Role of Management &Virtual Space for the Rehabilitation of Children Affected with Cerebral Palsy: A Review

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Abstract: - **Cerebral palsy is defined as a neuromotor disorder which limits the motor activity and is attributed by non-progressive disturbance in the brain during pre or post natal time. The motor disabilities of CP are usually accompanied by cognitive impairment, abnormalities in behaviour, difficulty in communication, impaired sensory perception, and seizure disorders. Although CP is a non-progressive and non-curable disorder then also it must be managed so as it does not grt worsen with time. The key issue of cerebral palsy is its treatment and management. There are various aids available for the same. In the recent years,there is emergence in the new technologies for the treatment of the CP. One of the such recent technology is virtual reality rehabilitation therapy. Virtual reality is an enviroment simulated by computer with the help of specific hardware and software. VR is emerging as a promising technology for various field, specially for the field of education and medical. VR therapy has many advantages over the conventional therapies, and now a days this became a more appropriate option for the treatment. This article dispense a review of the nature, type, treatment and management of the cerebral palsy.**

Keywords - Cerebral palsy; Virtual space; Motor impairment;Virtual Reality; Cognition; Tele Rehabilitation; Virtual Rehabilitation.

I. INTRODUCTION

CEREBRAL Palsy (CP), one of the neurological disorders among children which is remarked by non-progressive movement disfunction due to the disturbances of some occurring in the infant brain. Previously, the CP rate was 2 to $3/1000\ live\ birt$ but now the rate increases to 40 to $100/1000\ livebirt$ a mid of babies born prematurely[1].Among all other neurological disorder CP is the most frequent serious disorder affecting the family, the child's education and social life [2]. Up till, there is no any specific diagnostic protocol available for CP but the knowledge of such will responsible for the meet of accurate prognosis of it.

The world health organization (WHO) develop a system International Classification of Functioning, Disabilities and Health (ICF) that defines CP in a new way to understand and to think possible intrusion to clinicians, researchers and families [3,4]. CP affects mainly a child's physical or motor functionality furthermore it also affects the cognition of the child. But it doesn't mean that all the CP kids have cognitive impairment, some CP children have only motor functionality difficulty. Only approximatly 45% or two thirdof the CP population of kids suffers from some level of cognitive impairment [5]. However children with severe Cerebral Palsy have more odds of having cognitive impairment.

As Cerebral palsy is caused due to damage of brain so the person with CP may not be able to process the information in right manner or right way that comes from numerous sources. This means person experiences difficulty in understanding and processing the information. This is referred as cognitive or intellectual impairment. One can detect whether the child has cognitive impairment or not by performing simple IQ test. If $IQ \leq 70$ then he or she is considered as cognitively impaired but in practical cognitive impairment can be specific to the certain function. A number of brain functions that comes under cognition comprises of attention span, comprehension, decision-making, learning, memory, recognition, problem-solving, language skills, difficulty processing emotions & feelings, speech proficiency etc. There are many motor disorders that a CP kid deals with. Based on the intensity of disorder CP may classify as Mild, Moderate and Severe. Based on the position and degree of brain damage, the parts of body affected, the kinds of tone and movement problems present CP is classified as:-

$$CP]_{Movem.}: \begin{cases} Spastic \\ i.e.\ affectsabout\ 77-93\% \\ \\ Ataxic \\ i.e.\ affectsabout\ 2-8\% \\ \\ At\text{-}etoid(orDyskinetic) \\ i.e.\ affectsabout\ 2-15\% \\ \\ Mixed \end{cases}$$

$$\overline{i.e.Representationoftypesof CP\ onthebasisofmovement.}$$

$$CP]_{Body}: \begin{cases} Hemiplegia \\ (i.e.\ aleg\square ig\square lyaffect\&anarm \\ lessaffectofonesideonly) \\ \\ Diplegia \\ (i.e.\ bot\square legssignificantlymore \\ affectst\square anbot\square arms) \\ \\ Quadriplegia \\ (i.e.\ bot\square legs\&armsare\square ig\square ly \\ affectwit\square musclesoftrunk, \\ faceandmout\square) \end{cases}$$

$$\overline{i.e.\ Representationoftypesof CPonthe\ basisofpartsofbodyaffect.}$$

Motor disabilities ≥ 50% CP kids suffer from some other impairment related to brain damage which includs cognitive impairment, epilepsy and some psychosocial abnormalities. CP kids also suffer from behavioural challenges, sleep disorder, fatigue and anxiety. Now, the structure of this paper is follow as; besides introduction in section 1 , then we have management & treatment in section 2, followed on by the therapy case ofvirtual reality in section 3 and finally the paper ends with conclusion in section 4.

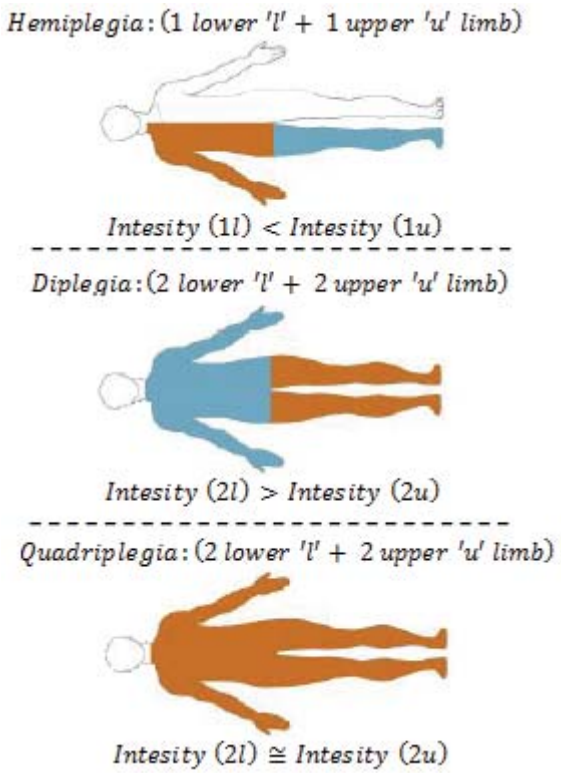

Figure 1 Represents the parts of body affected by cerebral palsy with different intensities. 'l' means lower limb and 'u' means upper limb.

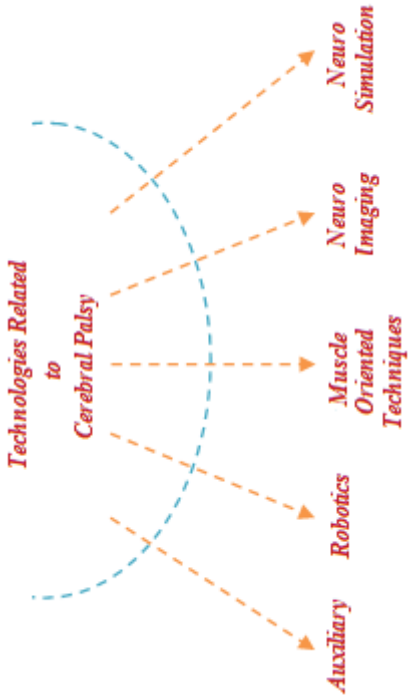

Figure 2 It represents the group of different emerging technologies for the case of neuro-rehabilitation of children affected with cerebral palsy.

II. Management And Treatment

Although Cerebral palsy is not curable, it is unavertible and need to be managed so that person dealing with different problem of it can live the life with fullest extent. As CP is a childhood problem so it must be managed from the infant age. Now a day's patient centred and family centred models are available, which shows that, every patient has unique difficulty, therefore, in order to deal with that, every patient need exclusive care and treatment[7,8]. This type of model may regard as *Team based model*or$T-model$ [6]. This $T-$ model provides constant care of physician which further more include management of chronic illness and coordinates with other team members for whole lifetime of a patient to make sure optimum health of the patient. The programme would come with management of primary, secondary and tertiary complications of chronic disorders, preventive care and maintenance of functional activities. A good parental and family care is required to manage it properly[8]. This model is dissimilar with that of the conventional medical model[7]. Every family can't afford this model as this become very expensive to hire a whole team so the best way is to contact a clinical care organization which has integration of medical, neurological and rehabilitative care.

CP treatment include therapies for the optimization of motor functionality of the CP children as well as the cognitive exercises to facilitate, maintain and develop cognitive abilities.CP treatment comprises therapy,

medication and surgery and make effort to get the most effective outcome of the situation.

$$CPTreatments:\begin{cases} T\square erapy:\begin{cases} P\square ysical\\ -T\square erapy\\ Occupational\\ -T\square erapy\\ Alternative\\ -T\square erapy \end{cases}\\ Medication\\ Surgery \end{cases}$$

$$\overline{i.e.Representationoftypesof CP\ management\&treatment.}$$

2.1 Therapies

Therapy is the attempt to recover health issues after diagnosis. Therapy helps person to raise stronger, feel better and make independent by corrective, rehabilitative and healing process especially after disease or disorder. Therapy uses interpersonal relationship to foster ones self-understandability, functionality, fitness and independence. Therapy facilitate individual to deal with problematic and difficult situation and environment in an efficient, effective and positive manner.

2.1.1 Physical Therapy

This is also known as physiotherapy. This is among one of the most effective treatment of the Cerebral Palsy. Physiotherapy focuses on gross motor skill of the child.It assist to fortify muscles and improve motor actions and maintains the bones from developing contractures[9]. Therapy begins soon after the diagnosis of the disorder. Treatment involves techniques like exercise and stretching that help to maintain and improve the movement. Physiotherapy encourage movement, develop coordination, improve muscle strength and balance, stops muscles from shortening and losing their range of movement that is contracture, maintain flexibility, optimize physical functioning levels and maximize independence.

2.1.2 Occupational Therapy

Therapy involves identifying problems that child have in carrying out everyday tasks. Occupational therapist target on the improvement of fine motor skills and on maximize upper body function and enhancing posture[9]. Occupational therapy facilitate child to be the master of fundamental activities of daily living, such as dressing, eating and using bathroom alone. This boots self-esteem and self-reliance of the child and also reduces their dependence on parents and care giver.

2.1.3 Alternative Therapy

Conventional therapies help the CP patient to improve their mobility, speech and overall independence. But every CP case is different so therapy and treatment plan for every patient should be based on their individual symptoms and difficulties. Complementary therapy means additional therapy with conventional therapy and Alternative therapy means which replaces the conventional therapy[10,11].Patient with coexisting conditions of CP respond better to these therapy.

$$AlternativeTherapy:\begin{cases} HippoTherapy\\ Acupuncture\\ ConductiveEducation\\ BehaviourTherapy \end{cases}$$

$$\overline{i.e.Representationoftypesof CP\ management\&treatment.}$$

2.1.3.1 Hippotherapy

Hippotherapy is a form of therapy which uses equine movement to improve and develop muscle tone and mobility, neurological and physical functioning by coordinating the movement of horse [10,11]. This is also referred as 'Equine therapy. Horse movement has their own pattern and rhythm which forces rider to mimic the rhythm in order to stay mounted on back. This allows joints, muscles and bones to align properly. Hippotherapy helps to improve physical as well as cognitive function. Physical benefit includes improvement of muscle tone, coordination, posture, balance and limbic system function. Cognitive benefit includes improvement of attention, visual coordination, tactile response, timing and ability to express thoughts and needs.

2.1.3.2 Acupuncture

Acupuncture therapy involves insertion of small needles into specific points of the body. This therapy is intended to relieve pain. Penetration of certain point of body with needles affects the flow of life force and helps to open, restore or enhance the flow [10,11]. When this therapy is used for CP treatment placement area of acupuncture needles are generally defined such as on scalp, ears, fingers, arms, legs and feet. Acupuncture helps CP kids to relief pain, improve voluntary movement, balance and coordination.

2.1.3.3 Conductive education

Conductive education is an inclusive method of learning for children with cognitive and physical impairment; this develops problem solving skill and daily life activities by repeatedly doing actions[10,11]. It makes easy for person to function and find solutions. Conductive education provides opportunities to learn everyday life activities, motivates and promotes self confidence.

2.1.3.4 Behaviour therapy

Behaviour therapy develops ability to manage stressful situations. This therapy focuses to teach how to deal with emotional challenges and unproductive behaviour. In behaviour therapy therapist identify troubling situation, thoughts and emotions of children; and empower them to handle challenging situation in more efficient and acceptable manner [12]. This improves the social skills of children.

2.2 Medication

Treatment with the help of medicines is called medication. Medicines help to manage some symptoms of CP, avert or reduces complications and medical conditions related to CP. Physician generally suggests medication for those who have seizures associated problem in CP [6]. Medication also help to manage movement related issues as well as secondary or coexisting conditions developed due to CP. Drugs prescribed for every individual are on the basis of their own symptoms. Even if two individual has same problem then also they may do better with different drugs. Some individual may require combination of two or more drugs. That totally depends on body condition and symptoms of that individual [13]. To avoid unnecessary side effects physician weigh pros and cons of medicines before prescribing them. Common CP conditions which can be treated with medications are seizures, spasticity, involuntary movement and incontinence.

2.3 Surgery

Surgery is one of the several options available to treat CP, although this is usually not the first option or choice of the treatment. Doctors recommend various physical therapy and medication first for the CP patient [13]. If these doesn't help enough, then surgery become a viable option for treatment. Individual with cerebral palsy undergo surgery on muscles, tendons, bones or nerves depending on their problems or difficulties. Surgery can correct or improve mobility, posture and alignment in legs, ankle, feet, hips, wrists and arms. Depending on problems of individual their surgery are different [6]. Muscle lengthening, tendon lengthening and tendon and muscle cutting are for muscle and tendon difficulties. Osteotomy for improvement of joints, Arthrodesis is to treat spasticity and reduced mobility. Surgery improves mobility, range of motion, posture and physical alignment; encourages independence and healthy physical development and prevents from complications and deformity.

$$i.e.\ (Motor + Cognition)\ management\ is\ very\ \ important\ for\ CP\ kids.$$

III. VIRTUAL REALITY THERAPY: VR THERAPY

Virtual reality is a virtual space, created by different software like OCCULUS VR, OCCULUS RIFT, UNITY 3D, UREAL ENGINE 4, VRAY VR AND 3DS MAX, VIRTALIS AND IRIS VR etc. and presented to the user in such a way that user have faith in it and accept it as real space [14]. VR can be categorised in three types "immersion, non-immersion and hybrid" [15]. In immersive system, person is encapsulated in virtual space and their all senses (vision, auditory and touch) are completely blocked from the surrounding environment. While in non-immersive system person's senses are remain intact with the external world. In hybrid system person feels real world with superimposed pictures of virtual space. Computer mouse, a data glove and position trackers are some of the input devices used in VR and computer and/or television screens, shutter glasses or head-mounted displays are output devices for the VR. This non-immersive virtual space is primarily experienced through 2 of the 5 senses, which are sight and sound, which may collectively regard as S^2senses.

$$i.e.Virtualspacebasedtherapyworkonthe\ groundofS^2senses.$$

The virtual space (or environment) makes possible for the patients to involve in activities similar to that encounter in actual life. In other words, it allows users to interact in a variety of sensory atmosphere and to obtain real-time feedback of their performance [27]. Therefore, virtual space technologie is one of the useful tools being used for cognitive research, evaluation, and rehabilitation. This virtual space therapy also commonly known as virtual reality therapy abbreviated as VR Therapy.

$$VRApplication: \begin{cases} CognitiveResearch \\ Evaluation \\ Rehabilitation \end{cases}$$

$$i.e.RepresentationofVRapplication$$

As VR provides cyclic practice and positive feedback, in order to enhance the functional independence in daily tasks, therefore it is responsible for the motor learning. This can be task specific. In other words, the outcomes, as a movement, so learned in this transferred to the real life of ones [27]. According to motor control and learning theories the motivation, repetition and target directed training should need to be consider in the treatment of children with CP, which sufficiently meet by VR therapy. Taking VR therapy further into account as a tool to treat cognitive impairment, it depends on many factors. These factors are specific patient population which means patients are treated for their specific problem. Rehabilitation protocol, VR-augmented or VR based therapy, which one is being used. Therapeutic approach, which approch a therapist use for rehabilitation.Proximity to the therapist, if patient is able to come to the clinic then therapy goes on in presence of therepist, otherwise telerehabililitation is used.

$$VirtualRehabilitation: \begin{cases} Specificpatientpopulation \\ Rehabilitationprotocol \\ Therapauticapproach \\ Proximitytotherapist \end{cases}$$

$$\overline{\substack{i.e.Representationoftypes \\ VirtualRehabilitation}}$$

3.1 Working of VR

VR takes the input from the person and utilize it to make them feel that they are in virtual space. It takes sensory feedback: visual perception, sound perception, position touch and force perception and olafactory perception to simulate the enviroment [15]. A control box is used for the interfacing of headset and computer. After interfacing system is ready to take person in a virtual world.

3.2 Working of VR for CP

VR enhances various motor and cognitive performances due to variety of factors. VR motivates and increase its dificulty level, this keeps patients keep going on the track. This is a fun way to make repetative practice of same thing with different methods, this keeps paitents indulge in the whole session. They keep parcticing therapy as game which helps to improve condition of the CP kids. Here some of the possible mechanism which describes the working of VR for CP.

3.2.1 Cortical reorganisation or brain learning

Research and studies showed that VR can enhance brain plasticity and brain reorganisation up to desirable results. Through active participation and repetition of movements which are assisted in motor learning cortical also changes. VR helps in neural plasticity through reorganisation of cortical [17].

3.2.2 Motor control

Studies and statistical data show the significant enhancement in motor and processing skills through VR, which includes balance, posture stability, walking and voluntary movement of muscles [16]. VR helps patients to control motor action to their own; make them more independent and balanced.

3.2.3 Motivation

VR increases difficulty level of exercise after achieving specific motor control, this improves effectiveness of physiotherapy. Variability, challenge and competitive factor of VR highly motivate the patients [18]. Many of the patient show their goal oriented response, which means motivation helps to enhance motor and cognition functions.

3.2.4 Other factors

Use of VR intervention enhances cognitive function level of participation and concentration. VR provides feedback to the participant, which give them sense of achievement that in turn motivate participant to improve their performance by cognitive planning and repetition. VR environment provide enjoyment and allow participants to enhance and show their creativity [19].

3.3 Benefits of Virtual Rehabilitation

Before discussing the advantages of virtual rehabilitation, let us discuss some characteristics of Conventional rehabilitation. First thing is itusually boring and dull for the patient because these rehabilitations are repetitive in nature which reduces patient's motivation and interest. Traditional rehabilitation is done on one-to-one basis; means at a time one therapist can work with one patient [20]. This makes therapy costly. Devices used in conventional rehabilitation therapy are generally not computerised, so there is no online database is available means error evolution of data is manual and tedious task. For classical rehabilitation both patient and therapist must be on same place. There are various advantages of virtual rehabilitation. All forms of virtual rehabilitation are very interactive and motivational. Especially video game based therapy in which patient competes against computer and computer provide them visual and auditory rewards, such as displaying massages ("well done", "wahoo", "amazing" etc.); motivates patient to exercise. So patient gets better results while having fun [14].

Another advantage is same VR hardware can be used for several type of patients, additionally as for various forms of exercise done on those patients.For example, one head-mounted display can be used for patient affected with post-traumatic stress as well as patients of post-stroke or attention deficits [21]. So virtual rehabilitation in all form is economical.Virtual rehabilitation offers specific and intensive treatment.VR plays a vital part in functional training and performance. Virtual rehabilitation is mainly game based rehabilitation so patient enjoy the therapy.At one time a therapist can manage more than one patient. As this is computer based therapy therapist can assign challenges to the patients and can monitor the on screen [22]. Aspatient do all challenges and work on computer and interfacing systems; database of patients stored in online database without any effort of patient or therapist. So it become very easy to access data of patients and analyse them.

Therapist can treat a remote patient without traveling to their places with the help of telerehabilitation.Telerehabilitation has major advantage for those patient who cannot travel to the clinic due to any reason. So therapist assist them through online video communication on regular basis [23]. Through telerehabilitation expert specialist of all over the world can assist patient of any area. This reduces the health care cost of the patient.VR helps to regain function and enhance over all abilities of the patient. VR enhance over all motor

functionality and especially helpful to enhance cognitive functionality of patient. VR helps to increase concentration and decision taking skills [24]. This introduces challenging tasks without risk, which helps in rehabilitation.

3.4 Challenges in Virtual Rehabilitation

Despite of many benefits, virtual rehabilitation have some limitations also. The very first challenge is it's throughout clinical acceptance. Medical studies regarding VR are underway and sufficient data is not available to satisfy criteria that VR is practical.Second challenge is attitude of therapist toward this technology. Some technologists think that virtual rehabilitation will replace therapist with computers. That's why therapist has negative attitude towards this. But the fact is this technology act as "force amplifier" for the therapist, allowing them to work with more patients at one time.VR interfacing is another challenge. These equipment are not designed as medical equipment, so there is difficulty in sterilization of these equipments making it unhealthy for repetitive use by different patients.Some time ago cost of VR equipments were very high making them not affordable by everyone. In recent years equipment cost has dropped, but that drop is not sufficient to make it available for everyone.Telerehabilitation suffers from inadequate communication infrastructure [23]. Telerehabilitation depends on telephone lines and internet connections, so network interruption is a big issue.

1V. CONCLUSION

CP is a ubiquitous neuromotor disorder, which is non-curable but manageable. Every CP patient differs from others in terms of physical and mental challenges and difficulty level. Management and treatment of CP patient is a multifaceted, multidisciplinary and multidimensional work, which has many parameters that must be taken into account. Therapists treating the patient must be familiar with all the conditions and comorbidities in order to provide patient optimum effective treatment. In recent time with conventional treatment, virtual reality based rehabilitation i.e. virtual rehabilitation is used to treat patients. This method has many advantages over the conventional method. Maximum study reports its advantage over convetional technology. It is a fun way and entertaining method which motivates and encourage the patients to complete their task without getting bored. This provides very effective results, as it is mainly computer based rehabilitation so data is transparently stored without any manual effort for the further use. With virtual rehabilitation patient feels more actively involved. Which provide better improved results.

REFERENCES

[1] P.M.Birgani, M.Ashtiyani, A.Rasooli et. Al, "*Can an Anti-Gravity Treadmill Improve Stability of Children with Cerebral Palsy?,*" IEEE 2016, pg. 5465-5468.

[2] Rosenbaum P, Paneth N, et.al,*"A report: the definition and classification of cerebral palsy April 2006"*Developmental medicine and child neurology supplement, 2007, pg. 8-14.

[3] Benjamin Klein, "*Mental health problems in children with neuromotor disabilities,*" Canadian paediatric society, Mental Health and Developmental Disabilities Committee Paediatric child health, 2016; 21(2):93-96.

[4] Mintaze Kerem Gunel et. al, "*Virtual Reality in Rehabilitation of Children with Cerebral Palsy,*" published by INTECH, 2014 pg. 273-301.

[5] Karen W. Krigger, "*Cerebral Palsy: An Overview*," American Family Physician, 2006, vol-73, no-1, pg. 91-100.

[6] Mindy L. Aisen et. al, "*Cerebral palsy: clinical care and neurological rehabilitation,"Lancet Neurol* 2011;vol-10:, pg. 844–852.

[7] Johanna Darrah, Mary C Law, et. al, "*Context therapy: a new intervention approach for children with cerebral palsy,* " NIH, Dev Med Child Neurol, 2011;53(7): pg-615-620.

[8] Viviane Marten Milbrath, et. al, "*The Family of children with cerebral palsy: perception about health team orientations,*" Text Context Nursing, Florianopolis, 2012, 21(4), pg- 921-928.

[9] Carolyn Green, Carrie Proch, and Susan E. Gara, *"The Changing Face of Cerebral Palsy: A Review of the Disorder and Its Treatment,"* J NEURO REHAB, vol-11, pg. 245-253, 1997.

[10] William L Oppenheim, "*Complementry and alternative methods in cerebral palsy,*" Developmental Medicine & Child Neurology, 2009, 51 (Suppl. 4), pg. 122-129.

[11] Gregory S. Liptak, *"Complementary And Alternative Therapies For Cerebral Palsy,"* Mental Retardation And Developmental Disabilities Research Reviews, 2005, vol-11,pg. 156–163.

[12] Linda D. Hill, "*Contribution of behaviour modification to cerebral palsy habilitation,"*Physical Therapy, 1985, vol-65, pg. 341-345.

[13] Areej Alshehri, Christian Bach, "*Challenges of cerebral palsy management,*" ASEE Conference, 2014.

[14] Ji-WonShin, et. al, "*Effects of conventional neurological treatment and a virtual reality training program on eye-hand coordination in children with cerebral palsy,*" Journal of Physical Therapy Science, 2015, pg. 2151-2154.

[15]Maryam Vafadar, "*Virtual Reality: Opportunities and Challenges*"IJMER, 2013, vol-3, pg. 1139-1145.

[16] Heidi Sveistrup, "*Motor rehabilitation using virtual reality,*" Journal of Neuro Engineering and Rehabilitation, 2004.

[17] Juliana M. de Oliveira et. al, *"Novel Virtual Environment for Alternative Treatment of Children with Cerebral Palsy,"* Computational Intelligence and Neuroscience,Volume 2016 (2016), Article ID 8984379, 10 pages.

[18] Pierre-Alain Joseph et. al, "*Virtual reality for cognitive rehabilitation: from new use of computers to better knowledge of brain black box?,"* Int J Disabil Hum Dev 2014; vol- 13(3), pg. 319–325.

[19] Michelle Wang, Denise Reid, "*Using the virtual reality-cognitive rehabiliotation approach to improve*

contextual processing in children with Autism," The Scientific World Journal, 2013, 9 pages.
[20] Mindy F. Levin, et. al, "*Virtua reality versus Conventional treatment of reaching ability in chronic stroke: clinical feasibility study,*" Springer Neurol Ther, 2012.
[21] Ana Lucia Faria, et. al, "*Benefits of virtual reality based cognitive rehabilitation through simulated activities of daily living: a randomized controlled trial with stroke patients,*" Journal of Neuro Engineering and Rehabilitation, 2016.
[22] Albert A. Rizzo, et. al, "*Analysis of assets for virtual reality applications in neurology,*" Neuro psychological rehabilitation, 2004, pg. 207-239.
[23] Albert A Rizzo, Dorothy Strickland, "*Challenges of Telerehabilitation in the Home Enviroment,*" Telemedicine Journal And e-Health, volume-10, 2004, pg. 184-195
[24] Larry F Hodges, et. al, "*Treating phychological and phsyical disorders with VR*," IEEE, 2001, pg. 25-33