

The Computer Assisted Rehabilitation Environment (CAREN): A Commentary

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The Computer Assisted Rehabilitation Environment (CAREN) is a virtual reality (VR)-based system that was developed by the Dutch company Motek Medical (Motekforce Link, Amsterdam, Netherlands) and has been used by clinicians for evaluation and treatment of various musculoskeletal, neurological, vestibular conditions [1]. It involves exposing the patients to challenging tasks in a controlled environment while maintaining the patient's safety. The technology is too expensive to be ubiquitously available, but some big rehabilitation facilities and hospitals in the United States like Cleveland Clinic, Massachusetts Institute of Technology (MIT), Brooke Army Medical Center has it. I personally have the opportunity of using this system in an upscale facility in New York (NY) City.

The CAREN system has a multi-directional moveable platform (Moog Inc., Elma, New York), a force plate mounted on a motion base, ten-camera 3D motion captures system (Vicon Inc., Oxford, UK) that can detect reflective markers placed on the patient, a big VR screen. The platform has six degrees of freedom with combinations of motions are possible [2]. It operates by means of hydraulic and mechanical control systems that are installed underneath its surface [3].

The software CAREN system uses (called D-flow) allows the use of different applications that can challenge different body system so that the patient can be introduced to real-life situations and get immediate feedback about his/her performance [1,2]. Thanks to the force plate installed, patients and clinicians can see how

much force is exerted by a single or a group of muscles, to allow them to see which muscle in the body is working or not working at any given time and then correct the performance as needed. All the components of the system are operating in a real-time feedback loop so that all movement of the body can be directly visualized. Safety of the patients is maintained all the time using a safety harness that the patient wears prior to using the system.

Virtual reality technology including CAREN system has been investigated on various conditions like Parkinson's disease, low back pain, knee osteoarthritis, traumatic brain injury, strokes, multiple sclerosis [2-11]. My colleagues and I are currently working on several projects using the CAREN system. We hope that the data we obtain will be beneficial to clinicians and researchers interested in using this type of advanced technology in rehabilitation, although there are some limitations for having this system available as I will discuss later.

Since our facility in NY sees mostly orthopedic-based cases, we used CAREN system to treat patients suffering from low back pain, scoliosis, post anterior cruciate ligament (ACL) injury and reconstruction, post low back surgeries, and other sport-related injuries. We also had some clients suffering from neurological disorders who came to use this technology including stroke patients and patients with traumatic brain injuries. Therapy using CAREN mainly targets balance, stability, coordination, and mobility. By exposing patients to challenging tasks, it reduces the fear of movement by allowing the patient to recognize their physical and cognitive potentials and tries to improve them.

During therapy, patients are using CAREN to play games built in the system that are designed to achieve specific treatment goals. Those games are not just entertaining, but rather therapeutic. All applications used in CAREN can be adjusted by the operator and the exercises can be offered with increasing complexity based on the therapy goals. This can be achieved through the movement of the moveable platform which can be small and gentle or big enough to push the patients to or beyond the limits of stability. Similarly, patients can be asked to focus on one thing at a time or clinicians can introduce various dual tasks that increasingly challenge the patient's physical and/or cognitive skills.

The applications that CAREN software provides can be used independently or in combination with external modification attached to the machine or to the patient. For example, we used CAREN in the treatment of scoliosis where we used an application called "the maze" and asked the patient to carry weight bag filled with water over both shoulders and hold it with both hands. During the task, the patient was asked to navigate through the maze which he/she can see in front of him/her in the big screen while maintaining his/her own balance and the balance of the weight over the shoulders. In this example, we used CAREN to stimulate specific back muscle activity aiming at correcting the scoliotic curve. The immediate feedback the patient gets while performing the task gives him/her visual and tactile inputs so that the patient is aware of their own muscular imbalance and is asked to try to correct it.

Another modification that can be incorporated in the system is that we used a sliding board attached to the moveable platform to add more challenging tasks especially for athletes returning to sports. The addition of the sliding movement of the lower extremity while moving the platform (which has six degrees of freedom) in different directions while performing a "car racing application" for example, maximally challenges the locomotor, somatosensory, visual, and sometimes vestibular systems which enables clinicians to decide whether or not the athlete is ready to return to sports.

We also used CAREN for stroke rehabilitation using "sailing the boat" application in which the patient is asked to navigate the sea using a virtual boat on the big screen. The leaning of the body forward will advance the boat; leaning back will slow down the boat speed, leaning right and left will change the direction of the boat to the right or left respectively. The complexity of the task can be increased or decreased by changing the sensitivity or the degree of the motion of the platform enabling the clinician

to activate muscle groups by encouraging the patient to put more weight and navigate to the desired direction as the patient visualize his performance on the screen.

One of the big advantages of using the CAREN system is that it trains the patients to maximize the use of their existing potentials and discover new strategies to cope with their deficits. Afterward, they can integrate those strategies into their daily lives for better functioning. The aforementioned examples are just a few of many usages of this neat technology in rehabilitation. On the other hand, not everyone can have virtual reality technology in their practice. It is an expensive technology, requires training to operate it, a large space to be installed, and adequate infrastructure [3]. The system is mainly used by big research centers and hospitals that can afford to have it especially the military research centers and hospitals.

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