

# **A Systematic Review of the Effects of Task-Oriented Intervention on Upper Limb Function in Stroke in Hospital-Based: 2015-2025**

Jung-Min, Han<sup>1</sup>, Young-Hoon, Kim<sup>1</sup>

<sup>1</sup>Ajou University Intermediate Care Hospital, Suwon, South Korea

Corresponding Author: Kim, Young-Hoon

---

## **Abstract**

*This study aimed to systematically review task-oriented intervention studies focusing on upper limb function in patients with stroke conducted in hospital settings. A literature search was performed using the PubMed, Embase, and Web of Science databases. The following search terms were used: (“stroke” or “brain attack”) and (“upper limb” or “upper extremity”) and (“task oriented” or “task related” or “task-oriented”) and (“intervention” or “program” or “rehabilitation” or “therapy”). Based on predefined inclusion and exclusion criteria, a total of 27 studies were selected for analysis. In hospital settings, task-oriented interventions were primarily applied to patients in the acute and subacute stages of stroke. Combined task-oriented interventions were more frequently implemented than single task-oriented interventions, with many studies incorporating electrical stimulation therapy. Among the included studies, 12 interventions demonstrated significant improvements in both pre–post comparisons within the experimental groups and between-group comparisons with control groups. Task-oriented interventions to improve upper extremity function in patients with stroke demonstrated significant effects when combined with electrical stimulation therapy from 2015 to 2019. In contrast, since 2020, task-oriented interventions combined with robotic therapy or virtual reality therapy have been shown to be effective. The results suggest that task-oriented interventions combined with electrical stimulation, robotic therapy, and virtual reality therapy demonstrate significant effectiveness in improving upper extremity function in patients with stroke. The present study is anticipated to provide fundamental evidence to support the development of future intervention strategies and subsequent research focused on optimizing upper limb functional recovery in stroke populations.*

**Keywords:** Hospital, Stroke, Systematic Review, Task-Oriented Intervention, Upper Limb Function

---

Date of Submission: 07-02-2026

Date of Acceptance: 17-02-2026

---

## **I. INTRODUCTION**

Stroke is one of the leading causes of death and disability worldwide and negatively affects the physical and mental health of millions of individuals each year [1]. Beyond physical impairments, stroke results in a wide range of functional deficits, including sensory, cognitive, emotional, and language impairments, as well as limitations in activities of daily living (ADLs) [2]. In particular, upper limb dysfunction caused by hemiplegia or quadriplegia is a major contributor to reduced independence in daily activities among individuals with stroke [3].

Impairments in upper limb function significantly reduce the ability to perform basic self-care tasks such as washing the face, brushing teeth, combing hair, and dressing [4]. In addition, they limit the performance of fine and repetitive hand movements required for activities such as eating, cooking, cleaning, laundry, and writing [3],[5]. These functional limitations often lead to restrictions in return to work and social participation, while prolonged dependence on others may result in psychosocial withdrawal and depression [6]. Therefore effective rehabilitation interventions targeting upper limb functional recovery are essential for improving the quality of life of individuals with stroke.

According to previous systematic reviews, various interventions have been applied to improve upper limb function in patients with stroke, with CIMT (Constraint-Induced Movement Therapy) and Task-Oriented

Intervention being the most actively studied approaches, followed by robotic therapy, mirror therapy, and VR(Virtual Reality) therapy[7]. Although CIMT was initially investigated more extensively than task-oriented interventions[7], subsequent studies have reported that task-oriented interventions may be more effective than CIMT[8],[9],[10],[11]. Furthermore, a meta-analysis demonstrated that interventions promoting an external focus of attention, such as task-oriented intervention, were more effective in functional recovery than interventions emphasizing an internal focus of attention, such as simple range-of-motion exercises [12]. These findings suggest that task-oriented intervention is a meaningful and effective rehabilitation approach for improving upper limb function in individuals with stroke, highlighting the need for a systematic analysis of how such interventions have been implemented in clinical practice.

Several systematic reviews have examined the effects of task-oriented interventions on upper limb function in individuals with stroke[13],[14],[15],[16],[17]. However, the present study differs from previous reviews in several important aspects. First, whereas prior studies included task-oriented interventions conducted across various settings, including both community and hospital environments, this study focuses exclusively on interventions implemented in hospital settings. Second, this study aims to investigate whether task-oriented interventions combined with advanced technologies, such as robotic therapy, have been increasingly applied after 2020. Previous research has indicated that advanced technologies, including robotic rehabilitation and virtual reality therapy, have been widely adopted in stroke motor rehabilitation since 2020[18]. Accordingly, it is hypothesized that the use of advanced technology-assisted task-oriented interventions has increased in studies published after 2020.

Therefore, the purpose of this study is to systematically review task-oriented intervention studies targeting upper limb function in individuals with stroke conducted in hospital settings. It is anticipated that traditional task-oriented intervention approaches were predominantly applied between 2015 and 2020, whereas interventions incorporating advanced technologies have been more frequently utilized since 2020.

## **II. Method**

### **2.1 Literature Search Strategy**

This study systematically analyzed research related to upper limb interventions for individuals with stroke, International electronic databases, including PubMed, Embase, and Web of Science, were searched. The search period was defined from January 2015 to October 2025. The following search terms were used: (“stroke” or “brain attack”) and (“upper limb” or “upper extremity”) and (“task oriented” or “task related” or “task-oriented”) and (“intervention” or “program” or “rehabilitation” or “therapy”).

#### **(i) Inclusion Criteria**

- (1) Studies including participants diagnosed with stroke
- (2) Studies with an experimental group and a control group design
- (3) Studies applying task-oriented interventions
- (4) Studies presenting upper limb function as the primary outcome
- (5) Studies conducted in hospital settings
- (6) Studies published in English

#### **(ii) Exclusion Criteria**

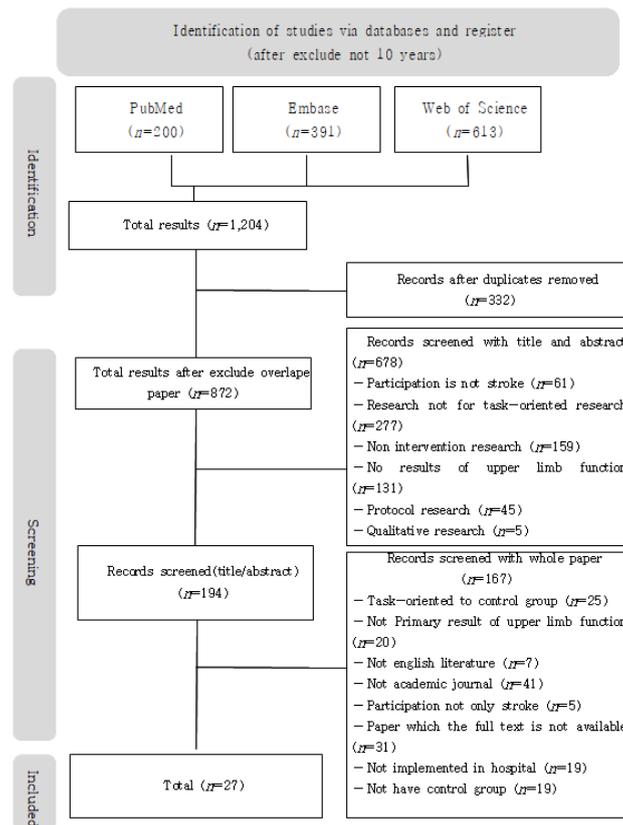
- (1) Studies in which task-oriented interventions were applied only to control group
- (2) Theses, dissertations, books, and study protocols
- (3) Conference proceedings, abstracts, and posters
- (4) Single-design studies, systematic reviews, and meta-analyses
- (5) Studies for which full-text access was unavailable

### **2.2 Study Selection Process**

The study selection process followed the PRISMA 2020 flow diagram guidelines [19]. Literature collection and screening were independently conducted by two occupational therapists holding master’s degrees. After removing duplicate records, titles and abstracts were initially screened to exclude studies that did not align with the purpose of this review. Subsequently, full-text articles were assessed to determine eligibility based on the inclusion criteria, and studies meeting the exclusion criteria were removed.

A total of 1,204 studies were identified through the database search. After removing 332 duplicate records, 872 studies remained. Following title and abstract screening, 678 studies were excluded due to irrelevance to the research topic. The full texts of 194 studies were assessed for eligibility, and 161 studies were excluded for the following reasons: task-oriented intervention applied only to the control group ( $n = 25$ ), upper limb function not considered as the primary outcome ( $n = 20$ ), non-English publication ( $n = 7$ ), not published in peer-reviewed journals ( $n = 41$ ), inclusion of participants with neurological conditions other than stroke ( $n = 5$ ),

unavailable full text ( $n = 31$ ), studies not conducted in hospital settings ( $n = 19$ ), and lack of a control group comparison ( $n = 19$ ). Ultimately, 27 studies were included in the final analysis (Figure 1).



**Figure 1: Flow Diagram of Manuscript Selection**

### 2.3 Data Analysis

To assess the methodological quality of the included studies, the Critically Appraised Topic (CAT) framework proposed by Arbesman (2008) was applied[20]. The proportion of randomized controlled trials (RCTs) relative to the total number of included studies was identified to represent the overall level of evidence. Additionally, the following characteristics of the included studies were analyzed: type of stroke, intervention providers, intervention types and methods, and outcome measures used to evaluate intervention effectiveness.

## III. RESULT

### 3.1 Methodological Quality of the Included Studies

Of the total 27 studies analyzed, 22 studies (81.4%) were classified as Level I evidence, consisting of randomized controlled trials (RCTs). Five studies (18.6%) were classified as Level II evidence, comprising case-control studies. No studies were classified as single-group studies, single-subject designs, or case studies, as the inclusion criteria required studies to include a control group.

### 3.2 Types and Methods of Task-Oriented Intervention

Analysis of stroke onset stages revealed that studies targeting patients in the acute and subacute phases were the most prevalent, accounting for 19 studies. Five studies included participants in the chronic phase, while three studies included individuals with stroke regardless of onset stage.

Intervention approaches were heterogeneous across studies. Ten studies implemented task-oriented training alone in the experimental group, whereas 17 studies applied task-oriented interventions in combination with other therapeutic modalities. Among these combined interventions, electrical stimulation therapy was the most frequently used ( $n = 6$ ), followed by mirror therapy ( $n = 3$ ), robotic therapy ( $n = 3$ ), virtual reality (VR) therapy ( $n = 2$ ), a combination of robotic and VR therapy ( $n = 1$ ), vibration therapy ( $n = 1$ ), and range-of-motion exercise therapy ( $n = 1$ ).

Regarding intervention providers, occupational therapists were involved in the majority of studies ( $n = 16$ ), followed by physical therapists ( $n = 7$ ). One study involved collaborative intervention by both occupational and physical therapists, while three studies reported interventions delivered by rehabilitation therapists.

Analysis of intervention dosage revealed that a session duration of 60 minutes was most common (n = 9), followed by 30-minute sessions (n = 8). In terms of weekly frequency, interventions were most frequently administered five times per week (n = 21), followed by six times per week (n = 5), and five to six times per week (n = 1). The most common intervention duration was one month (n = 12), followed by 1.5 months (n = 6). Overall, hospital-based task-oriented intervention studies most commonly applied a dosage of 60 minutes per session, five sessions per week, over a one-month period.

Analysis of studies published between 2015 and 2019 revealed that task-oriented intervention alone was the most frequently investigated approach (n=5). The next was task-oriented intervention combined with electrical stimulation therapy (n=4). In addition, one study combined task-oriented intervention with vibration therapy (n=1), and one study combined it with robotic therapy (n=1).

In contrast, analysis of studies published between 2020 and 2025 demonstrated a broader range of combined intervention approaches. Task-oriented intervention alone remained common (n = 5), while combinations with robotic therapy were reported in three studies (n = 3). Furthermore, task-oriented interventions combined with electrical stimulation (n = 2), virtual reality therapy (n = 2), and mirror therapy (n = 2) were identified. One study investigated a combination of robotic therapy and virtual reality therapy (n = 1), and another study examined task-oriented intervention combined with a telehealth-based intervention (n = 1).

### **3.3 Effects of Task-Oriented Interventions in Hospital Setting**

Upper limb function was most frequently assessed using the Fugl-Meyer Assessment–Upper Extremity (FMA-UE), which was employed in 21 studies. This was followed by the Wolf Motor Function Test (WMFT) in nine studies and the Action Research Arm Test (ARAT) in eight studies. Additional outcome measures included the Box and Block Test (BBT), Jebsen–Taylor Hand Function Test (JTT), Manual Function Test (MFT), grip strength, lateral pinch strength, hand dexterity assessments, the Motor Activity Log (MAL), and the Functional Test for the Hemiplegic Upper Extremity–Hong Kong version (FTHUE-HK).

The analysis of intervention effects revealed the following findings. In post-intervention comparisons between the experimental and control groups, 15 studies reported statistically significant differences across all outcome measures, while six studies reported significant differences in some measures only. Five studies reported no significant between-group differences, and one study did not report statistical comparisons. In within-group pre–post comparisons for the experimental groups, 22 studies reported significant improvements across all outcome measures, one study reported partial significant improvements, and four studies did not report statistical analyses. In contrast, pre–post comparisons within the control groups showed significant improvements across all outcome measures in 16 studies, partial improvements in four studies, no improvements in three studies, and no reported statistical analyses in four studies. A total of 12 studies demonstrated statistically significant changes in both between-group comparisons and within-group pre–post comparisons in the experimental groups.

## **IV. Discussion**

This systematic review aimed to identify research trends and intervention characteristics of task-oriented interventions for improving upper extremity function in hospitalized stroke patients by analyzing controlled studies comparing experimental and control groups. The included interventions were categorized into task-oriented intervention alone and combined task-oriented interventions with electrical stimulation, robotic therapy, virtual reality therapy, vibration therapy, or mirror therapy. Intervention effects were examined through between-group comparisons and within-group pre–post analyses. Among the included studies, twelve reported statistically significant improvements in both between-group and within-group comparisons, indicating the overall effectiveness of task-oriented approaches in enhancing upper extremity function.

Among the 27 selected studies, the majority targeted patients in the acute and subacute phases of stroke. This trend likely reflects the hospital-based rehabilitation environment, where minimizing impairments and promoting early functional recovery are primary goals, and where upper extremity–focused task-oriented interventions are frequently implemented[21],[22]. Most interventions were delivered by occupational therapists, with a typical dosage of 60 minutes per session, five sessions per week. This aligns with the professional role of occupational therapists, who facilitate functional recovery through meaningful, activity-based interventions[23]. Notably, studies employing a dosage of 60 minutes per day, five times per week consistently demonstrated significantly greater improvements compared with control groups, suggesting that this intervention intensity may be sufficient to elicit meaningful functional gains.

Regarding intervention type, combined task-oriented interventions were more prevalent than task-oriented intervention alone. This finding is consistent with previous research indicating that multimodal interventions produce greater therapeutic effects than single-modality approaches[13]. Among combined interventions, electrical stimulation was most frequently integrated with task-oriented training. Electrical stimulation facilitates muscle activation and neuromuscular recruitment, which may enhance motor performance during task execution, thereby producing

synergistic effects when combined with task-oriented practice[24]. Robotic therapy was the second most commonly used adjunct intervention. Robotic systems enable high-intensity, repetitive, and task-specific practice, which is essential for promoting neuroplasticity in stroke rehabilitation. Moreover, robotic assistance supports movement execution during task-oriented activities, facilitating motor learning and functional recovery[25].

A temporal analysis revealed that from 2015 to 2019, most studies focused on task-oriented intervention alone or in combination with electrical stimulation. In contrast, since 2020, there has been a marked increase in studies incorporating virtual reality and robotic therapy. This trend likely reflects rapid technological advancements and increased clinical adoption of digital rehabilitation technologies. For example, the robotic system used in the study by Hsieh et al. (2017) primarily assisted gross motor movements such as wrist pronation, supination, flexion, and extension[26]. In contrast, more recent robotic devices developed after 2020 often adopt glove-based designs that facilitate fine motor control and finger movements. This shift suggests an evolution from robotics targeting proximal or gross motor assistance toward devices supporting fine motor function and dexterity in task-oriented rehabilitation.

In hospital-based settings, combined task-oriented interventions demonstrated more consistent and robust effects than task-oriented intervention alone. This suggests that integrating sensory- or technology-based modalities—such as robotic therapy, electrical stimulation, and virtual reality—into task-oriented practice may generate synergistic therapeutic effects. Previous studies have similarly reported superior outcomes with combined interventions compared with single interventions in improving upper extremity function[13],[27], and the present findings further support this conclusion. Nevertheless, significant pre–post improvements were also observed in control groups receiving task-oriented intervention alone, indicating that task-oriented practice itself remains an effective therapeutic approach for promoting functional recovery.

Before 2019, most combined intervention studies demonstrating significant effects employed electrical stimulation[28],[29],[30],[31], highlighting its effectiveness in facilitating muscle activation and improving upper extremity motor performance in stroke patients. Since 2020, however, an increasing number of studies have reported positive effects from combining task-oriented training with advanced technologies such as robotic and virtual reality systems[32],[33],[34],[35],[36],[37]. Prior evidence supports the beneficial effects of robotic and virtual reality interventions on upper extremity motor recovery after stroke[38],[39]. These findings suggest that technology-assisted task-oriented rehabilitation may further enhance motor outcomes by providing augmented feedback, intensive repetition, and movement assistance.

#### **4.1 Limitations**

This study has some limitations. First, all included studies were published in English and conducted outside of the local context, which may limit cultural generalizability. Because task-oriented interventions may vary depending on cultural preferences for daily activities and functional tasks, future reviews should include studies published in diverse languages and cultural contexts. Second, only three databases were searched, which may have restricted the comprehensiveness of the literature retrieval. Third, although intervention effectiveness was identified, effect sizes were not calculated, limiting the ability to quantitatively compare intervention magnitude. Future studies should conduct meta-analyses to estimate pooled effect sizes and directly compare intervention efficacy across modalities. Despite these limitations, the present findings suggest that task-oriented interventions combined with electrical stimulation, robotic therapy, or virtual reality are effective approaches for improving upper extremity function in hospitalized stroke patients. Accordingly, the implementation of combined task-oriented interventions is recommended in clinical practice.

### **V. CONCLUSION**

This systematic review analyzed 27 controlled studies investigating task-oriented interventions for improving upper extremity function in stroke patients. Intervention types included task-oriented intervention alone and combined interventions with electrical stimulation, robotic therapy, virtual reality therapy, vibration therapy, and mirror therapy. From 2015 to 2019, task-oriented interventions combined with electrical stimulation were most frequently investigated and demonstrated favorable outcomes. Since 2020, an increasing number of studies have focused on robotic and virtual reality–based combined interventions, with consistently positive effects reported.

These findings suggest that integrating task-oriented training with electrical stimulation or advanced rehabilitation technologies may enhance upper extremity functional recovery in hospital-based stroke rehabilitation settings. Future research should further quantify intervention effectiveness through meta-analytic approaches and explore optimal intervention dosage, modality combinations, and patient subgroup responsiveness.

### **REFERENCES**

- [1]. Korean Disease Control and Prevention Agency, Stroke, 2020.
- [2]. Omar NH, Mohd Nordin NA, Chai SC, Abdul Aziz AF, Functionality among stroke survivors with upper limb impairment attending community-based rehabilitation, *Medical Journal of Malaysia*, Volume 75(2), 2020, 146–151.

- [3]. Raghavan P, Upper limb motor impairment post stroke, *Physical Medicine and Rehabilitation Clinics of North America*, Volume 26(4), 2015, 599.
- [4]. English C, Manns PJ, Tucak C, Bernhardt J, Physical activity and sedentary behaviors in people with stroke living in the community: A systematic review, *Physical Therapy*, Volume 94(2), 2014, 185–196.
- [5]. Legg LA, Lewis SR, Schofield-Robinson OJ, Drummond A, Langhorne P, Occupational therapy for adults with problems in activities of daily living after stroke, *Cochrane Database of Systematic Reviews*, Volume 7, 2017.
- [6]. Lee JY, Chang HK, Relations of stroke literacy, health literacy, stroke knowledge, and self-management among middle-aged and older adults, *Journal of the Korea Academia-Industrial Cooperation Society*, Volume 21(12), 2020, 719–730.
- [7]. Kim HH, Kim KM, Chang MY, Interventions to promote upper limb recovery in stroke patients: A systematic review, *Korean Journal of Occupational Therapy*, Volume 20(1), 2012, 129–145.
- [8]. Bhalla N, Shergill N, Comparison of task oriented therapy and modified constraint induced movement therapy along with functional electrical stimulation to improve hand function in sub acute stroke survivors: A randomized control trial, *Indian Journal of Physiotherapy and Occupational Therapy*, Volume 14(4), 2020, 84–90.
- [9]. Hussain M, Fatima A, Ahmad A, Gilani SA, Effects of task oriented rehabilitation of upper extremity after stroke: A systematic review, *Journal of the Pakistan Medical Association*, Volume 72, 2022, 1406–1415.
- [10]. Song GB, The effects of task-oriented versus repetitive bilateral arm training on upper limb function and activities of daily living in stroke patients, *Journal of Physical Therapy Science*, Volume 27(5), 2015, 1353–1355.
- [11]. Thant AA, Wanpen S, Nualnetr N, Puntumetakul R, Chatchawan U, Hla KM, Khin MT, Effects of task-oriented training on upper extremity functional performance in patients with sub-acute stroke, *Journal of Physical Therapy Science*, Volume 31(1), 2019, 82–87.
- [12]. Chua LK, Jimenez-Diaz J, Lewthwaite R, Kim T, Wulf G, Superiority of external attentional focus for motor performance and learning: Systematic reviews and meta-analyses, *Psychological Bulletin*, Volume 147(6), 2021, 618–645.
- [13]. da Silva ESM, Ocamoto GN, Santos-Maia GLD, Padovez RF, Trevisan C, de Noronha MA, et al., The effect of priming on outcomes of task-oriented training for the upper extremity in chronic stroke, *Neurorehabilitation and Neural Repair*, Volume 34(6), 2020, 479–504.
- [14]. Hussain M, Fatima A, Ahmad A, Gilani SA, Effects of task oriented rehabilitation of upper extremity after stroke: A systematic review, *Journal of the Pakistan Medical Association*, Volume 72, 2020, 1406–1415.
- [15]. Lee CY, Howe TH, Effectiveness of activity-based task-oriented training on upper extremity recovery for adults with stroke: A systematic review, *American Journal of Occupational Therapy*, Volume 78(2), 2024.
- [16]. Park SK, Lee JS, Task-oriented approaches to improve upper limb functions and activities of daily living in stroke patients: Systematic review and meta-analysis, *Korean Journal of Occupational Therapy*, Volume 29(1), 2021, 53–69.
- [17]. Winstein CJ, Wolf SL, Dromerick AW, Lane CJ, Nelsen MA, Lewthwaite R, et al., Effect of a task-oriented rehabilitation program on upper extremity recovery following motor stroke, *JAMA*, Volume 315(6), 2016, 571–581.
- [18]. Hu J, Zou J, Wan Y, Yao Q, Dong P, Li G, et al., Rehabilitation of motor function after stroke: A bibliometric analysis of global research from 2004 to 2022, *Frontiers in Aging Neuroscience*, Volume 14, 2022.
- [19]. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al., The PRISMA 2020 statement: An updated guideline for reporting systematic reviews, *BMJ*, Volume 372, 2021.
- [20]. Arbesman M, Scheer J, Lieberman D, Using AOTA's critically appraised topic and critically appraised paper series to link evidence to practice, *OT Practice*, Volume 13(5), 2008, 18–22.
- [21]. Müller M, Strobl R, Grill E, Goals of patients with rehabilitation needs in acute hospitals, *Journal of Rehabilitation Medicine*, Volume 43(2), 2011, 145–150.
- [22]. Rosewilliam S, Sintler C, Pandyan AD, Skelton J, Roskell CA, Is the practice of goal-setting for patients in acute stroke care patient-centred, *Clinical Rehabilitation*, Volume 30(5), 2016, 508–519.
- [23]. American Occupational Therapy Association, Occupational therapy practice framework: Domain and process, *American Journal of Occupational Therapy*, Volume 74, 2020.
- [24]. Khan MA, Fares H, Ghayvat H, Brunner IC, Puthusserypady S, Razavi B, et al., Functional electrical stimulation based rehabilitation systems for upper limb post-stroke recovery, *Frontiers in Neurology*, Volume 14, 2023.
- [25]. Wu J, Cheng H, Zhang J, Yang S, Cai S, Robot-assisted therapy for upper extremity motor impairment after stroke, *Physical Therapy*, Volume 101(4), 2021.
- [26]. Hsieh YW, Wu CY, Wang WE, Lin KC, Chang KC, Chen CC, et al., Bilateral robotic priming before task-oriented approach in subacute stroke rehabilitation, *Clinical Rehabilitation*, Volume 31(2), 2017, 225–233.
- [27]. Zai W, Xu N, Wu W, Wang Y, Wang R, Effect of task-oriented training on gross motor function, balance and activities of daily living in children with cerebral palsy, *Medicine*, Volume 101(44), 2022.
- [28]. Carrico C, Chelette KC, Westgate PM, Powell E, Nichols L, Fleischer A, et al., Nerve stimulation enhances task-oriented training in chronic motor deficit after stroke, *Stroke*, Volume 47(7), 2016, 1879–1884.
- [29]. Carrico C, Westgate PM, Powell ES, Chelette KC, Nichols L, Pettigrew LC, et al., Nerve stimulation enhances task-oriented training for moderate-to-severe hemiparesis after stroke, *American Journal of Physical Medicine and Rehabilitation*, Volume 97(11), 2018, 808–815.
- [30]. Kim SH, Park JH, Jung MY, Yoo EY, Effects of task-oriented training added to neuromuscular stimulation in chronic stroke patients, *Occupational Therapy International*, Volume 23(2), 2016, 165–174.
- [31]. Kirac-Unal Z, Gencay-Can A, Karaca-Umay E, Cakki FA, Task-oriented electromyography-triggered electrical stimulation after stroke, *International Journal of Rehabilitation Research*, Volume 42(1), 2019, 74–81.
- [32]. Sabbah A, El Mously S, Elgendy HHM, Farag MAAE, Elwishi AAB, Functional outcome of joint mobilization added to task-oriented training, *Egyptian Journal of Neurology Psychiatry and Neurosurgery*, Volume 56(1), 2020.
- [33]. Chen L, Chen Y, Fu WB, Huang DF, Lo WLA, Effect of virtual reality on hand function in subacute stroke patients, *Neural Plasticity*, Volume 2022, 2022.
- [34]. Choi JB, Cho KI, Effects of virtual reality-based robot therapy combined with task-oriented therapy in stroke patients, *Medicine*, Volume 103(27), 2024.
- [35]. He YZ, Huang ZM, Deng HY, Huang J, Wu JH, Wu JS, Task-oriented mirrored robotic training in subacute poststroke patients, *European Journal of Physical and Rehabilitation Medicine*, Volume 59(6), 2023, 660–668.
- [36]. Li Y, Lian Y, Chen X, Zhang H, Xu G, Duan H, et al., Task-oriented training assisted by force feedback hand rehabilitation robot, *Journal of NeuroEngineering and Rehabilitation*, Volume 21(1), 2024.
- [37]. Liu Y, Li JH, Tao JY, Li YZ, Xiong H, Virtual reality combined with task-oriented circuit training in subacute stroke patients, *Medicine*, Volume 104(31), 2025.

- [38]. Kim WS, Cho S, Ku J, Kim Y, Lee K, Hwang HJ, et al., Clinical application of virtual reality for upper limb motor rehabilitation in stroke, *Journal of Clinical Medicine*, Volume 9(10), 2020.
- [39]. Veerbeek JM, Langbroek-Amersfoort AC, Van Wegen EE, Meskers CG, Kwakkel G, Effects of robot-assisted therapy for the upper limb after stroke, *Neurorehabilitation and Neural Repair*, Volume 31(2), 2017, 107–121.