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Methods of Virtual Rehabilitation for Health Care Workers- A Review

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Abstract

Introduction: Virtual rehabilitation is the technique for rehabilitation in various virtual ways that are helpful, low-cost benefits, interactive atmosphere, concentrated learning and online feedback database for easy assessment and management.

Methodology: The methodology was accepted inclusion of 150 studies from various journal sites and with the need of the study to relate and analyze the virtual technology in the health care sectors and acceptance to its pros and cons in the health care sectors.

Results: There are various techniques that belong to virtual technology that are immersive, semi-immersive, and non-immersive with distinct features of different levels to no immersion depending on requirement. There are various requirements in the virtual technology that need to work for virtual rehabilitation such as sensors, touch screen, interactive technologies, sounds and more. The virtual technology not only works with rehabilitation but plays a wide role in other health-care services such as medicine, surgery, emergency, diagnostics, medical learning, counseling. There are various current scenario applications working in virtual world for health care according to the field.

Conclusion: The conclusion resulted with the virtual rehabilitation is required as successor to rehabilitation to the new world with more positive outcomes.

Keywords: Immersive, Non-immersive, Semi-immersive, Virtual reality

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Introduction

Virtual rehabilitation is a technology providing the virtual environments with the help of the 3 dimension devices, 2 D computers, joystick for the control, providing the atmosphere for the patient interactive and motivational [1]. According to the studies the virtual environment lead to ease in rehabilitation with better and early positive results, and early community life returning [2,3]. The rule for rehabilitation says that it should be qualitative in terms of effects, providing gain in the sensory and motor recovery. But the gain should be task specific as the results required and can be made with the helps of various modes in virtual rehabilitation by altering the environment and getting the feedback from the patients by their actions [4,5]. The rehabilitation through the virtual environment should be with early treatment , task specific, and there intensity repetitions [6]. According to a study the virtual reality have been in various fields of heath care and stood to be advantageous in medical, psycho-social, surgical, rehabilitation integration [7,8].

Concept Behind Virtual Rehabilitation

Virtual reality is the principle on which the virtual rehabilitation works, where virtual reality is the computer technology which demonstrates the different way of explanation with the help of 2-dimension view to 3-dimension view in case of gaming, rehabilitation, medical and many more. There was basic 3 concepts behind the virtual reality where first one is involving both the human factors to be interacted with virtual environment. The second part goes with the technological devices such as haptics, 2D devices, 3D devices, sensory integration devices. The third part involves the immersion techniques with level of perception [9].

The principle of virtual reality works on two interactions that is software and hardware where the software includes graphics, computing and hardware includes the interaction of human and computer phase.

Methodology

The aim for the study was to review the studies behind the virtual technology in the health care sectors in various fields of heath care environment leading to developing healthy society, and study the various changes that occurred with changes in decades behind, study the pros and cons of the virtual technology efficiency behind the health care sectors. In this study the articles were from 1971 to 2019 representing the changes and the technology updated in decades. Total 150 articles were studied in this study which were selected from google scholars, research gate, science direct and pubmed. The articles were selected with different keywords with virtual reality, immersive technology, non- immersive technology and semi-immersive technology. The articles were abstracts, full text, systemic reviews, randomized control trial and review studies.

Virtual Rehabilitation Devices

There are various types of virtual rehabilitation devices:

Immersive virtual rehabilitation

There is the requirement of consciousness acted in the virtual rehabilitation through all the senses [10]. Hence the immersive works on the technology with experience of 360 degrees exposure allowing to work on sensorimotor effects which can be depending to the visual effects required. Immersive technology is present with ability of creating illusion to sensitize the brain perception and work on motor actions, this creates an immersion of the patient hence termed as immersive virtual rehabilitation [11]. The immersive can be provided in these ways as when environment is considered with various types such as narrative where the patient is involved with the story, tactile as the sensation is provided to the patient in the virtual environment and strategy based that is initiating as the mental work to be encouraged [12]. There are two types of devices under immersive technology where either they are more or less immersive respectively , where Cave work as involving the same person when looked down in the virtual environment and facing the consequences present as the given situation where the head mounted technology is more immersive where there is different person in the environment playing patients role [13].

Non- immersive virtual rehabilitation

This is the technology where the patient is not enclosed in the 3 dimension view with head mounted device, but shown as the 2 dimensional view with computer or television provided in the room and patient is allowed to follow as the environment suggests such as games for rehabilitation [14]. According to a study the non-immersive virtual rehabilitation as mirror therapy where the computer is attached to the non-affected side as wore as gloves and the affected side is present on the virtual reality, where any action taken by non-affected, the action will be presented by affected arm in virtual reality letting the positive feedback to be presented. This acts best on complex regional pain syndrome and phantom limb pain and provided best analgesic results [15-17].

Semi immersive virtual rehabilitation

Semi immersive is a technology providing better exposure then non immersive and turning images and games to be more into real and feeling of immersed in that session, but it is not involved in cyber sickness as the immersive technology works [18,19]. There is the study done where semi immersive works best for cognitive, balance, walk in geriatric and incomplete spinal cord patients, tumors, stroke and traumatic brain injury [20-22] where the non-immersive not work that efficiently where the full immersive is quite stressful for senior citizens hence the semi immersive results better for virtual rehabilitation, without the presence of avtaars and providing the sensory stimulation whenever required s as to achieve the feedback [23-25].

System behind virtual rehabilitation[26, 27]

As shown in **Figure 1**

Procedure of virtual rehabilitation working [28]

As shown in **Figure 2**

Algorithm for immersive virtual rehabilitation (Figure 3) [29-33]

The immersive technology in the virtual rehabilitation can be followed with the help of games and situation creating.

Figure 3.1

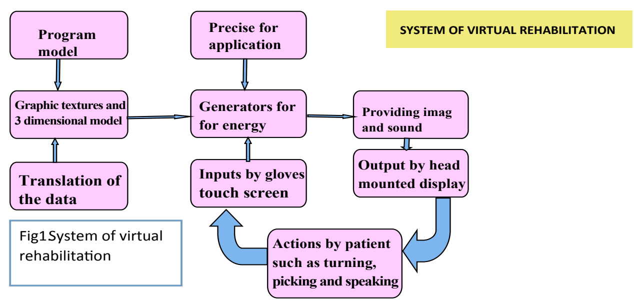

Figure 1 System of Virtual rehabilitation.

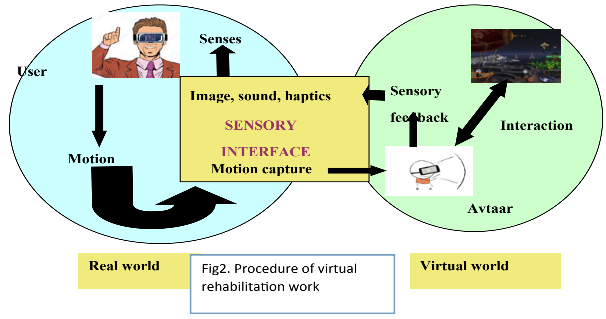

Figure 2 Procedure of virtual rehabilitation work.

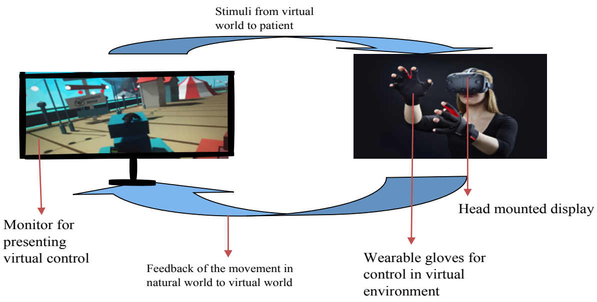

Figure 3 Immersive virtual rehabilitation.

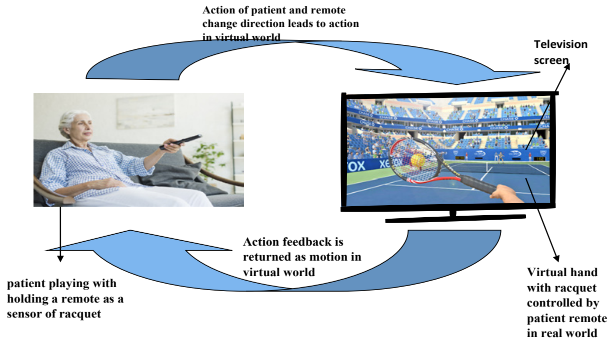

Figure 4 Non Immersive virtual rehabilitation.

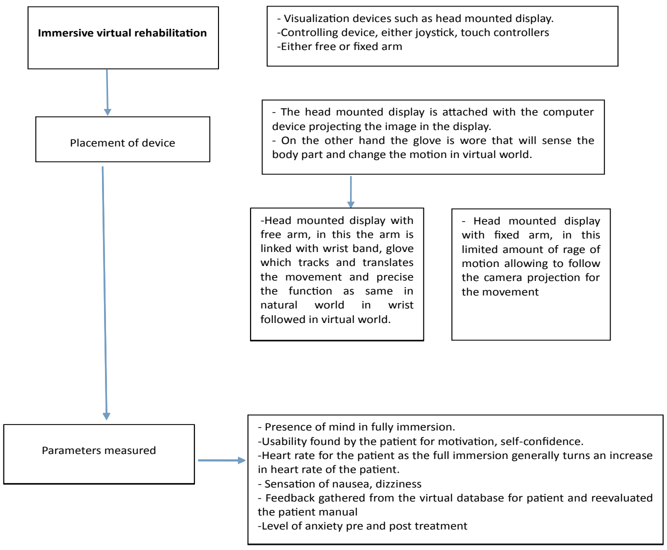

Figure 3.1

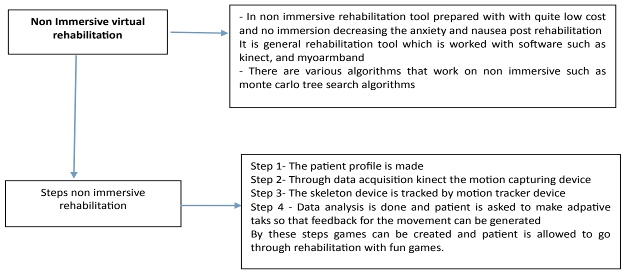

Figure 4.1

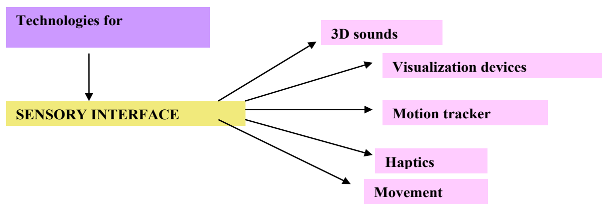

Figure 5 Technologies behind Virtual rehabilitation.

Algorithm for non- immersive virtual rehabilitation (Figure 4):

Figure 4.1

Technologies behind the virtual rehabilitation [34-37]

There are various device that play a major role in making virtual rehabilitation successful **(Figure 5)** [38-43].

3D sounds

3D technology is highly preferred in the virtual environment which provides the better impact on the individual and improves immersion, hence the sound if changed to 3D creates the better spatialization allowing better feedback. In this technology there is inclusion of headphones, computing 3-dimensional sound system, sound metaphors, multi-channel systems and sound localization for better perception of sound.

Visualization devices

These devices are made of different technologies such as LCD, OLED where the it is adjusted according to patient's eye capabilities as the general human eye resolution is 1 acrimin. There are 3 distribution of visual technology and names as families where first family depicts the screen size in where in front the patient stands, the size can be small or large sized which dependent on the requirement of exposure to virtual environment, second family depicting head mounted display as the individual eye have their own image that is created this created a better immersion and the third family depicts the volume changes as what the type of size of image as per the requirement of the patient.

Motion Tracker

These are the devices which act as copy or the avtaar for patient who is using. The benefit is that it act as eye movement tracker too as the motion of eye catches the motion is occurred, there are other various devices that acts such as joystick, glove, CAD system which are moved according to the action by the patient. There are other devices which keeps a record of full body motion that are tracked by complete body suits, tracking with the help of image creation.

Haptics

This is a device which controls the virtual environment allowing the ease to control the avtaar of the patient in virtual level and make them feel of reality, it can be achieved with the help of the joystick such as the exoskeleton of the robot arm, providing the sensation, perception and better force feedback.

Movement

The movement provides the feedback with the help of the system present in the body such as vestibular system, visionary, kineshthesis; the feedback obtained from these systems are essential to create virtual environment and to proceed with alteration in the rehabilitation. The devices used behind are treadmills, bicycle, head mounted display, rotation of platform, pressure sensors.

Techniques for the Virtual Environment Interaction By Patient [44,45]

Navigation [46]

There are various techniques that can navigate the patients end and avtaar ends with the help of techniques such as walking at same place will give the motion to avtaar, other is grab the air where the hand function of the patient will act as the reference to avtaar of virtual environment. According to a literature says that characteristics of navigation is egocentric as well as exocentric with the techniques of concrete navigation and abstract navigation resulting in game pad, go go navigation, grab the air, treadmill, bicycle and virtual companion.

The navigation procedure is taken with the help of exploration in the virtual world with the help of static display depending on the screen, such as by wearing a head mounted display the one can experience the virtual world with limited motion in the real world and experiencing better exposure and motion in virtual world, as the alteration can be made according to patients threshold either by rotation in the virtual world, or speeding or acceleration can create illusion in the patients mind providing better infinite effect. This can have effects such as nausea, or headache in some cases [47,48].

Manipulation [49]

It is the highly required techniques as after the navigation manipulation has to be followed by the patient where he or she can manipulate the virtual world, as one need precision and changes in virtual environment by controlling such as by mouse, joystick to begin with better interaction. The techniques such as voodoo doll techniques where the facilitation is increased with interaction process, second is aperture techniques enabling to focus and precise the virtual world. There are various devices for manipulation such as virtual hand, virtual pointer, Ray casting, world in miniature, Virtual tablet [50].

Tactile interfaces [51]

It is simply understood by the sensory interaction with the virtual environment, this creates the better tactile stimulation to the patient, that is faced by the avtaar in virtual world. This technology goes better with immersion virtual rehabilitation. The effects answers to go in which direction or action.

Gesture Technology In Virtual Rehabilitation (Figure 6)

Gesture interaction sensors

It is the technology with which better exposure can be experienced, hence the are various sensors that act like to control gestures. The sensors are used depending upon the action [52]. As given below in the figure depicted the types and sub types of sensors

Under wearable sensors there are data glove, are the most used sensors due to effect posture sensation as the movement of hand in real as its bending and motion will change the bending in virtual environment, this created the 3-dimensional effects and better relation among the real patient and its avtaar. This data gloves consist of better accuracy with smaller space for memory. There are various researches and depicted types like cyber touch and dexmo [53-55]. The inertial sensors are the miniature of MEMS that are inclusive of actuator, sensor and energy, these are present with higher sensitive material and present with acceleration motion recorder, they are very easily wearable on wrist and hand. There is literature they made a inertial sensors in shape of watch that can a keep a record of acceleration in the movement [56], where other literature demonstrates the feature present in the mobile phones [57]. There are EMG sensors also known as myoelectricity a wearable device that acts and produces the feedback according to the muscle action that is transferred as the myoelectric signal and that allows action in virtual world [58].

Touch device under gesture technology is inclusive of touch screen and stylus pen where touch screen is the mediator between the patent and the virtual world, this is inclusive of infrared technology, acoustic waves, pressure touch screen and capacitative touch screen [59]. The stylus pen is a new touch device in which you create the 2 dimensional on the surface which transmits the information to the other virtual world in 3 dimensional with the help of ultrasound, magnets, ray, electric tracing and tracking method [60].

Computer interaction technology [61-63] is gesture technology with no wearing of the external devices means no hassle just a interaction with computer virtual world, here the exposure is quite low due to different disruptions in environment, but benefited with all the low cost devices. There are various cameras that are used to make the image and quality better as earlier

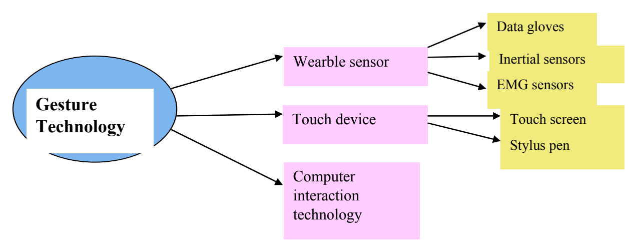

Figure 6 Gestures Technologies behind virtual rehabilitation.

monocular cameras and infrared cameras but in some studies they used histogram, vector method, and template matching method. There can be a use of binocular camera for better view.

Recognition of gesture technology [64-69]

Figure 6.1

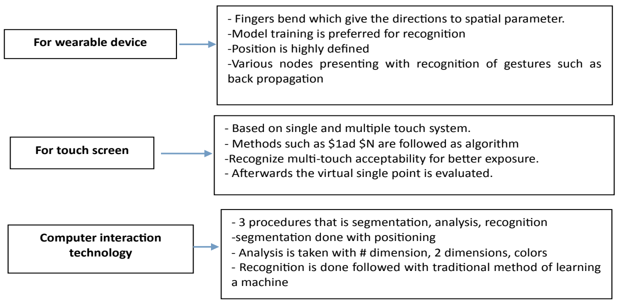

Figure 6.1

Virtual Reality In Different Aspects of Health Care

In Medicine

This is a new technology through which the virtual meetings the session of medicine can be provided, as benefited with different types of applications taking the health care onto the next stage [70,71]. There are various medical prototyping from where the doctor can be interacted with the patient and can have complete view, where there are special trainers to be prepared under to understand the anatomy in virtual environment [72].

As the patient is when explained with virtual environment the functioning of body, the results are betters uh as muscular activity [73-75]. According to a literature, virtual technology provided best feedback in autistic children when provided with virtual methods of treatment. The new system of pycho oncological virtual technology is that as it provides where the effect of chemotherapy sessions can be reduced as by virtual space experience and ease on the second day session of chemotherapy [76,77].

In Surgery

In surgery the virtual technology is way high on the aspect of surgery as there the traditional method of surgery gives the limited exposure but due to virtual reality the image guided surgery is possible with clear images of inner body , such as while the surgery of abdomen the exposure is quite limited hence the image guider can provide the anatomical exposure [78]. There are various trainers being trained to specially put a surgery on virtual technology such as temporal bone dissection, brain tumors, breast cancer, arthroscopic surgery, oesophageal intubation [79-82].

There can be the remote surgery with the help of telepresence that can ease the surgery even if the surgeon is not near, as the sites of surgery can be viewed under the virtual technology and the device attached as the sensors, joystick can make surgery successful, with low cost and high accuracy due to high exposure resulting in precision in surgery [83]. Due to virtual technology it has resulted in increase in endoscopic surgery, and in case of brain surgery the prior MRI and the virtual technology is accepted for the surgery and the robotic assistant is used in of virtual surgery [84,85]. The virtual technology is a source for pre planning and pre requisites for surgeons as that help to be listed what and how to be managed at the given condition, such as in case of neurological or psychosomatic disorders [86].

Diagnosis

The diagnostics have established where there was 2-dimensional view which due to virtual environment changed into 3dimensional view and better understanding towards anatomy they are specially engaged in the procedure such as bronchoscopy and colonoscopy [87].

Emergency management

There is a literature explaining about the Bio-Simmer as the virtual technology for emergency purpose and other literature made flight stimulator and following the same there are various other literature presenting the innovation but with the target of crisis in case of emergency the computer system can interact and the patient can be managed and be provided by first aid, this is highly useful and acceptable in armed forces where the management is to be fast [88-90].

Psychology

The virtual technology in psychology have stepped in years back, as very much useful in case of experimental psychology as providing the sensory stimulus with the different kind of technologies such as CAVE, head mounted display The results are easily recorded according to feedback of patient work [91].

Preventive medicine

It is the method to enhance the communication, confidence, motivation in pediatric patients where they are provided the virtual technology related video games enhancing their ability to function better [92].

Training and education in medical

Due to virtual technology the education and training is easier and better understandable than the traditional method where the virtual technology begins with anatomy from 2-dimensional view to 3-dimensional view where it is explaining the basics to modified surgeries [93].

Rehabilitation

The virtual technology has initiated the aspect of rehabilitation with the help of telemedicine, which highly useful, low cost, easily reachable and treatment can be provided from distant therapist. This is required with high bandwidth connectivity, with haptic devices, the controller device for patient and doctor, where the haptic system ensures that the feedback provided by the patient is reached to therapist and the required intensity is reachable to patient. There is a need for the robotic device to assist in the conditions at patients place [94-96]. The rehabilitation can be provided to the patients with fear such as agrophobia, claustrophobia, vision, deafness, inability to walk, wheelchair fear can be clarified with the help of virtual technology, where the patient is made to enter to the virtual environment with the base for basic fear so as to gain the confidence and which is increased further with the gain of feedback by the patient.

Need of Virtual Rehabilitation (Figure 7)

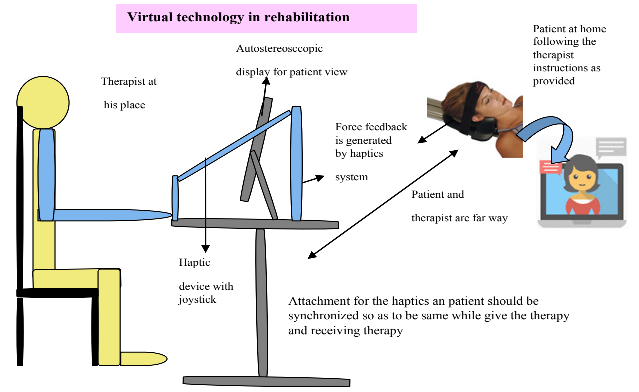

Figure 7 Working technology behind virtual rehabilitation.

The new term of virtual rehabilitation has been a question what and how is this possible to provide the rehabilitation in the virtual environment, by preparing the synthetic environment allowing various factors in the natural environment and combining into the one resulting beneficial effect, as the virtual world keeps a record of feedback, the changes presenting in the body of patient and motivation and encouragement changing the results. According to a literature the virtual world prepares the best motor rehabilitation changing from disability to most positive outcomes [97].

There are various benefits that makes the need for virtual environment to be made as for rehabilitation such as aspect of validation in terms of ecology, grasping a control on alteration of stimuli, every session feedback with reality, a tool for assessment and encouraging over the abilities of the patient to work on. The best part acts is there is the complete concentration of the patient in the therapy which engages the patient to give his or her full abilities. Hence there are various evidences that support virtual technology for rehabilitation and there was significant improvement in the patient when working with virtual environment [98-102].

The virtual rehabilitation is best working with to deal with fears such as flying, looking down from height, water fear, light fear which at times make the person feel nausea when faces the situation, as the stimulus cannot be altered in natural environment but can be recreated in virtual environment proposing with the idea for resolving this, hence by creating the progressing environment and changing the patient's ability to function well.

The virtual technology keeps the best track of patient's feedback by every means of databases, turning better for research purpose and providing the better outcomes. Whereas the virtual technology not only improved the rehabilitation but also initiated to deal with other health care services that conclude to be low in cost and high accuracy, low time consumption hence referred to telemedicine [103-105].

Current Scenario in Virtual Technology In Health Care

In rehabilitation

There are various applications which have stepped in for enhancement in virtual technology in rehabilitation such as equipment used in training children with the wheel chair that are motorized [106], exploring physical environment, eye tracker device for disability, Virtual technology for vision impaired where the virtual desktop follows the sight line as of the patient [107-109].

In medicine

There are various techniques such as control on virtual environments utilized for agrophobhia, eating disorders, autistic children [110-112]. The other techniques such as virtual reality with 3 dimensional glasses for dental treatment and oncological treatments. Building a virtual environment to relax, orientation to proprioception, stroke and many more [113-115]. The virtual technology in medical training is simulation by catheterization used in surgery such as ballooning in cardiac blockage [116].

In surgery

There are various techniques followed in endoscopic surgery for gall bladder removal, joint replacement surgery for orthopaedics by robots used locally, and compiling the real time images and video images or surgical view such as for neurological surgery. There is a system named as minimal invasive surgical trainer in which is a laparoscopic surgery machine in which the assessment and treatment is done and used in gynaecology, thoracic and abdominal surgery with better view with limited invasion [117-119]. Whereas in pre planning for surgery such as plastic surgery model as take the preview before the surgery, tendon transplant model which prior surgery justifies the post-surgical questions, craniofacial diastosis repair by 3 dimensional imaging and CAT scan, and netra systems for biopsies and neurological surgeries [120-122].

Diagnostics

In the diagnostics there are various applications that can work as diagnostic tool such as virtual clinic in this parkinson's patients are diagnosed and provided treatment, wireless communicating devices allowing the nurses, doctors to go through the patient profile even when patients are at home, video conference pilot where the rural places the doctors can prescribe the treatment even sitting miles away [123-125].

Future Challenges [126-130]

The thought for the virtual rehabilitation is the acceptance at the clinical level, that its should all the features that it requires to be followed by patient and therapist to there level of satisfaction,as the virtual acceptance feels by the therapist and patient is unsatisfactory at some level although the virtual rehabilitation is the proven fact that it aids the patient.

The other challenge is that therapist is replaced by computers, letting the therapist attitude to low down, but the myth had changed as the virtual rehabilitation is the force amplifier that enhances therapist work and increase in accuracy.

The challenge faced is that the virtual technology in surgery is difficult as the sterlization is required post-operative, where the child care related equipment are not available creating a challenge.

It's also came with challenge such as the decrease in cost does not mean that it is still affordable in various places and can be invested with all the sources, whereas the quality of networking is also not successfully created in the place need to be initiated that will lead to interrupted video tele rehabilitation leading the fact that patient will not be able to cope with this.

Discussion

The virtual rehabilitation came to be innovation in technology with the concept of virtual reality presenting the hardware and software turn into the device made for patients to work upon, and engaging them with from real word to virtual world presenting the same visualization with better effects of working. The devices with the virtual technology are such as haptics, auditory vestibular, olfactory, stimuli and changing the presentations whenever required for task specifications [131-134].

The virtual technology is even language specific to make the patient into his environment, the coding for virtual rehabilitation is created according to goals of task [135].

The virtual technology are in various areas of health care such as medicine, surgery, rehabilitation, diagnosis where not it provides the assessment protocol but also provides the treatment planned. The treatments are given specifically to cognitive variations or deficits by accessing them to various games to initiate the ability from disability, with a creation of various recreational activities that are oriented specific for these deficits.

The virtual technology comes with the promise to orient the patient and make fulfilled of work in activities of daily living with professional and work oriented activity, such as teh virtual rehabilitation also works with the patient to recover with driving capabilities if have lost due to accident or any other conditions [136-140]. There are various experimental studies going on the patients expecting for there motor learning, active learning, motivating and encouraging the patient to challenge the life by completing the task and fulfill the needs of there life, as this progress the therapist to alter and change in very patient and help to research better [141-145]. According to a study the virtual rehabilitation works best to tackle the fears that is creating a barrier to lift life in that condition, such as claustrophobia, acrophobia and many more [146-149]. The study found the virtual rehabilitation and proven to be highly effective in burn patients and treating the impairments such as auditory, sensory by enhancing virtual environments. The virtual rehabilitation is the encouraging technology which is progressing ahead with the abilities to encourage and not withdraw the abilities of the therapist to lag behind the computers. Th virtual rehabilitation establishing the virtual world by feeling it as the real world and motivating and improving in real world [150].

Conclusion

The virtual technology that created the virtual rehabilitation is useful tool for the rehabilitation and in the usage of the other health care services which have been proven for the more benefits and yet the research is continued. The only thing about the virtual technology is that it is highly benefited tool in the health care but the study says that it has to be looked for challenges to come up and resolve and allow the high number of patients to be a source of outcome from virtual rehabilitation.

Competing Interests

No competing interests are there.

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Author's Contributions

Participation for this article were equal in creating the article. Manuscript is verified and finalized by both the authors for publication process.

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Availability of data and material

Not applicable

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