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Virtual Reality Video Games to Promote Movement Recovery in Stroke Rehabilitation: A Guide for Clinicians

After stroke, people often have difficulty moving one arm and hand, but movement can improve with considerable practice. Arm movements may need to be repeated upwards of 2500 times for a person to approach his/her peak level of motor function.[1] Video-gaming technology can effectively deliver engaging, high-repetition movement practice. Use of video games for rehabilitation can be as effective as more conventional approaches.[2]

There are 2 types of inexpensive, commonly available gaming systems that can be integrated into rehabilitation programs: controller based and camera tracking. In order for the systems to be used most effectively, it is necessary for therapists and/or individuals with stroke to assess both system types to determine which system best suits their needs and impairments.
The following are examples of systems and games that incorporate movements that may be useful for rehabilitation. This is not intended to be an exhaustive list, as new games and gaming systems are constantly being introduced to the market.

Authorship

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Table 1 Comparison of Gaming Systems

Comparison Criteria	Controller-Based Systems (eg, Nintendo Wii, PlayStation Move)	Camera-Tracking/Motion Capture Systems (eg, Microsoft Kinect)
System description	• Game play is enabled by a hand-held device called a "controller" that has a built-in accelerometer and gyroscope to detect the direction and magnitude of acceleration for the player's hand movement. • A balance board accessory incorporates sensors to detect weight shifts while a player is sitting or standing.	• Game play is enabled with a video camera that uses an infrared depth sensor (located 4—13 feet from the player) to track the player. Players control game play by performing gestures or body movements.
Advantages	• Game play is not affected by equipment or people around the player because movement is tracked with a hand-held controller. • A therapist can address balance and postural control by adding balance board accessories. • A therapist can address grasp and fine motor skills because players are required to hold the controller and push buttons.	• Specific movement patterns drive game play, thereby discouraging players from using atypical or compensatory movement patterns. For example, the player cannot compensate for decreased shoulder flexion by leaning forward with the trunk. • Both simple and complex movements can drive game play; custom games can target particular motor sequences. • A figure on the screen mirrors the player's movements. This provides visual feedback on movement quality. • Fine motor skills and active grasp are not required because there are no buttons to push or controller to hold.
Limitations	• Since the system tracks only the movement of the controller, intended and compensatory movement patterns are indistinguishable. For example, a player can "throw" a bowling ball by twisting the trunk instead of swinging the arm. • Therapists are unable to adjust game settings (speed/difficulty of play). • Many games require the player to hold the controller and press/release small buttons.	• Older models do not detect hand, wrist, or forearm movements. • Shiny or reflective surfaces, such as mirrors, windows, or wheelchairs, can interfere with infrared detection of a player's location or movements. • The system can be confused by equipment or other people in the camera's view. This may result in the figure on the screen not matching the player's posture or movements. • Therapists are unable to adjust game settings (speed/difficulty of play).
Appropriate candidates	• Players who are able to grasp the controller and push/release its buttons	• Players who have some ability to move their arms away from their body
Impairments targeted	• Speed, coordination, and accuracy of arm movement[3-5] • Standing balance[6,7]	• Movement time, peak velocity, and functional arm use[7,8] • Range of motion and functional reaching[9] • Balance and weight shifting in sitting and standing[7]

Table 2 Examples of how Games can be used in Rehabilitation

System Games or Packages	Game Description	Body Part Targeted	Speed/Difficulty of Game	Movement Goals Addressed	To Control the Game, the Player Must Be Able to:
Wii Games					
Wii Sports (package)	Players imitate the motions required in various sports (eg, imitating the swing required for golf, tennis, and baseball).	One or both arms (game dependent)	Varies by game; some are self-paced, while others require movements in reaction to a target.	Upper extremity movement speed, coordination, endurance, and range of motion	Maintain grasp on the hand-held controller and push/release buttons during arm motion.
Wii Fit (package)	Players engage in balance (simple yoga poses), aerobic exercise (running in place), and strength-training activities (pushups or leg lifts).	Full body (emphasis on trunk stability)	Self-paced	Balance, weight shift, leg lifts, strength, endurance, weight-bearing through arms	Grasp a hand-held controller and push/release buttons. Maintain balance to stand or sit on a balance board that is the size of a small step.
Just Dance (game)	Players follow sequences of whole-body dance moves to receive a score.	Full body	Speed determined by song/dance selected	Imitation of whole-body postures with rhythmic full-body movements	Maintain grasp on the hand-held controller and push/release small buttons while simultaneously performing full-body movements.
Zumba Fitness (game)	Players follow dance-like exercise routines.	Full body	3 levels—based on speed and movement complexity	Imitation of whole-body postures with rhythmic full-body movements	Maintain grasp on the controller while imitating movements.
Wii Ware Arcade Games (package)	Players simulate arcade games (pool, air hockey, bowling, or snooker) by moving their arm(s) as they would in the real-world game.	One or both arms	Varies by game; some games are self-paced, while others require movements in reaction to a target.	Upper extremity movement speed, coordination, endurance, and range of motion	Maintain grasp on the hand-held controller and push/release small buttons during arm movements.

(*continued on next page*)

Table 2 (*continued*)

System Games or Packages	Game Description	Body Part Targeted	Speed/Difficulty of Game	Movement Goals Addressed	To Control the Game, the Player Must Be Able to:
Kinect Games					
Kinect Sports —Bowling	Players use 1 arm to imitate a bowling swing. Rotating the arm in different ways during the swing can create ball spin.	One arm	Self-paced	Targeted reaching, movement timing	Extend the arm away from the body and direct arm movement toward a virtual target.
Kinect Sports —Boxing	Players use 2 arms to punch or block opponent punches.	Bilateral arm use	Must react to opponent's movements. Speed increases with player success.	Movement speed, reaction to target	Perform punching and blocking motions with the arms while dodging and blocking opponent's movements.
Kinect Sports —Table Tennis	Players swing 1 arm as if to hit balls as they bounce or fly across the table.	One arm	Must react to opponent's volley. Speed increases with player success.	Targeted reaching, movement timing	Extend the arm away from the body in a swinging motion in response to a moving target on the screen.
Kinect Adventures —20,000 Leaks	Players use their limbs, head, and trunk to cover holes and cracks that cause leaks in an underwater tank.	Full body	Must react quickly to new leaks. Speed increases with player success.	Fast-paced forward, sideways, and overhead reaching	Move arms, legs, head, and trunk to plug "leaks" throughout the reachable workspace while standing.
Child of Eden	Players navigate through space to destroy and avoid targets using arm movements. Different arm movements activate different "weapons" to destroy targets. Both arms raised together overhead creates a large explosion.	Bilateral arm use	Must react to targets as they appear on the screen	Fast-paced forward, sideways, and overhead reaching	Extend one or both arms overhead and away from the body to destroy moving targets on the screen.