Milena Leino

Robotics in Upper Limb Rehabilitation Nursing

A Literature Review

Helsinki Metropolia University of Applied Sciences

Bachelor in Health Care

Degree Program in Nursing

Final Project

October 2016

Helsinki Metropolia University of Applied Sciences

Author(s) Title	Milena Leino Robotics in Upper Limb Rehabilitation Nursing 20 pages + 3 appendices 2016
Degree	Bachelor of Health Care
Degree Programme	Nursing and Health Care
Specialisation	Nursing
Instructor(s)	Juha Havukumpu, Senior Lecturer

Purpose of this final thesis is to view what kind of robots there are in use in stroke rehabilitation nursing, focusing on upper limb rehabilitation. At the same time this work will view the attitudes of patients and therapist towards robotics in the health care field.

Robots are present and with robots engineers are trying to develop the health care services. Robots have come to different health care fields different technology is used in rehabilitation nursing. Robots help patients to recover more quickly.

I am implementing this work as a literature review. Search of articles were done in three different databases EBSCO host, PubMed and Science Direct. The work ends up to use articles choose from EBSCO host and Science Direct, total 6 articles.

I did found that there are several robots in use and I will introduce in this work some of them that are in commercial cell and one prototype. Attitudes were introduced to be good but still people trust more real humans.

Rehabilitation robots exist but they are not in that big use. Studies show that robotic use in rehabilitation increases the outcome. The problem with robots is mainly high price and attitudes of the therapist.

Keywords	Stroke, robots, rehabilitation, hemiparesis, upper limb

Tekijä(t) Työn nimi	Milena Leino Robotics in Upper Limb Rehabilitation Nursing 20 sivua + 3 liitettä 2016
Koulutusohjelma	Degree Program in Nursing and Health Care
Suuntautumisvaihtoehto	Sairaanhoitaja (AMK)
Ohjaaja(t)	Juha Havukumpu, Lehtori

Tämän työn tarkoituksena on, tarkastella millaisia kuntoutusrobotteja käytetään aivoverenkiertohäiriöpotilaiden kuntoutuksessa, keskittyen yläraajan kuntouttamiseen. Samalla käydään läpi hoitajien asenteita hoitorobotteja kohtaan.

Robotiikka on tätä päivää ja sen avulla yritetään kehittää myös terveydenhuollon palveluita. Robotit ovat tulleet terveydenhuoltoon monelle eri alalle, myös kuntoutuksessa käytetään erilaista tekniikkaa. Robotit avustavat ihmisiä toipumaan nopeammin ja tehokkaammin.

Työ on toteutettu kirjallisuuskatsauksena. Tiedonhauissa on käytetty kolmea eri tietokantaa PubMed, EBSCO host ja Science Direct. Työssä päädyttiin käyttämään artikkeleita kahdesta eri tietokannasta jotka olivat: EBSCO host ja Science Direct, näistä tietokannoista valittiin yhteensä kuusi artikkelia joita tarkasteltiin tässä työssä.

Työssä selvisi, että markkinoilla on useampia kuntoutustyöhön sopivia robotteja ja tässä työssä esitellään niistä muutamia, jotka ovat kaupallisessa myynnissä. Asenteet robotteja kohtaan ovat pääasiassa positiivisia, mutta silti ihmiset luottavat edelleen enemmän ihmiskontaktiin kuin robotteihin.

Kuntoutusrobotteja on olemassa, mutta ne eivät ole suuressa käytössä. Tutkimukset osoittavat, että robotiikan käyttö kuntoutushoitotyössä parantaa lopputulosta. Ongelma roboteissa on niiden suuri hinta ja vielä hieman heikko hoitotyöntekijöiden asenne hoitorobotteja kohtaan.

Avainsanat	Aivohalvaus, kuntoutus, robotti, hemipareesi, yläraaja

Contents

Appendix 1. Research table

Appendix 2. Chosen articles table

Appendix 3. Poster

1 Introduction

Robots are the present day and the future. All over the history humans have been trying to use different kind of machines to help them in everyday life. In Finland developing the robots has been slow, there are only a few companies who are doing the developmental work. Same slowness is also noticeable in Europe too. (Jaakkola 2015.)

There are already many active robots in factories, so why not in health care too. By automatization many companies have decreased the unit costs, increased the quality and productivity (Mattila 2015). Big companies such as Toyota have done experiments and developments to create a working and useful care robot. They have released at least four different kind of care robots that help disabled people to manage in their everyday life. (Linnake 2011.)

In Europe there are more than million strokes per year and the number is rising (Bonita et al. 2006). Stroke rehabilitation patients are the biggest group to use rehabilitation services (Kallanranta, 1994). Every stroke rehabilitation is individual; 40 percent of stroke patients needs long term rehabilitation. In rehabilitation, the patient's capability in everyday living is improved. After three months of effective rehabilitation 50-70 percent of the patients are recovered as independent in everyday living, 15-30 percent have been left permanently disabled and 20 percent need inpatient care. (Aivoliitto 2015.)

Robots in rehabilitation nursing help patients to get back in shape. Thought attitudes towards robots vary. Recently published France research says that people are not taking advice from robots willingly. (Chetouani et al. 2015.)

In stroke rehabilitation a multi-professional work group is focusing on every symptom that a patient has. Their job is to improve the patient's life as much as possible. Only a half of the patients in Finland who are in need of effective stroke rehabilitation are getting it. (Aivoliitto 2015). Is there something that we can do to improve that? Can we use robotics and robots to improve that number?

Some people are afraid of robots to take over their jobs. In my opinion in the health care field that is not a very big thing to be afraid of. Patients need the human contact. It is said that robots are taking over the jobs but they are also producing new ones. (Mattila 2015.) In Finland the government is not considering them as futures workers. The founder of Robotics Finland, Cristina Andersson puts a big part of her hope to the health care field and development of robotics in there (Mattila 2015).

The head of the Mainio Vire company Leena Munter says that nowadays in Finland the use of robotics in health care is minimum. She says that there are a lot of places and possibilities to develop new working robots for example to elderly care. (Munter 2015.)

In this work I am focusing on already existing rehabilitation robots in stroke recovery.

2 Purpose and research question

My final thesis is about the use of robotics in stroke rehabilitation nursing, focusing on the rehabilitation of hemiparesis. I will focus on use of the rehabilitation robotics all over the world.

The purpose of this final thesis is to clarify what kind of robots there are in stroke recovery care by using a literature review. I am also going to view attitudes towards robotics in health care.

My research question is:
What kind of robots there are in use in rehabilitation nursing?

This topic is important because there are many people that need effective rehabilitation after a stroke, in Finland only half of the people are receives it. Information that comes out of this thesis are available for everyone who is interested in robotic use in stroke rehabilitation. It is also important to look the attitudes because robots are coming more and more in to our lives.

2.1 Connection to working life

The data will be available to everyone who works with stroke rehabilitation, not only nurses but physiotherapist and others too. This work will be published in the Theseus database.

I will publish a poster which introduces the results of my thesis.

2.2 Vision of the End Outcome

Studies will show that there are several different robotics in use on hemiparesis rehabilitation. I believe that there are nurses who are not that excited about robotics. I also believe that I will find some attitude problems. I think that robotics will give more space to nurses to be nurses and to be with the patient and be more in human to human contact with them. Patient education gets a bigger role in these kind of occasions. It can be frightening for the patient to start use robotics.

I think robots are working well but there is a big need to advice users to use these devices. I think younger patients have better attitude towards robots than older patients. I also think robots will help healthcare professionals to do their work and robots help them concentrate to the patient as a human.

3 Key concepts

In this final thesis keywords are: stroke, hemiparesis, robot and rehabilitation. In this chapter I am going to explain some of the concepts I am using and explain meaning in this thesis.

3.1 Stroke

Stroke is a traditional clinical term which means a brain function disorder caused by cerebral infarction, cerebral haemorrhage or subarachnoid haemorrhage. Mainly all strokes appear acutely and symptoms develop in minutes or hours. The faster the care the better the result is a fact in the case of a stroke. The most common symptoms of a

stroke are motor hemiparesis, down facial paresis, sensory hemiparesis, dysphasia, dysarthria, painless visual loss (amaurosis fugax and homonymous hemianopia), dizziness, nausea, vomiting, blurred vision, dysphagia and diplopia. (Käypähoito 2011.) During the last year (2015) there were 18 000 strokes in Finland, 4200 out of that number will renew a stroke during the same year. Stroke is the 3th common cause of the death in Finland. (Aivoliitto, 2016.) Comparing to year 2007 when there were 14 600 strokes in Finland. (Lindsberg et al. 2011.) we can see that the number is rising due the aging of the population. A stroke is common with people over 75 years old. It can occur in younger people too but the risk will increase with age. One of six people will get a stroke during their life. In every two seconds there is one stroke and in every six seconds one will die from it. Worldwide, stroke is the second most common cause of death. (Käypähoito 2011.)

Three months after a stroke about 50-70% of the patients are recovered independent in daily living, 15-30% are permanently injured and about 20% needs institutionalization. (Käypähoito 2011.) Stroke severity affects recovery. If there is a complete paralysis of the upper or lower limb, less than 15% will recover completely (Käypähoito 2011). According to Finstroke-research made in Finland, over half of the strokes happens to elderly, people over 75 years old. It is a challenge for the health care field because our population is getting older. Recovering from a stroke is usually linked to the patient's age, the younger the patient the better the outcome. (Kaarisalo 2011.)

The most high-quality years of life are lost because of a stroke, most of strokes can be prevented by taking care of the biggest risks. The biggest risks for a stroke are: elevated blood pressure, smoking, abdominal obesity, diabetes, atrial fibrillation and dyslipidaemias. (Lindsberg et al. 2011.) Heritability also increases the risk of a stroke, especially if the father has had a stroke (Marttila, J. 2015).

3.2 Hemiparesis

Hemiparesis is the major and most visible symptom of a stroke, it is a weakness of one side of the body and the muscles and this is called motor hemiparesis. It can also occur as a numbness of one side, this is called sensory hemiparesis. (Häppölä, O 2010.)

Usually weakness is more effective in the upper limb than the lower limb but can be seen in both. (Häppölä, O. 2010). Hemiparesis can occur on either side of the body. If

the paralysis is at the right side of the body, then the damage is at the left side of the brain and vice versa (Weiss 2011).

Hemiparesis occurs nearly every case of a stroke, 80% of stroke patients will suffer a weakness of one side of the body (National Stroke Association 2016). Weakness of one side of the body is a critical issue and it will effect on patient's everyday life a lot. It causes troubles with balance and walking, it decreases coordination skills and makes grasping objects harder (National Stroke Association 2016).

3.3 Robots

Robots are human-like devices but without emotions. Robots can perform the same tasks over and over again. A human or a computer can control a robot mainly robots are controlled by computers (Merriam-Webster Dictionary 2015). In the health care field robots are developed to help nurses and do work for them so that nurses can provide human-to-human contact to patients (Munter 2015). Robots are not going to replace humans but they are there to help and do all the hard work.

Not all mechanical devices are robots. Robot is a really popular word and almost everything that are mechanical is called robot. In definition of robot it is said that robot is a device that is not controlled by human (Merriam-Webster Dictionary 2015).

Robots are in nursing, 35 percent of all robotic use is in the healthcare field. Robots have been use in medicine already from early eighties. (Whyatt 2014.)

3.4 Rehabilitation

In general rehabilitation means bringing someone back to the normal state, to be able to work and operate, after an illness, an injury or a trauma (Merriam-Webster Dictionary 2015. s.v. rehabilitate).

Rehabilitation includes lots of different fields. It covers the human needs, from psychological to physical rehabilitation. People may need rehabilitation after a major trauma or a big event in life such as a dead of their closed one. Rehabilitation is mainly divided

into four different groups: medical rehabilitation, vocational rehabilitation, social rehabilitation and educational rehabilitation. (Kuntoutusportti 2016.)

Rehabilitation is important part of nursing. In many places at the health care field rehabilitation is part of the nurses' everyday work. All transfers are made with patients and they do everything they can by themselves. The key point in the rehabilitative approach is to keep the patient as operational as possible. (Harri-Lehtonen et al. 2014.)

The faster the rehabilitation starts the better results will occur.

3.5 Stroke rehabilitation

Stroke rehabilitation is a strongly multi-professional work (Käypähoito 2011). The team consist all needed professionals. These professionals are physicians, rehabilitation nurses, physical-, occupational-, recreational-, speech-language- and vocational therapist. Very important part of the team is mental health professionals. (OPN 2014).

3.5.1 History of stroke rehabilitation

History of stroke rehabilitation starts at the days that scientists first sort out what causes a stroke. In 1620s Johann Jakob Wepfer used pig's brain to discover what was the cause of a stroke (Licht 1975). As a creator of stroke rehabilitation can be kept Signe Brunnstrom she was the one who handled rehabilitation of a stroke. Brunnstrom was the one who used repeat movements of the limb and noticed that it will improve the recovery of the patient. (Levine 2008). Human brain will learn and forget fast. Stroke rehabilitation has been remarkably developed a lot in late 20th century and early 21th century.

3.5.2 Stroke rehabilitation now

Stroke rehabilitation is built on different phases. At the acute phase the diagnosis and the need for the care is defined. Acute treatment for a stroke can be a thrombolytic therapy or a surgery. (Käypähoito 2011.) Patient education is a really important part of the rehabilitation process, it improves the knowledge of patients themselves and their

closed ones. (Käypähoito 2011.) Occupational therapy is beneficial especially in rehabilitation activities of daily living (Lisenberg et al. 2011).

Position treatment is one of the first interventions in the rehabilitation of a stroke. When patient's position changes multiple times a day, many complications will be prevented. Position treatment activates body's sensations of rehabilitation and prevents body and extremes dysfunctions. Active rehabilitation will begin after an acute phase of a stroke, when patient is strong enough to get up from the bed. Active phase lasts as long as it is needed and it includes all movement therapies. (Käypähoito 2011.)

4 Literature review implementation

4.1 Review

Literature review means focusing on particular topic related matters and documented results. There are multiple reasons for doing a literature review and there are many ways to implement it. Narrative, so called telling review is identification and presentation, evaluation and interpretation of information relating to the topic matter. (Hirsijärvi at al. 2013.) Descriptive literature review is a most popular and mainly used because it is not that strict with all the rules. In descriptive literature review there is two main roads: integrative and narrative literature review. Methodically lighted review is narrative, by this way author can give a wide picture about the topic. Narrative literature review is focusing to make the outcome readable. (Salminen 2011.)

4.2 My review

I am going to implement my review as a narrative. I am looking for information that already exist and I will introduce, asses and interpret results I found. I am going to comment and question results I get.

In my information search I used three different databases, CINAHL (Ebsco), Pubmed and Science Direct. In my search I used words rehabilitation, stroke and robotic. First I did make a test search to see what these words will give to me. I add tables as an appendix about my search, about words and limitations that I used in the search (table 1).

After the first searches I decided to start limiting my search to get managed amount of the articles related to my topic. I set a goal of under 50 articles per search and did succeed quite well (table 2).

4.3 Selecting the articles

When I started to limit the articles that I am going to use I did look more carefully to my research question and topic of the thesis. I did first rank out articles by topic that did not fit to my topic, then I left with particular amount of articles. Out of these I am going to select articles based on abstract. In the abstract I am going to look that there is information that is useful for my thesis. The information has to be about robots used in upper limb rehabilitation after stroke. There have to be nurses or physiotherapist or occupational therapist related to robotic use. I am also looking attitudes towards robots in health care work. There will be articles related to that.

After choosing by abstract I do read all the articles through and decide if they are good for my thesis.

Information and articles that I am going to select have to be also from reliable sources. I am using sources that are EBSCO, PubMed and Science Direct. These all are databases that have reliable articles and researches about nursing and medicine.

I did choose 20 articles from EBSCO, 6 articles from PubMed and 3 articles from Science Direct. Out of these 29 articles I did choose 10 articles based on abstract (appendix 2). I ended up to 4 articles that I am going to use in my review.

Article research was a really challenging task. There were a plenty of articles available about stroke rehabilitation with robotics but just a few articles that were actually about nursing related to it. I had to do over again my search and change my searching words to find more suitable articles for this work. I did a lot of work with this and in the end I managed found something that I am able to use. I have to look at more carefully of my research question and think if there is something that I can change on it. I did end up to change my research question and managed to put it in that kind of form that I can answer to the question.

5 Results

I did found a couple of different robots in use. In this chapter I will introduce devices from the articles I have chosen, in total there were 4 robots introduced. All of the robots were concerning to rehabilitate reaching, craping, flexion and extension movements of the hand, though not all of the robots could perform all the tasks. Some of the robots were wearable and the others were big machines with or without a virtual environment. One of the robots was the first prototype and others three were already at commercial sell.

In articles there was one research about developing a new robotic devise to a rehabilitation nursing. I will speak about this developing process more at the future part.

I did choose two articles about attitudes of robotics in health care, one was about stroke rehabilitation robot and the other was about health-care robot in retirement village.

5.1 Myomo mPower

This devise is so called wearable robot. It is beneficial because of the small size and the weight. Myomo can be used out of the clinical environments and it is relatively easy to use. Devise is composed of an elbow band and EMG electrodes. These electrodes will take signals from the biceps or the lateral head of the triceps. Even though this robot is small and usable in different environments and easy to use there is still disadvantages in it. Because of the character of the robot it can be used only in extension and flexion of the elbow. (Bishop – Stein 2013.)

Devise is easy to use and it allows patients to use it by themselves. Patient just needs training how to position the EMG electrodes correctly. Devise is then freely to use in everyday life and that how it is easy way to strength elbow movements at home. (Bishop – Stein 2013.)

Safety features of Myomo were simple, devise has been set in such powers that it cannot harm human. There are mechanical stops that prevents hyperextension. (Bishop – Stein 2013.)

Figure 1. Myomo device. (Kirsner 2012)

5.2 ArmeoPower

Robot was designed based on ARMin robot. This device is big machine where patient is sitting in and working with virtual environment. In the robot there is a big mechanical arm that helps patient to make the moves in every direction where the hand naturally goes. AmeoPower is a machine that can train all the joints in the hand, a wrist, a shoulder or an elbow. With this robot hand grip and grasping exercises can be done. These exercises can be performed at the same time or individually, depending on patient's condition and stage of the rehabilitation. ArmeoPower works with passive and active exercises at the same time. The big plus for this device is that it gives feedback for it user, ArmeoPower gives visual feedback for it user. (Bishop – Stein 2013.)

This robot is easy to use. This device can be programmed to every patient's own needs. Therapist will design the exercises for the patient and the machine will record those movements to its memory and then perform the tasks to the patient. This machine has a 3-dimensional memory. When the patient gets better and better in his/hers tasks the therapist can make exercises more difficult and vice versa. Machine allows patient to train just that joint that is necessary and makes specific movements to every joint the therapist can decide all the movements that is used. (Bishop – Stein 2013.)

Infirmity of the machine is that it is big and not portable. Another weakness is that all the exercises performed in the machine are done in sitting position. Also the fact that

all the exercises are happening in the virtual environment does not support actions in everyday life. And even though this machine can train all the joints in the hand it is still limited with it movements. (Bishop – Stein 2013.)

Safety in this device is good. In the machine there is huge and very easily detected emergency button, by pressing the button whole machine shuts down. In case of error all the power from the device will shut down and it will give error message for the user. For safety of the patient, the therapist will insert limits for the motion. (Bishop – Stein 2013.)

Figure 2. ArmeoPower in action. (http://en.fysioline.fi/collections/hocoma-armeo)

5.3 Amadeo hand robot system

This robot is a big machine which is concerning to rehabilitate fingers extension and flexion. In the robot the patient's fingers are attached to devices slides with magnets, which is working relatively well. Unlike in ArmeoPower in Amadeo there is not virtual environment where patient is exercising but everything happens with assist of the com-

puter mainly playing computerized games. Machine will give real time visual feedback to it user. In the machine all the fingers can be trained at the same time or individually, the therapist will decide this. Amadeo will let the user at the next level if tasks are performed well enough and makes it more and more difficult. The therapist can overtake this task if seems to like it. This machine is really easy to use, therapist only needs to attach the patient's fingers to the machine and it will perform the rest. (Bishop – Stein 2013.)

Overall this is a good device but like with the others there is still some weaknesses also in this machine. Because of the big size of the machine it is limited only to use in clinical environments. Software is not wide enough and it is only capable to use active training and gaming modes. Without the virtual environment all the tasks performed in the devise are not naturally linked to real life situations. It is only capable to train flexion and extension of the fingers and the training of the thumb is challenging. (Bishop – Stein 2013.)

Figure 3. Amadeo hand system close picture of hand. (http://neuro-solutions.ca/amadeo/)

Safety features in this robot have been thought well. There are emergency buttons at the both side of the machine, which will shut the power of from the devise. Small magnets that are used to attach fingers to the machine will get off if too heavy forces are applied to the machine. These forces are constantly measured throughout the exercises. (Bishop - Stein 2013.)

Figure 4. Amadeo hand system in action (http://neuro-solutions.ca/amadeo/)

5.4 GENTLE/s system 1. Prototype

This devise is the first prototype of emerging robot GENTLE/s, it is a computerized system that has hand supporting system. This support provides painless and safe training for the patient, it will prevent partial dislocation of the shoulder. Training with GENTLE/s system is possible with active assisted, active or passive support, this allows anyone to use this devise despite the rehabilitation phase. The devise offers possibility to train both sides, it does not matter which side the injury was. Examples of movements are displayed at the computer screen and the patient will repeat movements by himself. Devise gives feedback to the user about how he will proceed the exercises. Therapist will insert the exercises in to the devise. (Coote – Stokes 2003.)

Because the device is so big it is not capable to be movable and that is why it must be used only in clinical environments. In GENTLE/s system patient is in seated position that makes the use of the devise impossible in everyday living. (Coote – Stokes 2003.)

Safety has been thought trough, connection of the patient to the devise has been done with magnets and these magnets will detach and release the patient if too big forces are detected. A big button for the same task is also visible in the devise. (Coote – Stokes 2003.)

Figure 5. Gentle/s 1. Prototype in action (Amirabdollahian et al. 2007)

5.5 Attitudes towards robotics in health care

I did found attitudes towards robotics, both patients and therapists. Altogether both patients and therapists were positive about robotics use in nursing. In the research made in 2003 it is said that patients think that treatment was consumable and it did not hurt at all (Coote – Stokes 2003). It is said that older people are especially interested to work with technology if it will help them to cope in everyday living (Broadbent et al. 2011). Patients were thinking that robotic physiotherapy was more compelling than traditional physiotherapy, on the other hand physiotherapist were thinking vice versa. There was mentioned that this result can be because the patients were volunteers in the research. (Coote – Stokes 2003.) Health care workers were also concerned about losing their jobs to robots (Broadbent et al. 2011). I did found also the fact that people like better robots that does not look like humans (Broadbent et al. 2011).

Bad attitudes towards robots may be due the lack of knowledge, there might be fears towards robots or robots are designed by thinking wrong target group. (Broadbent et al.

2011.) It is need to remember that robots are coming to health care to help the staff not to replace it.

6 Reflection

6.1 Reflection

In this thesis I reserved results about robots in stroke rehabilitation and about attitudes towards them, both were represented patients and therapists. One research article introduced three different upper limb rehabilitation devices, the article was a review and it looked the topic from a clinical perspective. Two research articles were about attitudes towards robotics in health care, other one introduced a robot used in upper limb rehabilitation and the other focused on attitudes generally. Fourth research article focused on the development of a new robot. Even though I did have only four different articles I think I got a good and wide perspective on the topic, all articles were different and the information that I received supported each other.

In general robotics are available for a stroke rehabilitation thus they are not in a great use. This fact was introduced in several article, there was also a reflection on why. The reason that arose most often was the high price of robotics. In the market has been more robotics available but they have been getting off because the demand has fallen (Broadbent et al. 2011). Costs can potentially lower with more research and development work that will produce more workable and movable devices. All the bad attitudes towards robotics must be removed it would bring more confidence towards robotics. Second fact about why robots are not in such a big use was the attitudes of therapist. Therapists were considered about their own workplace and if robotics were actually increasing the workload (Coote – Stokes 2003).

All devices introduced in the articles have weaknesses this is one thing that can be improved. Several devices were so large and heavy that it was impossible to use them anywhere else than in the clinical environment. This is the work for engineers develop a mobile but functional rehabilitation robot, and with the lower costs of course. When the technology evolves this might be possible. In the article about developing a new robot mentioned that new robots need to be able to make several different movements with the arm (Lu et al. 2011). If one device is capable to make more movements, it will

make the rehabilitation easier and does not require the exchange between the exercise machines.

Attitudes of patients towards health care robotics were positive, even so there were some concerns. Patients were concerned about the safety and the reliability of robots. Use of devices in a private duty rose also up as a problem (Broadbent et al. 2011). I would think that someone will more likely to take a robot with him to help in a toilet than other person but this is not the case. Perhaps these private duty robots should be more like humans. Therapists were concern about if devices will make the job for the patient (Broadbent at al. 2011). This might be because therapist is not feeling the patient and does not know how much they actually are doing by themselves. This problem should be solved by feedback from the device. Even though most of the devices were giving feedback it was not always about the success of exercise performance.

6.2 Ethics

This thesis was a part of a larger themes, service robotics and robotics in nursing. I did the work as a literature review about robotics in rehabilitation nursing.

While searching the articles for the analysis I used only reliable sources, these were EBSCO host, PubMed and Science Direct. I used English- and Finnish-language articles in knowledge base and in analyse only English. I did read a lot of abstracts of articles while I was deciding the articles for my thesis. I drew attention to my research question and it was important that the articles responded to this question.

I have respected the authors by using source references after every preferred sentenced, all the used articles will also found at the end of my thesis, in references list. The fact that I used only four articles in my analysis part will decrease the reliability of my thesis. All these articles were good quality and recently made. All the info that I got from these articles was respectable because not many researched have been done about this topic.

The reliability of this thesis can be decreased because of my language skills, I am not native English speaker and some miss understandings may have occurred.

I did have one mentor teacher to help me with this article and my English teacher has been going through the grammar of the work with me, even though I have corrected all errors.

7 The Future

In the future a lot of more researches are needed, for both robotics and attitudes. Even though robotics is the thing these days there are not enough people supporting it. All of my articles were also saying that more research should be done. These researches must be done in co-operation with both patients and caregivers. It is said that if we want to develop a working device it must be developed with people who actually know its intended purpose (Lu et al. 2011). Luckily this is the way that we walk in. If the financial affairs are in order that should not be a problem. Fortunately, there do already existing researches about developing new rehabilitation robot.

There were a lot of good recommendations for the new rehabilitation robot in the research done by Lu et al. (2011). In the research there was a survey that was sent to therapists all over the world and they did answer what kind of a new robot should be. Five out of tens of features rose up. There was mentioned that device should be able to perform various arm movements and it was hoped that the device is usable in sitting position. Because the feedback out of the exercise is really important, there was a wish that the device would give biofeedback to the patient. Since some devices are used in a virtual environment it proved to be good and it was at the list what features was hoped. Finally, therapists were thinking that it would be good if the device could be used both in a clinical environment and in a home of a patient. (Lu et al. 2011.) Now we just need to harness these good recommendations and build a working robot for health care.

For my opinion it would be really beneficial to do research about how these devices are and will effect to the care and rehabilitation of the patient. After this kind of research, it will be easier to develop new and even more beneficial robot for use of the health care industry. There is already existing researches about how beneficial it is to use robots in rehabilitation. This thesis will provide four different robots that are in commercial use and a natural continuation for this work would be a research about how especially these robots help rehabilitation in real life.

References

Aivoliitto
http://aivoliitto.fi/aivoverenkiertohairio_(avh)/kuntoutus (read 10.2.2016)
http://www.aivoliitto.fi/aivoverenkiertohairio_(avh)/perustietoa_avh_sta (read 5.10.2016)

Amirabdollahian, F. Collin, C. Gradwell, E. Harwin, W. Johnson, G. and Loureiro, R. 2007. *Multivariate analysis of the Fugl-Meyer outcome measures assessing the effectiveness of GENTLE/S robot-mefiated stroke therapy*. Journal of NeuroEngineerin and Rehabilitation 4:4. https://jneuroengrehab.biomedcentral.com/articles/10.1186/1743-0003-4-4 (read 3.6.2016)

Bishop, L. Stein, J. 2013 Three upper limb robotic devices for stroke rehabilitation: A rewiev and clinical perspective. *Neuro Rehabilitation* 2013. 33: 3-11. USA

Bonita, R. Bogousslavsky, J. Boysen, G. Mathers, C. Piechowski-Jozwiak, B. Truelsen, T. 2006. Stroke incidence and prevalence in Europe: a review of available data. *European Journal of Neurology* 2006. 13: 581-589.

Broadbent, E. Tamagawa, R. Patience, A. Knock, B. Kerse, N. Day, K. and MacDonald, B. 2011. Attitudes towards health-care robots in a retirement village. *Australasian Journal on Ageing* 31: 115-120. Acota.

Chetouani, M. Gaudiello, I. Ivaldi, S. Lefort, S. Zibetti, E. 2015. Trust as indicator of robot functional and social acceptance. An experimental study on user conformation to iCub answer. Paris Arxiv.org

Coote, S. and Stokes, E. 2003. Robot mediated therapy: Attitudes of patients and therapist towards the first prototype of the GENTLE/s system. *Technology and Disability.* 15: 27-34.

Harri-Lehtonen, O. Numminen, H. Vesala, H. 2014. Toimintakykyä ylläpitävä työote. *Kehitysvamma-alan verkkopalvelu Verneri*.
http://verneri.net/yleis/toimintakykya-yllapitava-tyoote read 10.2.2016 (read 11.12.2015)

Hirsijärvi, S. Remes, P. Sarjavaara, P. 2013. *Tutki ja kirjoita*. Helsinki: Kirjayhtymä

Häppölä, O. 2010. TIA:n entiologinen selvittäminen. *Suomalainen Lääkäriseura Duodecim*. 2015. Duodecim.
http://www.terveyskirjasto.fi/terveyskirjasto/tk.koti?p_artikkeli=nix00603 (read 10.1.2015)

Jaakkola, H. 2015. Robotiikka taapertaa vitkaan. *Tekniikka & Talous*. Helsinki. http://www.tekniikkatalous.fi/metallitekniikka/2015-06-03/Robotiikka-taapertaa-vitkaan-3322214.html (read 11.12.2015)

Kaarisalo, M. 2011. Aivohalvauksesta toipuminen. *Suomalainen lääkäriseura Duodecim*. 2015. Duodecim. http://www.kaypahoito.fi/web/kh/suositukset/suositus?id=nix00626&suositusid=hoi50051 (read 10.10.2015)

Kallanranta, T. 1994. Aivohalvauspotilaan kuntoutus. *Lääketieteellinen aikakauskirja Duodecim*. 1994:110(15):1419. Duodecim. http://www.duodecimlehti.fi/web/guest/haku;jsessionid=8B150B9EF78DFEEAB20052D18BF5BB17?p_p_id=Article_WAR_DL6_Articleportlet&p_p_lifecycle=0&_Article_WAR_DL6_Articleportlet_hakusana=istuminen&_Article_WAR_DL6_Articleportlet_p_frompage=haku&_Article_WAR_DL6_Articleportlet_viewType=viewArticle&_Article_WAR_DL6_Articleportlet_tunnus=duo40318 (read 10.10.2015)

Kirsner, S. 2012. *Myomo, selling robotic devices to assist with stroke rehab, is engineering its own recovery*. Innovation Economy. http://archive.boston.com/business/technology/innoeco/2012/02/myomo_selling_robotic_devices.html (read 3.6.2016)

Käypähoito suositus aivoinfarkti http://www.kaypahoito.fi/web/kh/suositukset/suositus;jsessionid=42A3361032258383B14AE65C759BE903?id=hoi50051 (read 10.10.2015)

Licht, S. 1975. *Stroke and its Rehabilitation*. Wavely Press, Inc. Baltimore.

Levine, P. 2008. *Recalling the Scientist Behind Stroke Rehab.* Physical Therapy & Rehab Medicine. http://physical-therapy.advanceweb.com/Article/Recalling-the-Scientists-Behind-Stroke-Rehab.aspx (read 3.6.2016)

Lindsberg, P. Sairanen, T. Häppölä, O. Kaarisalo, M. Numminen, H. Peurala, S. Poutiainen, E. Roine, R. Sivenius, J. Syvänne, M. Vikatmaa, P. Vuorela, P. 2011. Aivoinfarkti – Käypähoito -suosituksen päivitystiivistelmä. *Lääketieteellinen Aikakausikirja Duodecim.* Nro5, s. 500-501. http://www.terveysportti.fi/xmedia/duo/duo99402.pdf (read 11.12.2015)

Lu, E. Wang, R. Hebert, D. Boger, J. Galea, M. and Mihailidis, A. 2011. The development of an upper limb stroke rehabilitation robot: identification of clinical practices and design requirements through a survey of therapist. *Disability and Rehabilitation: Assistive Technology.* 6(5): 420-431.

Merriam, G. Merriam, C. 2015. Dictionary.
http://www.merriam-webster.com/dictionary/ (read 10.10.2015)

Mattila, R. 2015. Robotiikka- ja automaatioteollisuus kasvaa maailmalla – Suomi jarruttaa. *Tekniikka & Talous*. Helsinki.
http://yle.fi/uutiset/robotiikka_ja_automaatioteollisuus_kasvaa_maailmalla__suomi_jarruttaa/7912148 (read 11.12.2015)

Marttila, J. 2015. Aivohalvaus. *Terve-lehti.* Terve.fi (read 11.1.2016)
http://www.terve.fi/aivohalvaus/aivohalvaus

Munter, L. 2015. Robotteja hoitotyöhön jotta hoitaja voisi olla ihminen. *Tekniikka & Talous*. Helsinki.
http://www.tekniikkatalous.fi/maajohtajablogit/2015-06-24/Robotteja-hoitoty%C3%B6h%C3%B6n-jotta-hoitaja-voisi-olla-ihminen-3324541.html (read 11.1.2016)

National stroke association
http://www.stroke.org/we-can-help/survivors/stroke-recovery/post-stroke-conditions/physical/hemiparesis (read 12.2.2016)

Office of Communications, Public Liaison National Institute of Neurological Disorders and Stroke National Institutes of Health (OPN) 2014. *Post stroke rehabilitation.* Department of Health and Human Services, Bethesda, Maryland. https://stroke.nih.gov/documents/Post-Stroke_Rehabilitation_english_brochure.pdf (read 5.5.2016)

Salminen, A 2011. Mikä kirjallisuuskatsaus? *Vaasan Yliopiston Julkaisuja*. Vaasa
http://www.uva.fi/materiaali/pdf/isbn_978-952-476-349-3.pdf (read 10.10.2015)

Weiss, T. 2010. Hemiparesis – Facts and information. Neurological disorders. http://www.disabled-world.com/health/neurology/hemiparesis.php (read 10.10.2015)

Research table

Table 1. Searching for information, search words and limitations.

Database	Search words	Limitations	Hits
CINAHL	"stroke rehabilitation" and robotics	2000-2015 peer reviewed	313
	rehabilitation robots and "help nursing"	2010-2015 peer reviewed, europe	19
	"stroke rehabilitation" and robotics and nursing	2005-2015 peer reviewed, europe	10
	robotics AND "stroke rehabilitation"	2010-2015 peer reviewed	33
	robots and inhibits and nursing and stroke	2010-2015, academic journals	21
	stroke rehabilitation robots and nurse	2010-2015	31
PubMed	nursing and stroke and robotics	2010-2015	5
	"rehabilitation robotics" and stroke	2010-2015	23
Science Direct	"stroke rehabilitation" AND robotics	2010-2015	32

Chosen articles table

Table 2. Articles chosen by topic, abstract and full text

Database	Article chosen by topic	Authors	Article chosen by abstract	Article chosen by full text
EBSCO host	A pilot study of activity-based therapy in the arm motor recovery post stroke: a randomized controlled trial...Rabadi MH, Galgano M, Lynch D, et al. A pilot study of activity-based therapy in the arm motor recovery post stroke: a randomized controlled trial.	Janes WE; Wolf TJ; Baum CM	NO	
EBSCO host	Arm studio to intensify the upper limb rehabilitation after stroke: concept, acceptance, utilization and preliminary clinical results.	Buschfort R; Brocke J; Hess A; Werner C; Waldner A; Hesse S	NO	
EBSCO host	Effects of anodal and cathodal transcranial direct current stimulation combined with robotic therapy on severely affected arms in chronic stroke patients.	Ochi, Mitsuhiro; Saeki, Satoru; Oda, Taiji; Matsushima, Yasuyuki; Hachisuka, Kenji	NO	
EBSCO host	Effects of electromyography-driven robot-aided hand training with neuromuscular electrical stimulation on hand control performance after chronic stroke.	Rong, Wei; Tong, Kai Yu; Hu, Xiao Ling; Ho, Sze	NO	
EBSCO host	Effects of proximal and distal robot-assisted upper limb rehabilitation on chronic stroke recovery.	Mazzoleni, Stefano; Sale, Patrizio; Franceschini, Marco; Bigazzi, Samuele; Carrozza, Maria Chiara; Dario, Paolo; Posteraro, Federico	NO	
EBSCO host	Effects of robot-assisted upper limb rehabilitation on daily function and real-world arm activity in patients with chronic stroke: a randomized controlled trial.	Liao, Wan-wen; Wu, Ching-yi; Hsieh, Yu-wei; Lin, Keh-chung; Chang, Wan-ying	NO	
EBSCO host	Individual finger synchronized robot-assisted hand rehabilitation in subacute to chronic stroke: a prospective randomized clinical trial of efficacy.	Hwang, Chang Ho; Seong, Jin Wan; Son, Dae-Sik	NO	
EBSCO host	Influence of complementing a robotic upper limb rehabilitation system with video games on the engagement of the participants: a study focusing on muscle activities.	Chong Li; Rusák, Zoltán; Horváth, Imre; Linhon	NO	
EBSCO host	Nature, timing, frequency and type of augmented feedback; does it influence motor relearning of the hemiparetic arm after stroke? A systematic review.	Molier BI; Van Asseldonk EHF; Hermens HJ; Jannink MJA	NO	
EBSCO host	Neuro-rehabilitation robot-assisted assessments of synergy patterns of forearm, elbow and shoulder joints in chronic stroke patients.	Kung P; Lin CK; Ju M	NO	
EBSCO host	Systematic review of outcome measures used in the evaluation of robot-assisted upper limb exercise in stroke.	Sivan, Manoj; O'Connor, Rory J.; Makower, Sophie; Levesley, Martin; Bhakta, Bipinchandra	NO	
EBSCO host	The development of an upper limb stroke rehabilitation robot: identification of clinical practices and design requirements through a survey of therapists.	Lu, Elaine C.; Wang, Rosalie H.; Hebert, Debbie; Boger, Jennifer; Galea, Mary P.; Mihailidis, Alex	YES	YES

EBSCO host	The responsiveness and correlation between Fugl-Meyer Assessment, Motor Status Scale, and the Action Research Arm Test in chronic stroke with upper-extremity rehabilitation robotic training.	Wei, Xi-Jun; Tong, Kai-Yu; Hu, Xiao-Ling	NO	
EBSCO host	Three upper limb robotic devices for stroke rehabilitation: A review and clinical perspective.	Bishop, Lauri; Stein, Joel	YES	YES
EBSCO host	Haptic robots and rehabilitation of the hemiplegic upper limb.	Blondeau, Alban; Garbani, Mathieu; Cheret, Louis; Biseux, Guillaume	NO	
EBSCO host	Attitudes towards health-care robots in an retirement village	Broadbent, Elizabeth; Tamagawa, Rie; Patience, Anna; Knock, Brett; Kerse, Ngaire; Day, Karen; MacDonald, Bruce A	YES	YES
EBSCO host	Robot mediated therapy: Attitudes of patients and therapist towards the first prototype of the GENTLE/s system	Coote, Susan; Stokes, Emma	YES	YES
EBSCO host	Engineers developing robots with nurse aide-like abilities.	O'connor, John	YES	NO
EBSCO host	Potential of robots as next generation technology for clinical assessment of neurological disorders and upper-limb threpy.	Scott, Stephen H.; Dukelow, Sean P	YES	NO
EBSCO host	Using the robotic device reaplan as a valid, reliable, and sensitive tool to quantify upper limb impairments in stroke patients.	Gilliaux, Maxime; Lejeune, Thierry M.; Detrembleur, Christine; Sapin, Julien; Dehez, Bruno; Selves, Clara; Stoquart, Gaëtan	NO	
Pubmed	Upper-limb kinematic reconstruction during stroke robot-aided therapy	Papaleo E, Zollo L, Garcia-Aracil N, Badesa FJ, Morales R, Mazzoleni S, Sterzi S, Guglielmelli E.	NO	
Pubmed	Robotic exoskeletons: a perspective for the rehabilitation of arm coordination in stroke patients	Jarrassé N, Proietti T, Crocher V, Robertson J, Sahbani A, Morel G, Roby-Brami A.	NO	
Pubmed	Does upper limb robot-assisted rehabilitation contribute to improve the prognosis of post-strokehemiparesis?	Duret C, Gracies JM.	NO	
Pubmed	Interventions for improving upper limb function after stroke.	Pollock A, Farmer SE, Brady MC, Langhorne P, Mead G, Merholz J, van Wijck F.	YES	NO
Pubmed	Robotic therapy provides a stimulus for upper limb motor recovery after stroke that is complementary to and distinct from conventional therapy.	Brokaw EB, Nichols D, Holley RJ, Lum PS.	YES	NO
Pubmed	Adaptive training algorithm for robot-assisted upper-arm rehabilitation, applicable to individualised and therapeutic human-robot interaction.	Chemuturi R, Amirabdollahian F, Dautenhahn K.	YES	NO
Scince Direct	Robot-assisted rehabilitation of the paretic upper limb after stroke: The ARAMIS* robotic system	L. Pignolo, G. Dolce, L.F. Lucca, G. Basta, S. Serra, M.E. Pugliese	NO	
Scince Direct	A Novel Hybrid Rehabilitation Robot for Upper and Lower Limbs Rehabilitation Training	K.X. Khor, H.A. Rahman, S.K. Fu, L.S. Sim, C.F. Yeong, E.L.M. Su	YES	NO
Scince Direct	A Physio-Neuro Approach to Accelerate Functional Recovery of Impaired Hand after Stroke	Subhasis Banerji, Christopher Wee Keong Kuah, John Heng, Keng He Kong	NO	

Poster

Upper Limb Rehabilitation Robots

Picture from: http://ectron.websitesorted.com/amadeo-robotic-hand-therapy.

Amadeo

Considering to rehabilitate fingers extension and flexion.

MyomoMpower

Considering to rehabilitate elbow extension and flexion. Wearable model, relatively easy to use.

Picture from: http://www.nxtbook.com/nxtbooks/apta/

Picture from: http://www.gentle.rdg.ac.uk/

Gentle/s system 1. PROTO

Considering to rehabilitate movements of arm and shoulder.

Uses a virtual environment.

ArmeoPower

Considering to rehabilitate a wrist, an elbow and a shoulder.

Uses a virtual environment.

Picture from: http://www.anagennisimedicalresort.com/rehabilitation/Rehabilitation_methods/Armeo_therapy

Made by: Milena Leino