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Title: A Rehabilitation Program of Exoskeleton-Assisted Body Weight-Supported Treadmill Training with Non-Immersive Virtual Reality for Stroke Patients

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Author Questionnaire

- 1. Microscopy:** Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**

- 2. Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **Yes, all done**

- 3. Filming location:** Will the filming need to take place in multiple locations? **No**

Current Protocol Length

Number of Steps: 14

Number of Shots: 36

Introduction

Videographer: Obtain headshots for all authors available at the filming location.

- 1.1. **Zhengwei Chen:** We explored whether combining exoskeleton-assisted treadmill training with game-based VR could enhance dual-task performance and balance in stroke survivors during early rehabilitation [1].

1.1.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B.roll:3.7.2-3.7.3*

What are the current experimental challenges?

- 1.2. **Zhengwei Chen:** It remains challenging to maintain patient engagement throughout intensive sessions, especially in early stroke recovery when fatigue and attention deficits are common [1].

1.2.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B.roll:3.7.1*

What significant findings have you established in your field?

- 1.3. **Zhengwei Chen:** Our study suggests that this combined approach may help stroke patients better manage balance during walking [1].

1.3.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B.roll:4.1*

What advantage does your protocol offer compared to other techniques?

- 1.4. **Zhengwei Chen:** This approach enhances both physical recovery and cognitive engagement, providing a richer and more effective rehab experience [1].

1.4.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B.roll:4.2*

How will your findings advance research in your field?

- 1.5. **Zhengwei Chen:** Our findings support integrating multimodal technologies in stroke rehab and provide preliminary evidence to guide future randomized controlled trials [1].

1.5.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera.

Videographer: Obtain headshots for all authors available at the filming location.

Ethics Title Card

This research has been approved by the Institutional Review Board (IRB) at Peking Union Medical College Hospital

Protocol

2. Donning and Adjusting the Weight-Supported Exoskeleton System

Demonstrator: Zhengwei Chen

- 2.1. To begin, turn both handles on the robotic arm counterclockwise to loosen them [1]. Pull the exoskeleton outward to clear the treadmill runway and create space for the patient [2].
 - 2.1.1. WIDE: Talent rotates both handles counterclockwise on the robotic arm, focusing on hand movement and handle mechanics.
 - 2.1.2. Talent pulls the exoskeleton away from the treadmill.
- 2.2. Guide the patient onto the treadmill runway from the rear ramp to the front [1]. For patients that are unable to walk, assist them in entering with a wheelchair and position them at the front [2].
 - 2.2.1. Talent guiding a patient onto the treadmill runway.
 - 2.2.2. Talent assisting a patient in a wheelchair at the front of the runway.
- 2.3. Lower the harness of the suspension system using the remote control [1]. Adjust the harness to sit flush with or slightly below the back of patient's head to ensure proper alignment [2].
 - 2.3.1. Talent uses the remote control to lower the harness from the suspension system.
 - 2.3.2. Shot of the harness being aligned with the back of patient's head, verifying correct positioning.
- 2.4. Then unstrap the harness to begin dressing the patient [1]. If the patient is standing, apply the unfastened harness to the torso from behind and secure the straps around the torso and thighs [2]. Ensure all straps are comfortably tightened [3].
 - 2.4.1. Talent unfastens all straps of the harness to prepare for donning.
 - 2.4.2. Talent applies the harness from behind and fastens the torso and leg straps.
 - 2.4.3. Shot of leg and torso straps being snugly adjusted for comfort and safety.

- 2.5. If the patient is in a wheelchair, lift the torso slightly away from the backrest [1]. Thread the unfastened harness around the torso and secure the straps comfortably [2]. Wrap the leg straps around the thighs and fasten them [3].
 - 2.5.1. Talent lifts the patient's torso to create space behind the backrest.
 - 2.5.2. Shot of the harness being threaded and strapped around the patient's torso while seated.
 - 2.5.3. Shot of the leg straps being secured snugly around the thighs.
- 2.6. Now, elevate the weight-supported system to bring the patient into a standing position [1-TXT]. Use the remote control to adjust the weight reduction as needed and observe the data on the unit screen [2]. Raise the patient slightly while ensuring that their feet do not hang [3].
 - 2.6.1. Talent presses the remote to elevate the suspension system. **TXT: Stop when the harness tightens**
 - 2.6.2. Talent adjusting weight levels with a remote.
Videographer: Please pan to the unit's screen
 - 2.6.3. Shot of the patient being raised slightly.
- 2.7. If the patient is in a wheelchair, gradually elevate them into a standing position using the suspension system [1]. Once upright, remove the wheelchair from the runway [2]. Adjust the weight reduction using the remote control as needed [3].
 - 2.7.1. Shot of the Suspension system being used to lift the patient gently from the seated to the standing position.
 - 2.7.2. Talent removes the wheelchair from the treadmill area.
 - 2.7.3. Talent adjusting weight reduction with the remote.

3. Donning and Operating the Exoskeleton

- 3.1. Reset the exoskeleton by pushing it inward from its opened position [1]. Then, rotate both handles clockwise to engage the immobilization device [2].
 - 3.1.1. Talent pushes the exoskeleton inward until it is positioned over the treadmill.
 - 3.1.2. Close-up of both handles being rotated clockwise into the locked position.

- 3.2. Press down on the folded and suspended exoskeleton to shift it from a seated to a standing configuration [1]. Then instruct the patient to lean back against the exoskeleton's torso support [2] and attach the thoracic anchorage straps around the patient's chest securely [3].
 - 3.2.1. Talent presses down on the top of the suspended exoskeleton to transform its position into standing.
 - 3.2.2. Patient leans back slowly into the support structure.
 - 3.2.3. Talent fastens thoracic straps across the patient's torso, checking for proper fit.
- 3.3. Adjust the height of the exoskeleton to align the motor axis of the arms with the patient's hip and knee joints [1]. Then secure the thigh and calf straps, ensuring a snug and safe fit [2]. NOTE: VO is modified for the removed and modified shots.
 - 3.3.1. Talent adjusts the height control.
 - 3.3.2. ~~Talent tightens the waist belt with a firm pull and checks for comfort.~~ NOTE: Shot not filmed.
 - 3.3.3. **Securing the thigh strap to the torso harness and** shot of thigh and calf straps being wrapped and locked into place. NOTE: Shot modified
- 3.4. For exoskeleton operation, launch the control software on the computer [1]. Enter the patient's basic information into the system [2].
 - 3.4.1. SCREEN: 3.4.1-3.4.2.mov 00:03-00:12
 - 3.4.2. SCREEN: 3.4.1-3.4.2.mov 00:18-00:38
Video Editor: Please speed up the video
- 3.5. Adjust treatment parameters within the software [1]. Set the walking speed to 1.5 kilometers per hour, duration to 20 minutes, and apply the default joint mobility settings for both hips and knees [2]. Then click on **Start** to begin therapy [3].
 - 3.5.1. SCREEN: 3.5.1-3.5.3.mov 00:00-00:08
 - 3.5.2. SCREEN: 3.5.1-3.5.3.mov. 00:09-00:16
 - 3.5.3. SCREEN: 3.5.1-3.5.3.mov 00:17-00:23
- 3.6. Next, launch the **ZEPU (Zee-poo) Gait Training and Evaluation** software on the computer [1]. Select the **Game** option to activate the VR training mode [2].
 - 3.6.1. SCREEN: 3.6.1-3.6.2.mov 00:00-00:04

3.6.2. SCREEN: 3.6.1-3.6.2.mov 00:04-00:10

3.7. Guide the patient during exoskeleton-assisted movement [1]. When one leg is in the swing phase, instruct the patient to actively control it [2]. When the leg is ready for propulsion, instruct the patient to forcefully propel it and perform hip flexion [3].

3.7.1. Talent guiding the patient during exoskeleton-assisted movement.

3.7.2. Talent pointing out swing phase and encouraging the patient to activate muscles accordingly.

3.7.3. Talent pointing out propulsion phase and encouraging the patient to activate muscles accordingly.

Results

4. Results

- 4.1. The Berg Balance Scale score showed a statistically significant increase from 43.88 to 48.38 after 4 weeks of treatment [1].
 - 4.1.1. LAB MEDIA: Table 3 and Figure 3A *Video Editor: Please emphasize the row corresponding to BBS(score) in Table 3 and the light grey column corresponding to "Post" in Figure 3*
- 4.2. The Timed Up-and-Go test time decreased from 21.88 seconds to 17.63 seconds, indicating improvement without statistical significance [1]. The Functional Independence Measure score increased from 92.75 to 98.75, reflecting a clinically positive trend though not statistically significant [2].
 - 4.2.1. LAB MEDIA: Table 3 and Figure 3B *Video Editor: Please emphasize the row corresponding to TUG (score) in Table 3 and the light grey column corresponding to "Post" in Figure 3*
 - 4.2.2. LAB MEDIA: Table 3 and Figure 3C