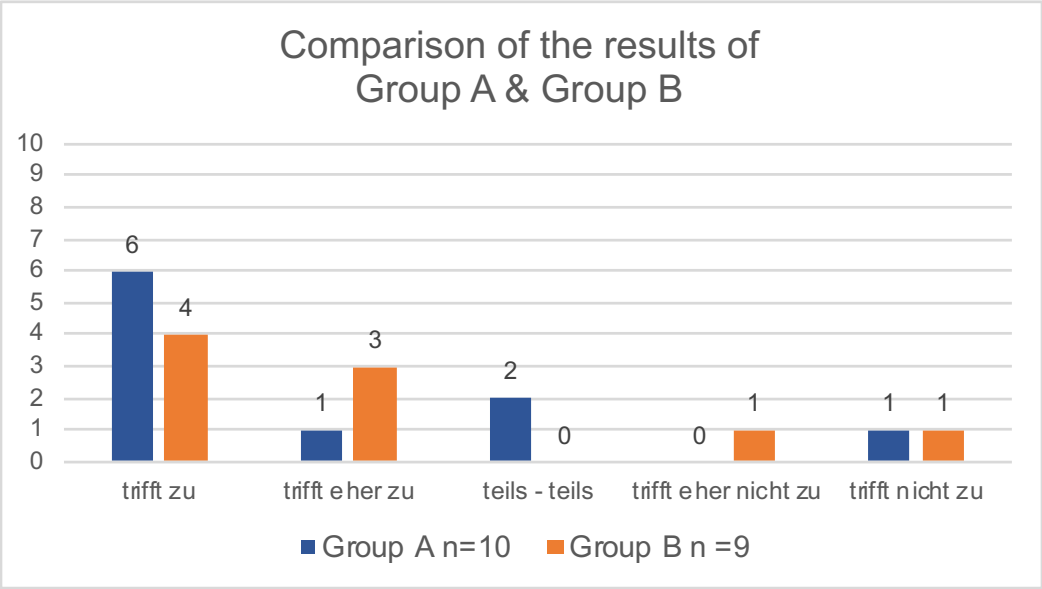

Diagram 17: Question 10 – comparison of the results

Diagram 17 reveals some slight differences between the answers of the two groups.

A total of 6 out of 10 participants (60%), and therefore more than half of group A, gave the answer "trifft zu". The answers "trifft eher zu" and "trifft nicht zu" were chosen by 1 participant (10%) each and the remaining 2 participants (20%) chose "teils – teils" as the answer option. Answer possibility “trifft eher nicht zu” was chosen by no one.

In Group B, on the other hand, slightly less than the half - 4 out of 9 participants (44.4%) - opted for the answer "trifft zu" and 3 others (33.3%) voted for "trifft eher zu". Nobody chose the answer option "teils – teils", while the remaining two participants (11.1% each) split up between "trifft eher nicht zu" and "trifft nicht zu".

Overall, the answers given by both groups gave a similar average value. For group A the value was 1.90 while group B scored an average value of 2.11.

On the basis of the results above and the comparison performed, the two research questions Q1 and Q2 can be answered as follows:

Research questions:

- Q1: Will the automated eCoach be better or less accepted by participants than the personal feedback?
- Q2: Is it possible to replace the personal feedback with the automated eCoach?

Based on the responses received from both groups and the resulting numerical values and mean values, it can be said that the eCoach at the current stage of development with the features currently included, received less approval from the participants than the face-to-face feedback. For each of the 10 questions there was more positive resonance from the participants who received their feedback from the physiotherapist. The transfer of knowledge and the implementation of the measures of the given feedback succeeds subjectively better through face-to-face feedback and can therefore also be regarded as better accepted. In order to maintain the quality of the feedback and to bring the greatest possible benefit to the participants of this measurement, it can be said that the eCoach cannot replace personal feedback-coaching at the current stage of development.

In the following pages the results of the usability test for the eCoach and an answer to the research question Q3 will be presented and described.

4.2 Evaluation of the usability study

Below, the analysis of the online questionnaire of group B, to evaluate the usability of VivaBack's eCoach is presented. As already mentioned before, due to a measurement error of unknown cause, in the end 9 out of 10 measurements could be used for the further procedure.

In order to test the usability of the eCoach, the so-called SUS (explanation and description can be found in chapter 2.6) is used. The modified SUS questionnaire was used to calculate the so-called SUS score. The calculation scheme of the SUS score is based on the assumption that a value between 0 (worst imaginable application) and 100 (best imaginable application) can be reached. After the questionnaire is evaluated, the numbers received are summed up and then multiplied by 2.5. [38]

Finally, the average SUS score is determined from all statements. Statement 10 was not included in the calculation process for determining the SUS score due to the lack of a valuation basis. The result can be interpreted as a numerical value.

The diagram below (Diagram 18) shows the response rate of the participants:

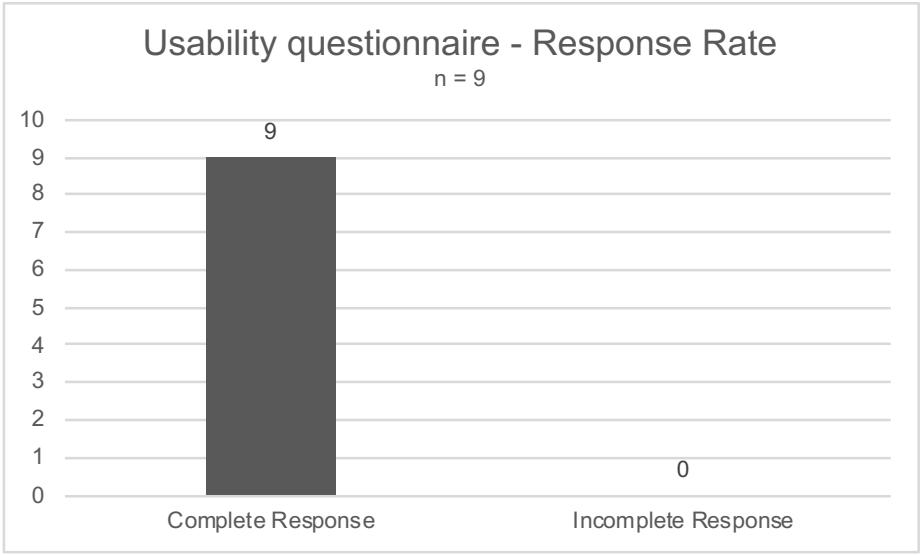

Diagram 18: Usability questionnaire – Response Rate

Statement 1: „Ich bin mit dem eCoach-Feedback zufrieden.“

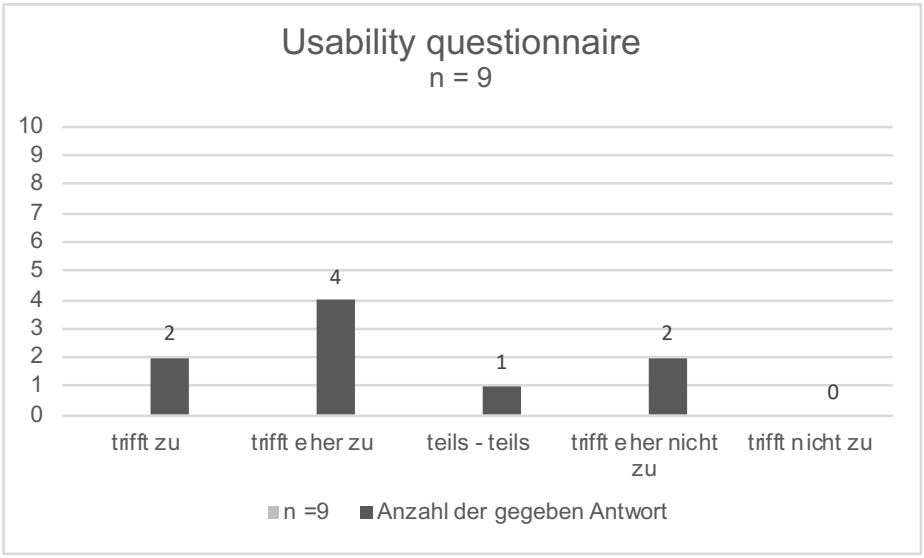

Diagram 19: Usability questionnaire – results of statement 1

As shown in Diagram 19, 2 participants each (22.2%) chose the answer "trifft zu" or "trifft eher nicht zu". 4 participants (44.4%) selected the statement "trifft eher zu" while only 1 participant (11.1%) chose the answer "teils – teils". No one opted for “trifft nicht zu” as answer.

Statement 2: „Ich empfinde den eCoach als einfach zu nutzen.“

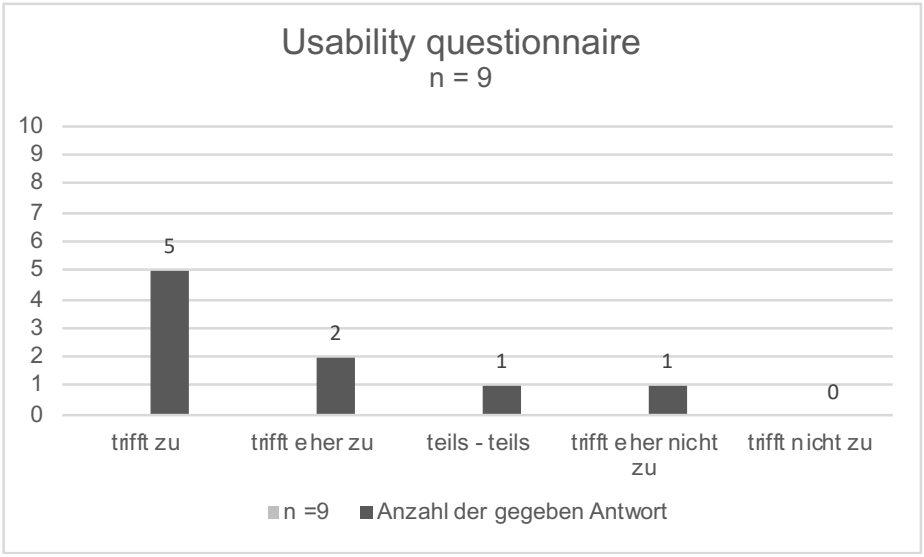

Diagram 20: Usability questionnaire – results of statement 2

As the Diagram 20 above shows, 5 participants (55.5%) gave the answer "trifft zu", 2 other participants (22.2%) chose "trifft eher zu" and 1 participant each (11.1%) chose "teils – teils" or "trifft eher nicht zu" as the answer.

Statement 3: „Ich denke, dass ich technischen Support brauchen würde, um den eCoach zu nutzen.“

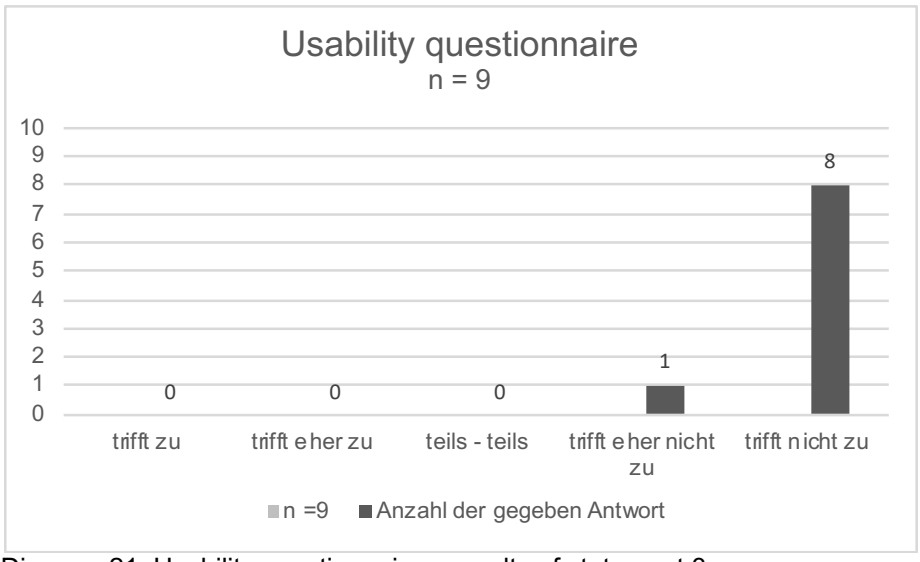

Diagram 21: Usability questionnaire – results of statement 3

As can be seen in Diagram 21 only two answer possibilities were picked. 8 out of 9 participants (88.8%) gave the answer "trifft nicht zu" and only 1 participant (11.1%) gave the answer "trifft eher nicht zu".

Statement 4: „Ich finde, dass die verschiedenen Funktionen des eCoach gut integriert sind.”

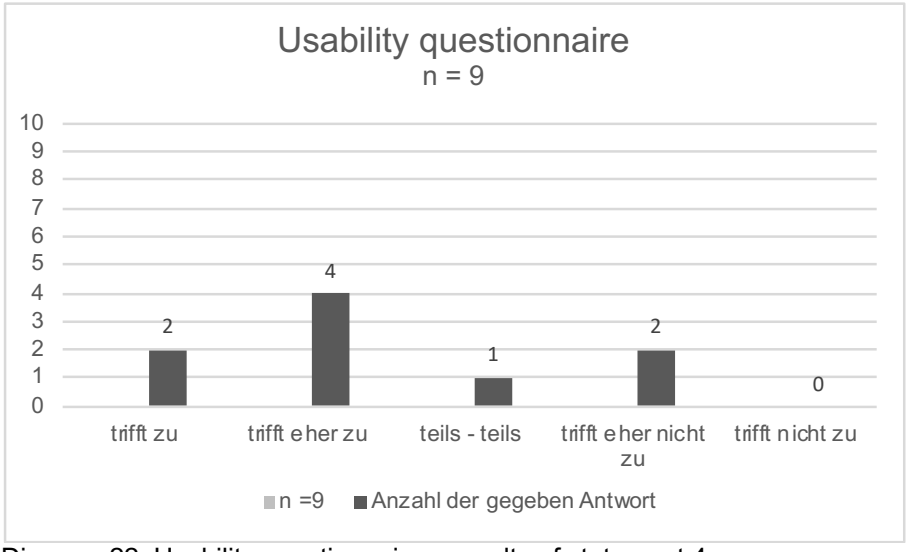

Diagram 22: Usability questionnaire – results of statement 4

With this statement 2 participants (22.2%) chose the answer "trifft zu", 4 other participants (44.4%) chose "trifft eher zu" and 1 participant (11.1%) chose "teils – teils" as most accurate answer. Only 2 participants (22.2%) answered with "trifft eher nicht zu". No one chose "trifft nicht zu".

Statement 5: „Ich finde, dass es im eCoach zu viele Inkonsistenzen gibt.“

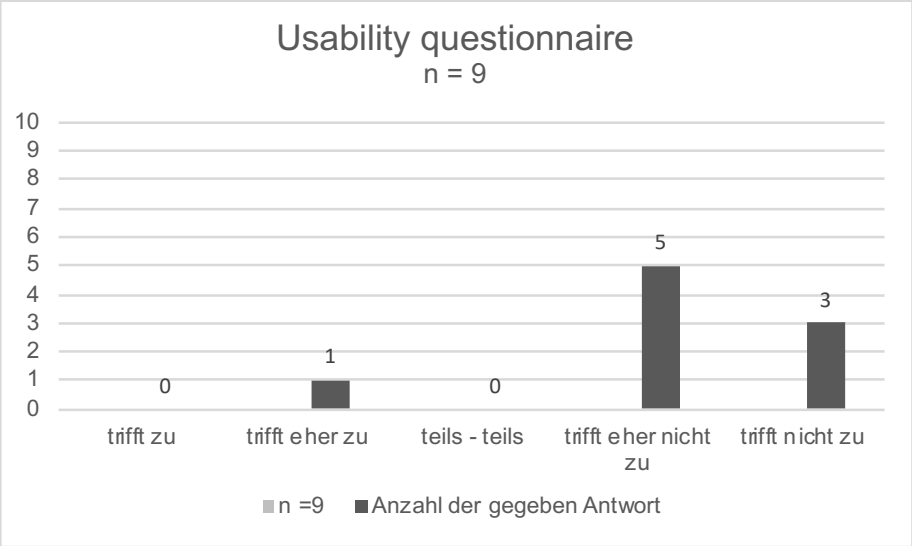

Diagram 23: Usability questionnaire – results of statement 5

Diagram 23 shows that the majority of 5 participants (55.5%) chose the answer "trifft eher nicht zu" and even 3 participants (33.3%) chose the answer "trifft nicht zu". Only 1 participant (11.1%) opted for "trifft eher zu". Answer options “trifft zu” and “teils – teils” were picked by no one.

Statement 6: „Ich empfinde den eCoach als unnötig komplex.“

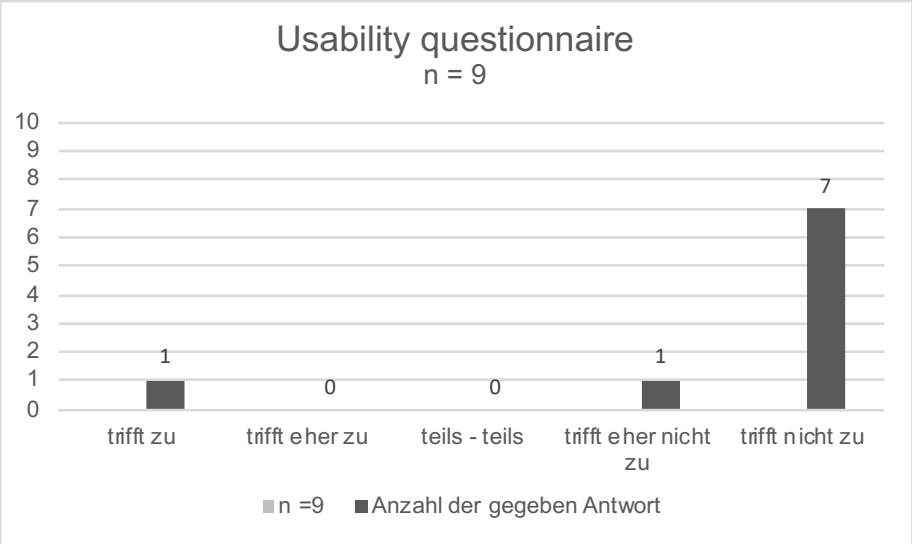

Diagram 24: Usability questionnaire – results of statement 6

As can be seen above (Diagram 24), 1 participant (11.1%) chose the answer "trifft zu". None of the participants chose "trifft eher zu" or "teils – teils". 1 other participant (11.1%) opted for "trifft eher nicht zu" while the remaining majority of 7 participants (77.7%) chose "trifft nicht zu" as the most suitable answer.

Statement 7: „Ich empfinde die Bedienung als sehr umständlich."

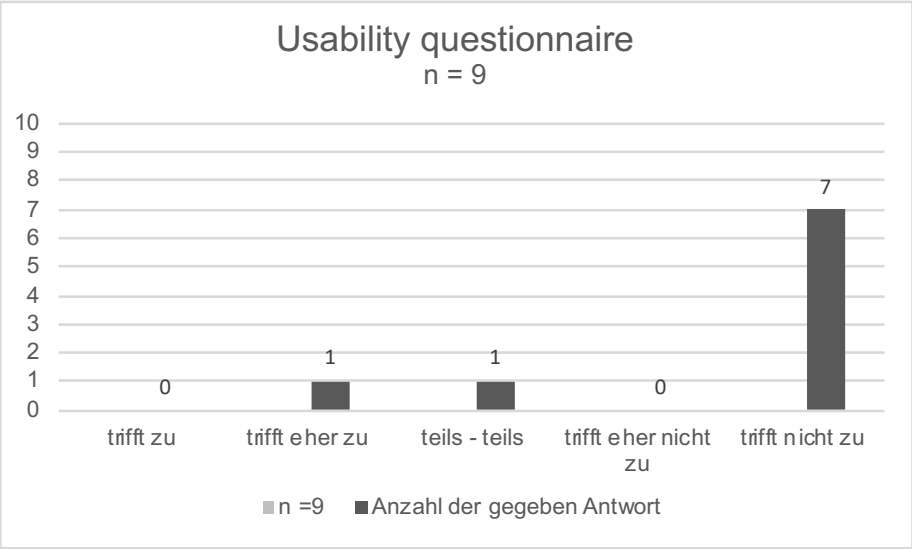

Diagram 25: Usability questionnaire – results of statement 7

Diagram 25 shows that no participant chose "trifft zu" or "trifft eher nicht zu" as answer. In each case 1 participant (11.1%) decided on the answer possibility "trifft eher zu" and "teils – teils". The remaining 7 of the 9 participants (77.7%) opted for "trifft nicht zu".

Statement 8: „Ich habe mich bei der Nutzung des eCoach sehr sicher gefühlt."

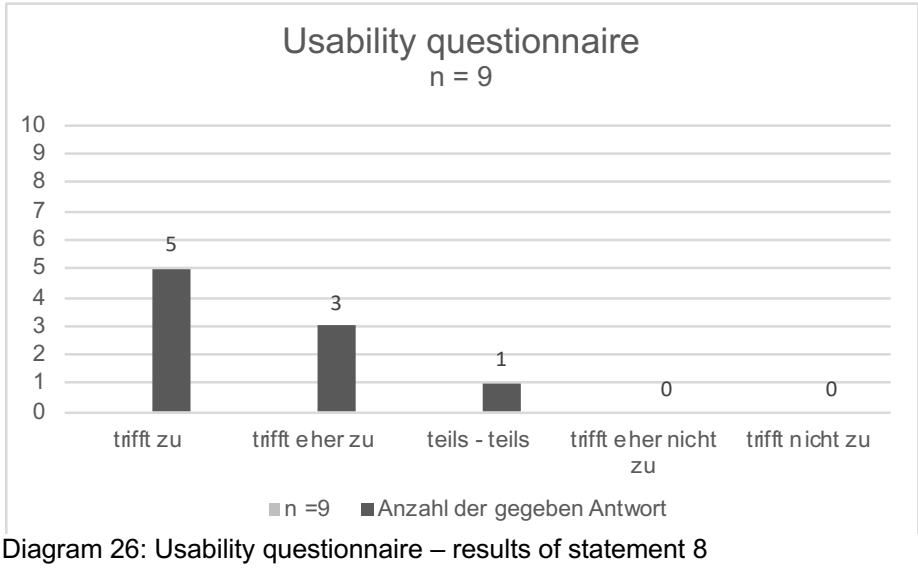

Diagram 26: Usability questionnaire – results of statement 8

As can be seen in Diagram 26, 5 out of 9 participants (55.5%) chose the answer "trifft zu", 3 others (33.3%) chose "trifft eher zu" and only 1 participant (11.1%) gave "teils – teils" as answer. None of the participants opted for the other two possible answers "trifft eher nicht zu" and "trifft nicht zu".

Statement 9: „Ich musste eine Menge Dinge lernen, bevor ich mit dem eCoach arbeiten konnte.“

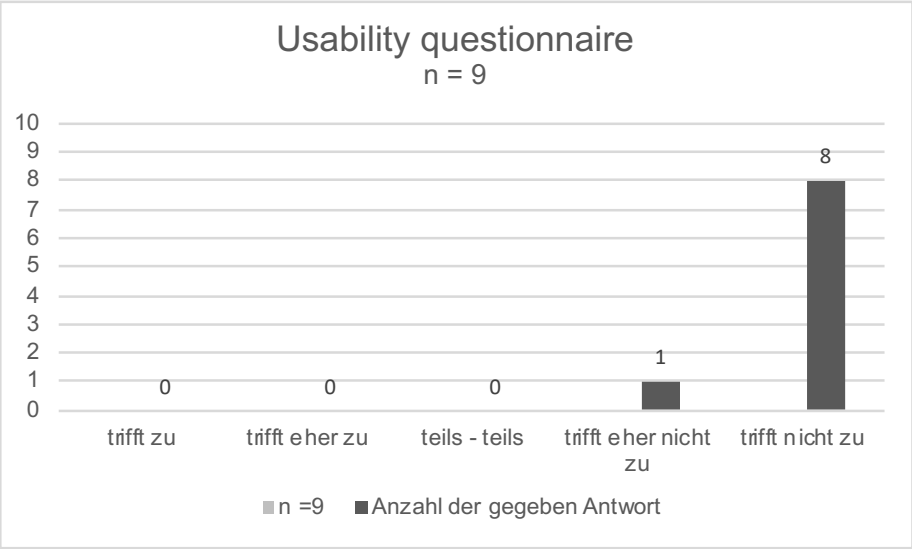

Diagram 27: Usability questionnaire – results of statement 9

As Diagram 27 shows, a majority - 8 out of 9 participants (88.8%) - voted for the answer "trifft nicht zu". 1 other participant (11.1%) chose "trifft eher nicht zu". None of the participants decided on any of the remaining 3 options.

Statement 10: „Folgende Verbesserungsvorschläge zum eCoach / Feedback-System habe ich:“

Table 6 below summarizes and presents the subjective improvement suggestions given by the participants. Most of the suggestions for improvement were given with regards to the prepared video material. Especially the lack of dynamic and the seemingly unsuitable background of the chosen videos could be improved according to the participants. Suggestions for comparison of the individual results with other groups of people, summaries of the individual results or feedback on wearing comfort were also given. Only 3 participants did not make suggestions, comments, etc. at all.

• More appealing videos	• dynamic camera work. • various position recordings. selecting a better background (no reflective or distracting background). • better integration of text in the videos (e.g. display explanatory

	images during the video - especially for the positions of the spine) • auto play of the videos in combination with the video menu at the introduction feels confusing • generally, giving a better overview of the issues addressed • explanations in videos are sometimes unnecessarily lengthened (e.g. that the back positions should be balanced, and that dynamic has a positive effect on the health of the back) • complete overview of the recorded data with interactive links (e.g. click on a part of the displayed data and this measurement section will be explained and suitable exercises will be presented) is missing
• Take-home data	• 1-page PDF with a kind of summary and graphic representation of the data would be desirable
• Comparison to others	• possible comparison of one's own results with other groups of people or the average population, etc.
• Hardware	• wireless sensors would be desirable regarding wearing comfort

Table 6: Usability questionnaire – Improvement suggestions by participants for statement 10

As already described in chapter 2.6, the SUS score must be calculated according to a certain scheme. As also already explained, there is a score of 0 - 4 for each answer of the SUS. Table 7 shows the connection between answer possibility and the corresponding numerical value.

“trifft zu”	“trifft eher zu”	“teils – teils”	“trifft eher nicht zu”	“trifft nicht zu”
5	4	3	2	1

Table 7: Example for a Likert-Scale with linked numerical values

To obtain the SUS score, the position value of question 1, 3, 5, 7 and 9 are each scaled minus 1. For questions 2, 4, 6, 8 and 10, the number of the scale position must be subtracted from the value of 5. The numerical value obtained after these two operations is then multiplied by 2.5. This results in the final SUS score which is not a percentage value. For people who are less familiar with the SUS, it has become established to use the SUS score as simple numerical value due to a lack of standard template and the variety of evaluation schemas. Basically, the value can be between 0 - 100. A schematic representation of the further significance of this score is presented below (Table 8).

100	Perfect System
> 80	Good to excellent system
> 60 - 80	Marginal to good system
< 60	Reference to considerable usability problems

Table 8: Coloured classification scheme of the SUS score

By modifying the original SUS questionnaire, the calculation of the SUS score must also be adjusted. As already mentioned, the predefined questions are 5 positively-worded (1, 3, 5, 7 & 9) and 5 negatively-worded questions (2, 4, 6, 8 & 10). When adapting the questionnaire, an attempt was made to maintain the balance between positive and negative questions - this was also achieved in one of the two cases (see chapter 3.5.2). However, the other positively-worded question (SUS question 7) was replaced with a question that suggests neither positivity nor negativity towards the system. In the end, it was question 10, which actively asks for suggestions for improvement regarding the entire VivaBack process and should therefore be considered "neutral".

Due to this modification and the changed questions and changed order, a new order (as close as possible to the original) had to be created for an accurate calculation of the SUS score (Table 9).

Order of questions for calculating the SUS score			
SUS	OLD	NEW	Question
1	1	1	Ich bin dem eCoach – Feedback zufrieden.
2	6	2	Ich empfinde den eCoach als unnötig komplex
3	2	3	Ich empfinde den eCoach als einfach zu nutzen.
4	3	4	Ich denke, dass ich technischen Support brauchen würde, um den eCoach zu nutzen.
5	4	5	Ich finde, dass die verschiedenen Funktionen des eCoach gut integriert sind.
6	5	6	Ich finde, dass es im eCoach zu viele Inkonsistenzen gibt.
7	10	exclusion or mean value 20	~~Ich kann mir vorstellen, dass die meisten Leute das System schnell zu beherrschen lernen.~~ ~~Folgende Verbesserungsvorschläge zum eCoach / Feedback-System habe ich~~
8	7	8	Ich empfinde die Bedienung als sehr umständlich.
9	8	9	Ich habe mich bei der Nutzung des eCoach sehr sicher gefühlt
10	9	10	Ich musste eine Menge Dinge lernen, bevor ich mit dem eCoach arbeiten konnte.

Table 9: Order of questions for calculating the SUS score

The final calculation scheme for the SUS score (Figure 11) was therefore performed once without taking into account to the exchange of questions 7 and 10 and once taking into account and assuming 20 as the average value of all the answers.

The obtained numerical values of each answer possibility (linked to the given answer possibilities) from each participant were added for each individual question. Then these numerical values of all questions were summed and multiplied by 2.5. This result was divided by the total number of participants (n=9) to give the final SUS score.

Question	SUS score of each answer						
Q1	24						
Q2	31						
Q3	29						
Q4	35						
Q5	24						
Q6	28						
Q7	0 / (20)						
Q8	31						
Q9	33						
Q10	35						
Total	270 (290)						
Calculation of the SUS score					Final SUS score		
		270 * 2,5	= 675	675 / 9	= 75 -> Marginal to good system		
Calculation of the SUS score with Q7 / Q10 (mean value = 20)							
		290 * 2,5	= 725	725 / 9	= 80,5 -> Good to excellent system		

Figure 11: Calculation scheme for the SUS score

The answer to the research question about the usability of the eCoach is as follows:

Research question:

- Q3: Is it possible that the eCoach can achieve a SUS score of at least 80 or more in a usability test?

If question 7 is not included in the calculation (Figure 11), a SUS score of 75 results. If this value is now interpreted on the basis of the classification scheme (Table 8), it can be said that the value of 75 lies at the upper boundary between “marginal to good system” and can therefore be evaluated as a rather good system. If an average value of 20 is assumed for question 7 (Figure 11), a SUS score of 80.5 is achieved. This would in turn mean that the usability of the eCoach can be classified as a “good to excellent system” according to the classification scheme used (Table 8).

An interpretation of the results as well as the strengths and limitations of this paper are presented in chapter 5. An outlook for further investigations is also given in chapter 6.

5 Discussion

This paper presents a usability study and an acceptance analysis of a sensor-based system, developed by VivaBack for tracking the individual back posture during a working day. It compares the two different feedback methods and simultaneously provides information about the usability of the eCoach. However, there are strengths and limitations in this paper that legitimize discussion.

The first question about the overall satisfaction of the feedback method received shows clear differences between the two groups. It can be interpreted that participants of group A who received the face-to-face feedback were overall clearly more satisfied with their feedback (average value 1.10) than participants of group B who received their feedback from the eCoach (average value 2.44).

With the second question - whether participants can move and sit more balanced since the consultation - the result of group A was again more positive than with group B. This is also reflected in the different average values (group A 1.50 and group B 2.78). Therefore, it can be said that participants from group A were able to pick up on and implement the contents conveyed much better.

The third question asked about the transfer of knowledge through feedback to raise awareness for one's own back health. On average, both groups gave similar answers. There was neither a clear and predominant agreement or disagreement for group A, nor for group B. If the average values are taken - group A 2.10 and group B 2.67 - it can be seen that they are not too far apart. Therefore, it can be interpreted that both feedback methods had a similar effect with regard to raising awareness for the health of the back.

When asked in question 4 whether the participants could move their backs better subjectively since the feedback, there were clear differences between the two groups. Based on the average values, it can be seen that participants from group A with a value of 2.30 were subjectively better at implementing the contents discussed in their everyday lives than participants from group B - average value 3.56.

When asked in question 5 about the ability to use different seating positions since the feedback, there were also clear differences between the two groups. As the average values show, participants from group A (average value 1.80) were subjectively more successful in changing their sitting positions since the feedback in everyday life than participants from group B (average value 3.22).

The answers to the question 6 whether the participants are subjectively more successful in adapting their workplace to their individual needs since the feedback resulted in the following. Roughly distributed responses were received within both groups. The average value for group A was 2.88, while group B had a value of 3.33. It can therefore be said that the participants from the face-to-face feedback were able to implement the contents somewhat better.

The question 7 about the improvement of the subjective well-being of the back since the feedback did not result in a clear approval or rejection. This is also confirmed by the average value. Group A achieved an average value of 3.00 and thus positions itself in the neutral range between approval and rejection. Group B with an average value of 3.67 is also in the neutral to negative range.

When asked in question 8 about understandability and general information and knowledge transfer on personal back health, both groups gave positive answers overall. Nevertheless, it can be seen that participants from group A with an average score of 1.30 were slightly more satisfied than participants from group B with an average score of 2.22.

The question 9 about the clarity and presentation of the visual data was also assessed positively by both groups. Here, too, the average values show that participants in Group A were slightly more satisfied with an average value of 1.60 than participants in Group B with an average value of 1.89.

The last question of the questionnaire, which asks for a repeated measurement to determine the long-term progress of personal back health and posture, was also answered positively by both groups. After all, a majority of 60% of the participants from group A indicated that they would perform a repeated measurement for the evaluation of long-term progress. The average for group A was 1.90. In Group B, 44.4% reported they would participate in a repeated measurement to measure long-term progress and 33.3% reported to participate more rather in such a repeated measurement. Overall, the average score was 2.11 for Group B.

If the results of the survey are examined and compared between the two groups, it can be seen that the responses from group A - who received their feedback through face-to-face coaching - were more positive in each of the 10 questions than those from group B who received their feedback from the eCoach.

If the mean values of the 10 questions within the respective group are added and divided by the number of questions, the following values are used for the final comparison of both feedback methods.

In order to evaluate and interpret the satisfaction and acceptance of the given feedback method as a whole, it can be interpreted that participants from group A with an overall average value of 1.94 were clearly more satisfied with the feedback process, knowledge transfer and implementation of the information received than participants from group B who achieved an overall average value of 3.09.

With regard to usability, the result can be interpreted in two different ways. Depending on which result is used for the rating, the final SUS score drops into two different classifications. If the SUS score of 75 is used, it can be considered a "marginal to good system". If 80.5 is used as the SUS score, it can be described as a "good to excellent system". Due to the fact that the value of 75 is the upper limit of "marginal to good" and the value of 80.5 is the lower limit of "good to excellent", the system can be interpreted as a "solid good system".

If the results of the study are interpreted in such a way that the acceptance is deduced from the knowledge transfer, from the general satisfaction of the feedback and from the implementation of the measures received through the feedback methods, then can be identified, that the face-to-face feedback is better accepted and also has more benefit for the participants. This result shows that the feedback given by a physiotherapist is better assimilated and accepted. However, if one considers that the eCoach is still a prototype, the outcome of this investigation was comprehensible and foreseeable. The fact that the eCoach has achieved a SUS score of at least 75 to even 80.5 and can therefore be rated as a good system and speaks for the good work done by the company VivaBack. This leads to the fact that the eCoach should not yet be used as a stand-alone feedback method, as there are still too serious shortcomings in the transfer of knowledge. What can be considered, however, is to offer the further developed eCoach as a supportive measure in order to offer the participants a possibility to access the data at home, even after the coaching with the physiotherapist to view parts of the coaching repeatedly.

However, one of the major limitations of this study was the small number of participants. Although the inclusion criteria and exclusion criteria allow a wide number of participants, no conclusions can be drawn about the results for the general population due to the selected setting and the resulting lower number of participants. In order to achieve an even more significant result, a larger number of participants would be useful. A longer time period between receiving the feedback and sending out or answering the questionnaire would also be worth considering in order to be able to assess the subjective effect or behavioural change more precisely. However, this is due to the time constraints. A further limitation is the coordination with the cooperation partner to borrow equipment,

evaluate the individual data, give feedback etc. always in relation to the given time window. Also, the adaptation of the SUS questionnaire and the resulting calculation of the SUS score does not give one final result and therefore leaves some room for interpretation. It should also be noted that, due to the participants selected (all with a strong link to technology and health) and the small number of participants, this is not a representative sample and therefore the results do not apply to the general population.

One of the strengths of this paper is the simplified presentation and comparison of the results by means of average values. This enables the reader to better understand the participants' satisfaction with the feedback received. Also, what is of great interest for the company VivaBack, is the usability test that was carried out in the prototype stage. It gives the developer new input and suggestions after a hands-on test from the users for further development of the eCoach before it is used as ready for series implementation. Especially the open question with room for suggestions for the participants can play an important role for the further development of the eCoach.

To provide a further outlook, the following points are named which can underpin the results of this work or even provide some new findings. In order to assess the long-term effect of subjective changes in back posture, movement, well-being, etc. of the participants, a long-term measurement should be considered. In addition, the study would be even more representative for the comparison of the two presented feedback methods with a significantly larger number of participants and if both groups would get both kinds of feedback. In the case of a larger number of participants, a more precise statistical evaluation of the data with calculated significance levels etc. could be carried out. This would further enhance the direct comparison of the systems. If the participants' suggestions from the open question 10 are taken into account and analysed or implemented in the eCoach, it would make sense to retest or compare both feedback methods again.

6 Conclusion

This paper gives an overview of the existing problem of back pain and the further diagnosis and treatment processes. The literature research shows that back pain is a global problem with massive effects on the population and especially workers and employers.

By using VivaBack's sensor-based system, the problem of back pain can be viewed, analysed and managed from a new perspective. A study was therefore carried out to measure the back posture of 20 participants over a period of time. The subsequent feedback methods - face-to-face feedback from a physiotherapist on the one hand and feedback from the automated eCoach on the other - were tested with regard to knowledge transfer, acceptance and usability.

The results of the study show that there is an overall greater subjective satisfaction of participants who have received feedback from the physiotherapist. These participants stated that they had gained more knowledge about the personal health of the back and that they were more able to integrate the tips, tricks and exercises into their everyday lives than the participants from the other group.

Therefore, the first and second research questions could also be answered in such a way that the eCoach does not enable the same knowledge transfer at the current stage of development and is also not accepted in the same way as the personal face-to-face feedback. It can therefore be said that the eCoach cannot replace face-to-face feedback at present. This may depend on several factors. Possible factors may be that the respective technical affinity and openness of the participants from the eCoach group plays a significant role, or that there is no opportunity for participants to ask direct questions to the eCoach. Thus open questions remain. Another possible reason for the reduced knowledge transfer or the lack of acceptance of the eCoach could be that the exercises presented cannot be checked directly by the coach and corrected if necessary. The feedback from the eCoach therefore misses the interaction between participant and coach.

With regard to the usability of the eCoach, it was found that it was a good system overall. The participants who completed the questionnaire on usability were generally satisfied with current the state of development. By the open question (question 10) the participants could still communicate personal suggestions, wishes or criticisms. This can bring considerable added value for the further development and improvement of the entire eCoach. However, the third research

question - whether the eCoach can achieve a usability SUS score of 80 or more - could not be answered clearly. Due to the fact that only 9 of the 10 measurements could be used to determine usability, two different SUS scores were finally achieved. On the one hand a SUS score of 75 was achieved, on the other hand a SUS score of 80.5. Since these two values are at the borderline between "marginal to good" and "good to excellent", the eCoach can be rated as a "solid good" system.

To sum up the results of this work, it can be said that the eCoach is convincing with its usability and can be evaluated as a good system, but it does not achieve the same effect in terms of knowledge transfer and the same quality of feedback as the face-to-face feedback by the physiotherapist. The reasons for this can be various (some have been mentioned above). Especially the visual processing and the graphical representation of the measurement data seems to be very well done by VivaBack.

On the basis of the results of this work, the following new research questions can be formulated in order to gain further knowledge in this thematic area.

- How efficient is the long-term effect of the feedback?
- Can the implementation of an interactive chatbot positively influence the feedback quality of the eCoach?

Nevertheless, the feedback of all participants can have a significant influence on the further development of the eCoach and it would be worth considering a renewed comparison of both feedback methods. However, it should be considered that a larger and more meaningful number of participants would be desirable and that both groups of participants also receive both variants of the feedback. Thus, it would be possible to compare the two methods even more precisely and more meaningfully. For this reason, it would be worth considering offering the eCoach as a supportive tool for participants in order to be able to access the individual data and measures from home as well.

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Appendix

A. Questionnaire for knowledge transfer and acceptance of the feedback

Usability-Test und Akzeptanzanalyse des automatischen Feedback-System-Prototyps von VivaBack im Vergleich zum persönlichen Feedback-Coaching.

Seite 1

Herzlich Willkommen!

Sie sind eingeladen, an meiner Umfrage "Usability-Test und Akzeptanzanalyse des automatischen eCoach von VivaBack im Vergleich zum persönlichen Feedback-Coaching" teilzunehmen. Bei dieser Erhebung werden Probanden gebeten, die Fragen zur Wirksamkeit und Akzeptanz der Beratung und Wissensvermittlung durch VivaBack´s Feedback-Systeme zu beantworten.
Das Beantworten des Fragebogens dauert ca. 5 Minuten. Ihre Teilnahme an dieser Studie ist völlig freiwillig und ist für Sie mit keinen vorhersehbaren Risiken verbunden.
Ihre Antworten werden streng vertraulich behandelt und die Daten werden verschlüsselt und nur für diese Studie verwendet.
Wenn Sie zu irgendeinem Zeitpunkt Fragen zur Umfrage oder zu den Auswerteverfahren haben, können Sie sich an den Studienleiter per E-Mail an dh171808@fhstp.ac.at. wenden.
Vielen Dank für Ihre Zeit und Unterstützung.
Bitte beginnen Sie jetzt mit der Umfrage, indem Sie auf die Schaltfläche "Weiter" klicken.

Seite 2

1.Sind Sie mit dem persönlichen Feedback zufrieden? *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

2. Durch die VivaBack-Beratung habe ich gelernt, wie ich ausgeglichen sitzen und mich bewegen kann: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

3. Durch die VivaBack-Beratung habe ich gelernt, wie wichtig es ist, mich regelmäßig zu bewegen, um Rückenschmerzen vorzubeugen: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

4. Seit der VivaBack-Beratung gelingt es mir subjektiv besser meinen Rücken regelmäßig zu bewegen: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

5. Seit der VivaBack-Beratung gelingt es mir besser verschiedene Sitzpositionen zu nutzen: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

6. Seit der VivaBack-Beratung gelingt es mir besser meinen Arbeitsplatz (Bildschirm, Sessel, Tastatur, etc.) auf meine Bedürfnisse anzupassen: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

7. Seit meiner VivaBack-Beratung ist mein Wohlbefinden des Rückens subjektiv besser geworden: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

8. Das Feedback-Verfahren war leicht verständlich und ich konnte neues Wissen zu meiner persönlichen Rückengesundheit erlangen *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

9. Die visuelle Datenaufbereitung bzw. Darstellung war übersichtlich und klar: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

10. Ich würde eine wiederholte Messung zum Langzeitfortschritt meiner persönlichen Rückengesundheit und Körperhaltung durch die Firma VivaBack durchführen. *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

B. Usability Study – modified SUS-questionnaire

Gruppe B Usability-Test und Akzeptanzanalyse des automatischen Feedback-System-Prototyps von VivaBack im Vergleich zum persönlichen Feedback-Coaching.

Seite 1

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Sie sind eingeladen, an meiner Umfrage "Usability-Test und Akzeptanzanalyse des automatischen eCoach von VivaBack im Vergleich zum persönlichen Feedback-Coaching" teilzunehmen. Bei dieser Erhebung werden Probanden gebeten, die Fragen zur Wirksamkeit und Akzeptanz der Beratung und Wissensvermittlung durch VivaBack´s Feedback-Systeme zu beantworten.
Das Beantworten des Fragebogens dauert ca. 5 Minuten. Ihre Teilnahme an dieser Studie ist völlig freiwillig und ist für Sie mit keinen vorhersehbaren Risiken verbunden.
Ihre Antworten werden streng vertraulich behandelt und die Daten werden verschlüsselt und nur für diese Studie verwendet.
Wenn Sie zu irgendeinem Zeitpunkt Fragen zur Umfrage oder zu den Auswerteverfahren haben, können Sie sich an den Studienleiter per E-Mail an dh171808@fhstp.ac.at. wenden.
Vielen Dank für Ihre Zeit und Unterstützung.
Bitte beginnen Sie jetzt mit der Umfrage, indem Sie auf die Schaltfläche "Weiter" klicken.

Seite 2

1.Sind Sie mit dem persönlichen Feedback zufrieden? *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

2. Durch die VivaBack-Beratung habe ich gelernt, wie ich ausgeglichen sitzen und mich bewegen kann: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

3. Durch die VivaBack-Beratung habe ich gelernt, wie wichtig es ist, mich regelmäßig zu bewegen, um Rückenschmerzen vorzubeugen: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

4. Seit der VivaBack-Beratung gelingt es mir subjektiv besser meinen Rücken regelmäßig zu bewegen: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

5. Seit der VivaBack-Beratung gelingt es mir besser verschiedene Sitzpositionen zu nutzen: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

6. Seit der VivaBack-Beratung gelingt es mir besser meinen Arbeitsplatz (Bildschirm, Sessel, Tastatur, etc.) auf meine Bedürfnisse anzupassen: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

7. Seit meiner VivaBack-Beratung ist mein Wohlbefinden des Rückens subjektiv besser geworden: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

8. Das Feedback-Verfahren war leicht verständlich und ich konnte neues Wissen zu meiner persönlichen Rückengesundheit erlangen *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

9. Die visuelle Datenaufbereitung bzw. Darstellung war übersichtlich und klar: *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

10. Ich würde eine wiederholte Messung zum Langzeitfortschritt meiner persönlichen Rückengesundheit und Körperhaltung durch die Firma VivaBack durchführen. *

	trifft zu	trifft eher zu	teils - teils	trifft eher nicht zu	trifft nicht zu
Antwort:	◯	◯	◯	◯	◯

C. Information for probands and declaration of consent

ProbandInneninformation und Einwilligungserklärung zur Teilnahme an VivaBack‘s sensorbasierter Messung der Rückenhaltung und anschließender Online-Befragung im Rahmen der Masterarbeit:

Usability-Test und Akzeptanzanalyse des automatischen Feedback-System-Prototyps von VivaBack im Vergleich zum persönlichen Feedback-Coaching.

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer!

Sie sind herzlich eingeladen, an der sensorbasierten Messung zur Rückenhaltung und der Online-Umfrage im Rahmen meiner Masterarbeit "Usability-Studie und Akzeptanzanalyse des automatischen Feedbacksystem-Prototyps VivaBack´s im Vergleich zum persönlichen Feedback-Coaching" teilzunehmen.

Die Messung erfolgt anhand 3 auf der Haut aufgeklebten Sensoren, die für den Messzeitraum (6 bis 8 Stunden) befestigt unter der Kleidung getragen werden.

Die Umfrage erfolgt über einen Online-Fragebogen. Sie erhalten den Link zur Teilnahme via E-Mail und können via PC, Smartphone oder Tablet teilnehmen.

Das Ausfüllen des Fragebogens, der 10 Fragen beinhaltet, dauert ~ 5 Minuten. Ihre Teilnahme an dieser Umfrage ist völlig freiwillig. Mit der Teilnahme an dieser Studie sind keine vorhersehbaren Risiken verbunden.

Alle erhobenen Daten werden anonymisiert und nur für den Zweck dieser Studie verwendet.

1. Wozu dient diese Studie?

VivaBack ist ein österreichisches Unternehmen, das ein tragbares Sensor-System entwickelt hat, um die Rückenhaltung während eines Arbeitstages aufzuzeichnen. Das Ziel von VivaBack ist einerseits mögliche unilaterale Belastungen oder Belastungsmuster zu identifizieren und Aufschluss über die Rückenhaltung zu geben, und andererseits professionelles, individuelles Feedback anzubieten, um die persönliche Rückengesundheit zu verbessern und Bewusstsein dafür zu entwickeln.
Die derzeitige Feedback-Lösung basiert auf einem persönlichen Feedback-Coaching nach erfolgter Datenauswertung durch einen Mitarbeiter der Firma VivaBack.
Um den nächsten Schritt zu gehen, arbeitet VivaBack an einem automatisierten Feedback-System.

Diese Studie dient dazu, einen Vergleich der beiden Feedback-Varianten zu ziehen, um herauszufinden, wie das automatisierte Feedback-System akzeptiert wird und wie adäquat die Wissensvermittlung und Beratung ist.

Zusätzlich erhalten ProbandInnen der Gruppe B einen Fragebogen zur Nutzerfreundlichkeit der Webseite, die die persönlichen Datenaufbereitung des automatisierten Feedback-Systems beinhaltet.

2. Sammlung, Verwendung und Gewährleistung des Datenschutzes der akquirierten Daten

Die Daten über die Rückenhaltung werden mittels Sensoren erhoben. Dabei wird die PatientInnenidentität anonymisiert und die Daten verschlüsselt.
Das Ausfüllen des Online-Fragebogens im Rahmen dieser Studie erfolgt ebenfalls anonym.
Die akquirierten Daten werden ausschließlich im Rahmen dieser Masterarbeit gesammelt und verarbeitet.
Die Ergebnisse werden zu keinem Zeitpunkt mit namentlicher Nennung verknüpft und die Teilnahme ist ausschließlich freiwillig.

3. Einverständniserklärung

Name ProbandInn (in Druckbuchstaben) _____

Ich bin damit einverstanden, an der sensorbasierten Messung zur Rückenhaltung teilzunehmen. Ich bin darüber informiert worden, dass 3 Sensoren auf der Haut befestigt werden und diese für die Messdauer unter meiner Kleidung zu tragen sind.
Ebenso bin ich damit einverstanden, an der Online-Befragung „Usability-Study and acceptance analysis of VivaBack´s automatic feedback-system-prototype in comparison to the personal feedback-coaching“ teilzunehmen.

Ich habe die insgesamt 2 Seiten umfassende ProbandInneninformation und Einwilligungserklärung gelesen, verstanden und bin ausreichend über mögliche Nutzen und Risiken dieses Forschungsprojekts informiert.
Ich bin damit einverstanden, dass die im Rahmen dieser sensorbasierten Messmethode und der Online-Befragung über mich erhobenen Daten aufgezeichnet, anonymisiert und ausschließlich für wissenschaftliche Zwecke weiterverarbeitet werden.

Ich habe eine schriftliche Kopie der ProbandInneninformation und Einwilligungserklärung erhalten und erkläre hiermit meine freiwillige Teilnahme an diesem Forschungsprojekt

_____ _____

Datum Unterschrift ProbandInn

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