Project "intelligent exercise equipment for cardiac rehabilitation"

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Abstract

We[1] have studied the possibilities to develop and implement a new individualized exercise-tool based on robotic technology and artificial intelligence. A tool which enables meaningful and motivating rehabilitation of patients and at the same time brings the physiotherapist improved ways to monitor and document the effect of the rehabilitation in individual and competitive activities.

We have estimated the basis for and the consequences of further development of a new electronic jumping mat intended for playgrounds. The new prototype is initially tested in relation to the rehabilitation of cardiac patients. In the long term, the estimation will be basis for a decision on the tool's benefit as a new intelligent tool for rehabilitation and exercise.

The exercise-tool is developed through an iterative interdisciplinary prototype development process. IT developers, designers and programmers connected to the Maersk Institute at the University of Southern Denmark have, in cooperation with physiotherapists in charge of the rehabilitation of cardiac patients at the Department of Rehabilitation at the Funen Hospital in Svendborg, generated ideas and wishes for the new tool. The tool consists of 30 floor- and wall-based, flexible mats (slaves") plus 2 "master" mats.

The new intelligent exercise-equipment is systematically used and assessed by therapists and patients connected to the Department of Rehabilitation's cardiac rehabilitation group from September 1st 2006 until December 31st 2006. The intelligent therapy tiles are used on the same basis as other exercise equipment, and the patients are tested both at the initiation and the end of the 8 week course. Both patients and therapists have participated in group interviews at the end of the course and video-documentation of the use of the equipment has been made.

Both patients and therapists find the new intelligent therapy tiles motivating and promising. Exercise on the intelligent exercise mats challenges both circulation, balance, ability to respond and coordination, and it is estimated that the new tool holds a great potential for further development. The fact that patients by the use of the intelligent therapy tiles interacts *on* a technological user-interface is unique about this tool. The aspect of developing the user-interface is interesting as it enables the patient's possibility to interact *according* to the user-interface (= by hand) and *in* the user-interface (= the virtual surroundings).

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Background
For patients with more or less chronic needs for rehabilitation, ball-games and other competitive activities are often more motivating than e.g. walking bars, a treadmill, stairs or a rowing machine or an exercise bike.

The idea with this project is at test new individual ways of training, which the patients find meaningful – ways of training that can motivate the patient and will render probable that the patient on a long term will continue a life of physical activity. (*Rehabilitation – from problem to principle*, Huset Mandag Morgen A/S, 2004).
In the long view, it is essential for the physiotherapist to improve the possibility to monitor and document the individualized rehabilitation. Performance settings on an ergometer bike, a treadmill or a rowing machine are well-known. But it is a bigger challenge to monitor and document the exercise output on individual and competitive activities.

In the endeavor to find new rehabilitation equipment that lives up to the above mentioned wishes, it is obvious to squint at the existing initiatives that involves the use of artificial intelligence, robotic technology and 3 D-graphics and animation in relation to sports, games and play.

A literature search reveals an explosive growth in the number of articles on the use of new technology in connection with rehabilitation, but only few articles describes relevant projects with a high level of evidence (see result section, page 5)

Not least when it comes to the latest development within the industry of computer games that has an enhanced focus on involving the entire body in accomplishing the game. One example is Nintendo Wii (see e.g. http://www.nintendo.com/home). Here the player is equipped with a game console that can be compared to, for instance, a tennis racket that is used for physical virtual participation in the game.

Another and more local example is the Maersk Institute for Production Technology at the University of Southern Denmark (SDU), along with the robot company Entertainment Robotics and the playground company Kompan. Together they have developed an electronic jumping mat for the future intelligent playground.
The fundamental idea is to move from inactive computer games on vertical screens to an active game where the player moves him- or herself around on the horizontal intelligent electronic mat, and from this action the device reacts with different color patterns and sounds according to the players movements (see figure 1)

Figure 1

Around the turn of the year 2005-2006, these new tendencies, possibilities and needs formed the basis for the initiation of cooperation between the Department of Rehabilitation at The Funen Hospital and the Maersk Institute, Entertainment Robotics and the Danish Center for Health Telematics. Together they aimed to develop the electronic jumping mat into an intelligent exercise-tool for adult patients.

Problem description

Our project aims to answer the following questions:

- How can the intelligent play-device be transformed to an intelligent exercise-tool?

- Is it possible to develop a new exercise-tool with the potential to help:
  - more patients to find the rehabilitation both meaningful and motivating?
  - the therapist gain new equipment in the rehabilitation process?

- Which effects plays a part in relation to the implementation process of the first version of the intelligent exercise-tool, focusing on an estimation of technology, patient and the organizational aspect?

- Which ideas can be generated for further development of the intelligent exercise-tool in order to create potential for versatile ways of exercise and relevant monitoring of patients?

Purpose

This project aims to carry out an evaluation of the conditions for, and the consequences of, further development of the technology behind the electronic jumping mat in order to make a decision of whether the tool can be used profitably in the future as an intelligent exercise-tool.

In the short view, the answer can be used as a basis for decision ahead of a continuous development of this new tool at the Funen Hospital.

Method

A close cooperation between the Maersk Institute at SDU, Entertainment Robotics, Center for Health Telematics and the Department for Rehabilitation at the Funen Hospital (FH) has been established, and together they carried out *an iterative prototype development process*.

Hereafter, the Department for Rehabilitation was in charge of practical prototype-testing involving cardiac patients using the prototype as a part of their rehabilitation-process over a period of 3 months.

The following evaluation methods were used:

- Literature search
- Interviews with patients and physiotherapists
- Video recordings of exercises
- Physical tests of performance

Target group
Cardiac patients[2] were chosen as primary target group for the prototype-development and testing while other patient groups would be secondary target groups when it comes to use of the intelligent exercise-equipment.
The target group for answering the questions mentioned in the problem description is decision makers in the hospital service.

Content

The iterative prototype development
As a part of the initiation of the project in January-February 2006 the intelligent jumping mat, as mentioned originally intended for children, was laid out in the Department of Rehabilitation to give rise to new ideas.

The development of the play device into a tool for exercising was originally a matter of hardware development. The tool hade to be developed so that it fit the needs of the target groups, and also, in a longer view, to give the physiotherapists a possibility to control the rehabilitation of the patients.

The prototype development turned out to be a creative iterative process between the involved parts, whether IT technicians, IT developers, physiotherapist, designer etc.
The physiotherapists brought up the following wishes in the development process:

- It must be possible to use the mats both on floor and wall
- The mats must be easy to move around in order to be a flexible tool
- Adjustable to the older/adult target group
    - The mats must have a level surface (contrary to the playground version)
    - More precise direction on how to step/push in proportion to the light signal
    - The area of the respective mats must be slightly enlarged
    - It must be possible to see the light signal when stepping on it/pushing it
- Graduation of the pressure has to be possible
- The supply of exercises must have various games and not just one as in the playground version)

[2] Patients with ischemic heart disease – that is AMI, Stent-operations, By-pass operations etc. and patients with heart insufficiency – that is patients with heart failure, pacemaker, and heart valve operated etc.

After a number of meetings the new tool was developed. See figure 2-4

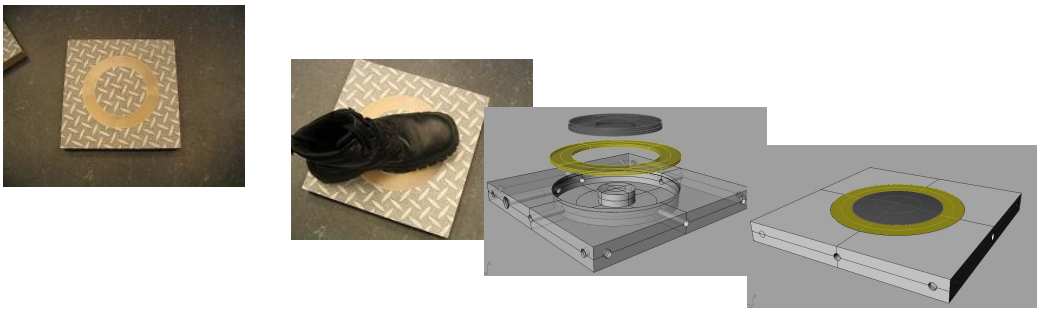


Figure 2

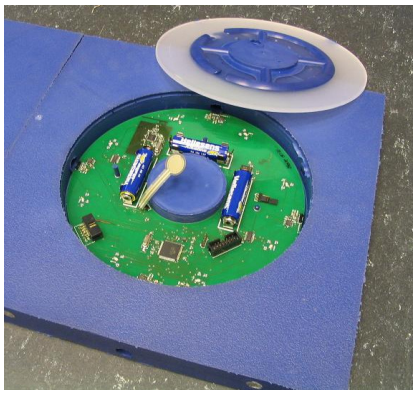


Figure 3

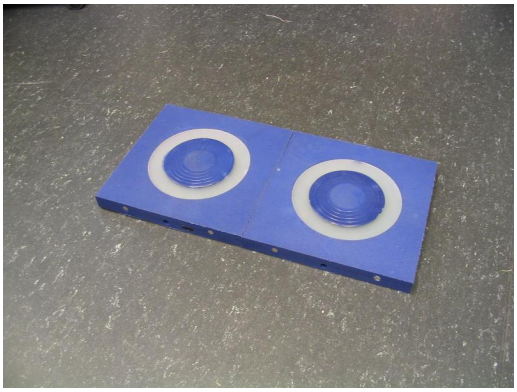


Figure 4

Each single mat includes, as it is shown on figure 3, a printed circuit board. Therefore, each single mat is a small independent computer. One of the mats is developed as a control unit, a master. Thus it controls all the other mats by using infrared light signals.
When and if the tool is used in a combined floor and wall exercise, a radio communication between the horizontal and the vertical mats is necessary.
The mats are attached to each other through the magnetic connections on the side. If the mats are to be placed vertically, they are hung on a large magnetic board by the magnets on the back of the mats.

The first prototype was provided with the following exercises:
Colorrace: One to six contestants has to touch/step on as many luminous mats as possible on time. Colorrace is especially suited for execution both on the floor and on the wall.
Lunge: One participant stands on 2 tiles. The participant has to step forward on a tile as soon as it lights up and hereafter return to the starting point.
Stepper: One participant stands on 2 tiles and tries to step on as many tiles as possible while the clock is running. An indicator shows the step frequency with green, yellow and red light (see table 1, top of page 6 and video clip at http://www.sygehusfyn.dk/wm216477).

The practical prototype testing
The new intelligent exercise equipment has systematically been used and evaluated by therapists and patients connected to the heart rehabilitation group at the Department of Rehabilitation at FH in Svendborg from September 1st 2006 until December 31st 2006.

Considerations regarding choice of target group
A newly published MTV-report[i] highlights the importance of physical exercise for cardiac patients.
Circulation training is the primary content of the 2 weekly exercise séances of 1½ hour and the use of a new exercise tool could be introduced on the same premises as other training activities.

The group of hip-alloplastic patients and patients with fractures near the hips were considered as possible target group for the prototype testing, as it was expected that the new tool made balance training and walking with weight adjusted carrying possible. But this group does not have a special need for circulation training.

It was decisive for the choice of using the cardiac rehabilitation group that most of the training of hip operated patients is individual training and the wish was to use the dynamic that arise when more people are training as a group. It also spoke in favor of the cardiac rehabilitation group that a systematic testing and registration of the cardiac patients was already made.

During the period of prototype testing the tool has continuously been developed and complemented. Thus, by the end there is more possible ways to use the tool[3] than at the beginning where the tool consisted of one master and 10 intelligent therapy tiles for one level use.
The possibilities of test set-up available at the beginning have been kept throughout the process, in spite of the fact that the possible ways of use has been developed.

Test and interview procedures
All patients that entered the 2 cardiac rehabilitation groups were asked to participate in the prototype testing project.
At the same time, the patients received orientation on the fact that it meant using the intelligent therapy tiles on the same terms as other exercise tools, and that it involved tests of approximately 15-20 minutes in connection to initiation and termination of the 8 week course.
The exercises that was used and the tests are listed in table 1, following page.
Finally, they were informed on that participating in the course also meant participating in an interview of 20-30 minutes at the end of the course.
The physical tests took place individually and the interview took place in groups. Some patients were asked whether it was all right to make video footage of them completing the tests.

[3] At the end the tool consists of 2 masters, 30 intelligent therapy tiles with radio connection between vertical and horizontal tiles.

Number of patients, drop out, number of completed tests, number of completed interviews

A total number of 21 patients started in the cardiac rehabilitation group from September 1st until November 10th 2006. 2 patients ended the course half way due to adjoining disease, one patient did not wish to participate.

This meant that a total of 18 patients have participated in the prototype testing. Hereof only 2 were women. The average age is 62, with a range from age 51-78.

All patients completed the physical testing, but only 13 patients completed an adequate number of tests for the results to be valid. There is only one woman among the 13 patients. The average age is 61 with a range from age 51-71.

The reason for the lack of completion for the 5 patients was:

One became physically ill during the test, one refused to be tested a second time, and the 3 remaining patients was not able to complete because of technical problems with the mats. The signal between the mats did not work and the output could not be registered. The same problem occurred in additionally 4 cases among the test-participants, but here the problems were limited to the "step exercise" (see enclosure 1).

15 patients have participated in group interviews. Lack of time was the reason for the remaining 3 people not to participate. 2 physiotherapists who have been in charge of the cardiac rehabilitation of groups were both interviewed.

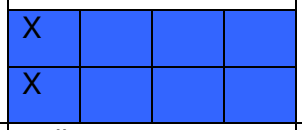
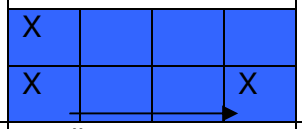
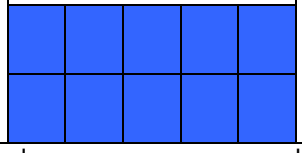
Exercises	Time	Set-up	Effect of training	Output
Stepper, Side by side	1 min.	8 tiles 4 "dummies" 	Circulation, fitness, endurance	Number of steps pr. min + Heart rate
Lunge	½ min.	8 tiles 4 "dummies" 	Balance, coordination, concentration	Number of lunges pr. min.
Color-race, floor	1 min.	10 tiles In one row 	Fitness, endurance, concentration	Number of hits pr. min. + Heart rate
Color-race, Wall	1 min.	10 tiles In 2 rows 	concentration, balance, coordination	Number of hits pr. min. + Heart rate

Table 1. The blue hatched squares are supposed to illustrate the set up of the mats. X´s shows the position of the feet during the exercise.

Results

Information retrieval

A MESH-retrieval has been made in MEDLINE/PubMed with the tags “Artificial intelligence”, “Rehabilitation” and “User-Computer Interface”. This resulted in 32 articles of which only one (not relevant) is a randomized controlled experiment.
Four articles, all with a lower level of evidence, are perceived as relevant. The fact that no articles were found with a high level of evidence is perceived as the fact that intelligent training is in its making.
The same search in Cochrane resulted in descriptions of 2 clinical experiments of which only one is relevant.
Similar searches in Embase, Cinhahl, Pedro and MTV project databases gave any results.
The 5 chosen articles are described briefly in the following section.

Technical note (evidence level IV) on robot-arm-trainer from University of Geneva, Italy[ii]

The article describes the development of a robot-arm-trainer named ”Braccio de Ferro”, which translated into English means something like Iron Arm and Popeye the Sailor arm!
The idea behind the robot arm is that it undertakes parallel movements according to the patient’s movements. It has the possibility of moving in all levels/dimensions, and the idea is that the physiotherapist can be replaced by the Popeye the Sailor arm!
From this it does not appear whether real tests of the Popeye the Sailor arm – the article describes primarily the technical specifications behind the idea.

Technical note (evidence level IV) on virtual arm trainer from Twente, the Netherlands[iii]

A group of Dutch engineers has used virtual reality in an experiment in the training of the arm on apoplectic patients.
The exercise which they try to imitate is a situation where an apoplectic patient grabbing a round stick with both hands and a ball is thrown towards the patient, who pushes the ball back using the round stick.
The virtual exercise situation is described as a relative success in spite of problems of:
- making the virtual setting sufficiently 3-dimentional
- imitating the natural resistance in the movement

It is mentioned that the exercise-tool holds the possibility of training coordination, timing and increased movement in a situation where the presence of the therapist does not limit the range.

Description of first results (evidence level IV) in connection to use of walking robot from Switzerland[iv]

A group from the Technological Institute, the university and hospitals in Zürich has developed and tested the so called lokomat, a walking-robot that has been tested in the training of patients with injuries on the spinal cord (Same walking-robot is presently being tested in Denmark at Hammel Neurocenter)
The walk-training on a treadmill, where the spinal cord-injured patient is supported by a “clinging robot”, is useful in connection to enhancing the amount of walking training, and

has, at the same time, advantages in connection to evaluation and documentation of the walk-training.
The importance of the lokomat supporting and cooperating (by the help of bio feedback) related to the patients voluntary walk contrary to predefined movements, are prioritized.

Descriptive study (evidence level III) from USA, on force-feedback in relation to apoplectic patients[v]
A group from Wisconsin, Milwaukee, USA has tested a car simulator on 8 apoplectic patients. They had a wish to perform a meaningful exercise with the purpose of enhanced activity for the apoplectic arm through the use of force-feedback towards the non-affected arm to diminish the activity.
The idea was taken from the concept behind Constraint-Induced Movement Therapy (CIMT), which a recently published randomized controlled prospective study[vi] has shown evidence of.
As the CIMT immobilizes the non-affected side totally, the force-feedback mechanism graduates the level in which the non-affected body-part must be activated – this show future perspective.

Description (evidence level IV) of EMG released equipment for rehabilitation of apoplectic patients[vii]
A group from Massachusetts, Cambridge, USA presents an arm-trainer for apoplectic patients, in which horizontal movements are initiated by electromyographic signals. It is based on the theory of integration of integration of senses where the EMG-signals are picked up according to the patients' attempts to initiate a hand movement, but where the signal does not reach the threshold value for the actual value.
When the EMG-signal is picked up a robot supported movement is initiated, helping the patient to do the desired movement.

Interview with patients and physiotherapists

Patients
The patients were asked an overriding question:
How do you experience the use of electronic mats for the rehabilitation?
Furthermore, they were asked to describe:
Advantages and disadvantages in using the electronic mats for rehabilitation?
In the following quotes (*in italics*) are used to support the appearing themes (<u>underlined</u>)

<u>A needed new exercise-tool:</u>
"It has a lot of potential, it is exciting and alternating compared to other exercises"
"I have thought that it is a good thing with something new, it would else just be exercise bikes, treadmills etc., and obviously this area must have electronic development, and that is great – preferably as much variation as possible to consider all needs…"
"At the beginning I was somewhat skeptic, I thought that it was quite silly, but soon I saw that it was fun indeed."

<u>The exercise requires a high heart rate</u>
"Even if it looks easy it can "drag" the heart rate to a new level so much that one is about to fall on ones behind down there"

The competitive aspect is motivating

The benefits are that more people are able to use the same tool; it is not the case when you are sitting alone on an exercise bike where you are able to "free-wheel down hill". Now there is always a lamp that lights up and if one is not quick enough, somebody else will overtake."

"I used it to compare a little with the others, what are they able to do and what can I do"

"I think that it should be used for competitive purposes. When attending a rehabilitation program then it is not always funny, then a competitive aspect helps. And having experienced a heart attack it is not always just as exciting to have to do exercise; it has to be some thing that spices it up a little and that I think the tool is good for…"

Need for quality development of the tool

"There are some teething troubles, e.g. it is annoying when the equipment falls apart (Comment: and the exercise/the game stops) *because people really go at it"*

"Functionally it is not stable and that is annoying"

"One mat broke when I stepped on it" (Comment: Man weighing 115 kg)

Training concentration, coordination, balance and reaction + ideas on other patient categories

"There is something about concentration involved which the other lacks, therefore it could e.g. be used for other patient categories."

"Something with sound and light might be good, also for other patient categories, something like playing a rhythm or melody, or find specific patterns."

"We are supposed to use our minds too, to coordinate and use orientation and so on…"

"We compete against each other, that is much more fun, we are really competing when facing each other; then the heart rate increases and we enhance our balance and reaction."

Need for increased accessibility for the patient, and better illustration of results in order to test on own hand

"It could be fun and motivating if it was possible to illustrate and show ones position in the competition, among each other, if we were a little behind Nils, then one could try to give it a little extra…"

"With a tool like this I would like to be able to test myself, it could be each 2nd week…"

"It could be beneficial to be able to test one from exercise to exercise. It must be better and more visible for the patient, also with the possibility to go down and test oneself."

"We have not used it enough; it has to be more accessible for how to use it alone. We have been dependent on the presence of the therapists.

Need for enhanced control and individualization in choice of exercise

"Everybody on the team has to be on the same level, also in the beginning, - we were very excited and it was hilarious. For others it was a little tough as it involves pushing and nudging, and that can seem scary".

"I did not find it very funny, that is because I was not ready to be there – it was too fast, intense and confusing when many people were jumping forth and back, and most of them were younger and more able to move around."

"I may suggest that it could be controlled a little more, so that when one has stepped on a tile, one could step back and let others come forward. We had a big guy on our team and that could make it hard to find space enough…"
"I haven't used the mats that much, but I think that they have been an excellent tool, 1 or 2 persons together, but if more than 2 persons were involved, it did not work, then I was likely to step back. There is not as much solidarity as when we e.g. play hockey."

The physiotherapists
The physiotherapists were asked to generally evaluate the use of the tool in the rehabilitation of cardiac patients, and to generate ideas for a continuous use and development of the tool.

A needed new tool that requires individual focus
"It wakes something else in the more cautious patients, and it brings "sheer madness" to the others. They laugh, they fight and they have fun. It is clear that it has a benefit. One forgets because one is playing."
"It is wonderful that there are no given set-ups."
"It is good and flexible. If one is only able to reach the first field in the Stepper, then that is ok. The level can really be individualized."

The use of the mats in relation to group exercise can be difficult
"It has been difficult to use the tool fully due to the composition of the team, e.g. with some of the more cautious patients. And in periods only some have been able to exercise while others waited."
"The tough boys/ blusterers, they thought that it was so much fun…"
"It is a problem when you have a group, some easily gets to stand still and watch. However, we have solved it by some using the mats while others use other exercise equipment. But actually, we not supposed to whip, it is the patients' own choice."
"Colorrace is still the most picked, (especially the version with 10 in a row on the floor)*, but that is because it is in teams. The stepper is also amazing, but it does not benefit much when 8 watch while 1 person participates."*

Need for more accessibility for the patient
"It is right that if there were some buttons that said e.g. Colorrace, then it would be easier for the patients, and then some of them would have used it, that I am sure of."
The Stepper and the Lunge would function well for individual training".

Need for development of the tool
They care about how many points they score and then it is tiresome when it does not function."
"The idea is really good, but now, when almost all of the outpatient treatment is in the municipalities, we must prepare ourselves for an older and weaker clientele on the hospitals. But it is not impossible that some of them can use it, but with different exercises."
"We should consider how to enhance the use of arms and hands, maybe the occupational therapists should participate here."
"It should use sounds too; sounds could indicate success or the contrary, or to use rhythm and music. Maybe something with pattern-recognition involving both sound and light."

"The idea of combining Colorrace and Lunge is good, where one continuously has to return to the starting point to get a general view, and here the combination of floor and wall would be obvious."
"The mats placed in a walking bar would be good, to train 2, 3 and 4-point walk, but it would require a study on what the right learning method would be."
"It would be a super good idea to test the mats on athletes too, they are much more motivated. It is very unfortunate that the equipment is not used after 3 PM."

Functionality of the mats
"I think that they take up much space down here and it takes time when one has to move equipment.
"It is a nice design, both to look at and step on, and the magnets are not complicated at all. Not when it comes to making the patients help out either."

Physical tests of performance
The 18 patients who have used the mat for rehabilitation in on average experienced an increase in function on 24% (enclosure 1) measures by the stair-test[4], which is a tool chosen for measuring function level on cardiac patients at FH in Svendborg.
In comparison the patients have during the period preceding the prototype testing had an increase in function on 27%.
Therefore, nothing indicates that the use of intelligent therapy tiles brings a change in level of function.
Looking closely at the 13 patients who were thoroughly tested (enclosure 2), it shows that 3 out of 4 tests show approximately the same improvement as the stair-test, while one single test, Colorrace on floor, which is the most used exercise, surprisingly does not show improvement.
At the same time it is worth noting that as well Colorrace on the floor as Stepper demands a total of 86% of the maximum heart rate. Both are very requiring and training for fitness and endurance as Colorrace on the floor demands an average heart rate on 75% of the maximum heart rate[5] and stepper demands a total of 86% of the maximum heart rate.
Colorrace on the wall is not similarly demanding on the heart rate compared to the fitness-training effect, but the average progress, compared to number of touches reached, is anyhow relatively high. The same goes for Lunge, which primarily must be seen as an expression improved balance and coordination.

Video footage of the exercises
Watch video footage of the different exercises on http://www.sygehusfyn.dk/wm216477.

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[4] Same stair used each time on the present address
The test involves one floor up and one floor down.
The test is initiated at stair-step 1same level each time on the present address.
If the patient stops halfway the number of points the patient has reached on the previous level is kept.
The patient is tested individually
The patient runs/walks on the stair according to the intensity around effort-level 13 on Borgs effort-scale ("the talking level")
The patient walks/runs in the inner lane of the stair where the banister is located.
The patient can use the banister – if doing so, it must be noted.

[5] Estimated maximum heart rate, meaning. 220 – age.

Discussion

We succeeded in developing a prototype on the intelligent exercise equipment, which both patients and therapists find motivating and filled with perspectives. The rehabilitation using the intelligent therapy tiles is challenging for circulation, balance, reaction and coordination.

The use of the new tool in the rehabilitation of cardiac patients did not improve the patients functionality measured in accordance to the stair-test.
Anyway, it is estimated that the new equipment holds a great potential for development.
First of all it goes for the development of software, to make it possible for therapists in a larger extend to provide individualized rehabilitation and to monitor and document the outcome of the exercises.
The user interface, where the patient has to chose the exercises, must also be developed in order to become more user friendly.

The intelligent therapy mats has a potential for further development when it comes to more flexible use.

This means:

- being used for other patient groups,
- that the tool can be developed for rehabilitation over a distance,
- that the tool can be developed so that the patients over extremity to a much larger extend can be used, preferably in virtual surroundings, where the entire pattern of movement is made meaningful for the individual patient.

Imagine an apoplectic patient that throughout life has had a passion for badminton, who by the end of the course can play a game of virtual badminton, while the therapist has programmed the game on order to emphasise rehabilitation of the patients force and control-problems in his or her right arm…
And imagine a gold-player who has been injured with a near hip fracture, who can take a virtual game of golf with a buddy from Düsseldorf while he, in the Department of Rehabilitation in Svendborg, improves his balance and weight carrying on the broken leg…
Or imagine a gambling geriatric patient with cognitive problems and a need for physical activity, who moves around in a large game of Memory, in he is not playing a physically demanding game of back-gammon with a cousin in Skjern…

Returning from these future scenarios on the flexible potential of the tool that to a large extend involves the patient's participation, the testing of the flexibility of the first prototype that was a big wish from the therapists, "cost a little" compared to the reliability, which it is a high priority to solve in the following process of further development.

The literature on artificial intelligence within the field of rehabilitation is increasing fast, but most studies have a lower level of evidence.
Most of the intelligent exercise-tools being developed presently have a user interface that is quite controlling towards the rehabilitation. The user interface in this prototype is more independent of the traditional computer interfaces (e.g. keyboard, computer mouse, screen and joystick). It can be argued that the patient through the intelligent exercise-tool moves on the user interface itself, which is the unique about this tool. As mentioned there

are possibilities for a development of the user interface that makes it possible for the patient to move him- or herself with the user interface (0 in the hand) and in the user interface (=the virtual surroundings).

Literature

[i] Zwisler, A-D; Nissen NK; Madsen M; DANREHAB-group
Heart rehabilitation, a medical technology evaluation. Evidence from literature and the DANREHAB-experiment.
Copenhagen: National Board of Health, Center for Evaluation and Medical Technology Evaluation, 2006
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