The Existing of Supportive Technology Tools for Hand Motor-impaired User: A systematic Literature Review

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ABSTRACT

Diabetes Users who encounter physical and motor impairment persist in struggle to archive the target of performance in the form of hand gesture improvement. Hand gestures are allowed people to give a sign as a communicate medium and to hold, grip and pinch the object. The low ability of hands makes the movement or gesture limited and difficult for them to do the routine activity. This review aim to evaluate the effect of whether the existing supportive technology can assist the hand motor-impairment user. A total of 31 papers were identified and only 10 papers were selected in this review. In this paper, the existing supportive technology tools in the field of motor rehabilitation which is focused on hand motor-impaired users are reviewed. The existing of supportive technology for hand motor-impaired user is not a new field as the paper reviewed from 2014 until 2019. There are few innovations or initiatives from the previous research and study that give a positive effect on the users were identified. Future research is needed to further appreciate and improved the desired role of people with hands motor-impaired in meaningful technology development.

Keywords: *Effectiveness, Hand gesture, Motor-impaired user, Supportive technology*.

I. INTRODUCTION

Gestures are the movement of the body or hands to give a sign for people who have a motor-impaired problem for an example, deaf, mute, hand injured that causes the ability to pinch, grip and hold the object and etc. Freehand gestures allow other forms of input to improve the usability and performance of selection tasks [1]. Hand gestures recognition can be applied in many areas such as computer games, mobile games, home-based rehabilitation, education, robotics and recognition of children with autism.

Hand motor impairments may be viewed in two part which is a deficit in motor execution and in higher-order processes [2]. Basically, a deficit in motor execution happen from weakness, spasticity and abnormal synergies. Whilst, a deficit in higher-order processes lead to poorly formed sensorimotor associations that drive to impaired motor control. The treatments depend on the view taken. Motor-impairment is commonly assessed with disease-specific, subjectively scored and low-resolution scales, or occasionally with cumbersome marker-based motion capture [3]. Based on previous study, the hand motor-impaired involve stroke rehabilitation, Parkinson's disease and orthopedic rehabilitation.

In recent years, the combined use of wearable robotic systems and human-machine interfaces has been proposed as a tool for complementing and restoring impaired functions in users with motor disabilities [4]. Besides that, digital approaches to physical rehabilitation are becoming increasingly common and embedding these new technologies within a musical framework may be particularly motivating [5]. Every approaches have advantage and disadvantage towards the user. According from previous study, there are a few existing supportive technologies have been designed and developed to give an experience to the hand motor-impaired user. On the other hand, users who have the potential to show large performance improvements often have little or no experience with independent mobility and may need a significant amount of training before they can perform the test trials [6]. Therefore, the research and study has been conducted from previous researchers to determine whether the development of the supportive technology have assist the user to improve their functionality of hand gesture.

Furthermore, robots have been used for most clinical trials of robot-assisted movement training to physically assist the limbs of patients as they attempt desired movements and/or play computer-guided activities and games [7]. Thus, more supportive technology is needed in term of the usability of the application towards the user.

In this study, we will focus on the supportive technology for user who dealing with hand motor-impaired problem. This study aims to evaluate the effect of existing supportive technology to assist hand motor- impaired user.

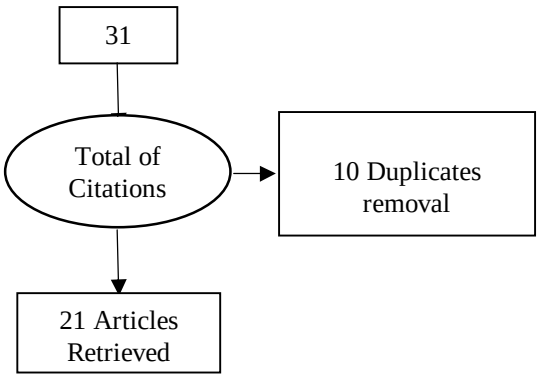
II. METHOD

Based on this review, the relevant papers were researched in SCOPUS, IEEE and Google Scholar as the reference materials. There are a few steps to follow for this systematic review paper. First, plan the systematic review and included the research question, the inclusion and exclusion criteria, the research strategy, the data collection instruments and method and criteria for the analysis of the results. The review question was: "What are the effects of existing supportive technology on hand motor-impaired user?" The criteria that has been considered of this review is the impact of supportive technology on user although it was contribute a small positive effect. Next, find the papers at the website document search by using a combination of keywords. For example, {'Supportive Technology} AND {'Hand Gesture OR Motor-impaired} AND {'Effectiveness}. The exploration was filtered to the year 2014-2019 as references to review. This is because to provide the review still relevant and up to date. From this step, the result for searching papers has been provided a lot and includes various areas.

The second step is to focus on the studies by filtering the title of research and the abstract. Papers that were not relevant to the research will be eliminated or excluded from the selection and vice versa. For an example of selected papers were the topic that relates to rehabilitation, hand gesture of motor-impaired, supportive technology, and the effect to user. As a result, the number from the searching papers reduced.

III. RESULT

A total of 31 relevant papers were identified. There are a few papers were excluded as they did not suitable for the topic. The Figure 1 shows the final sample for analysis has consisted of 10 papers which are the papers that were related to the idea of this topic.



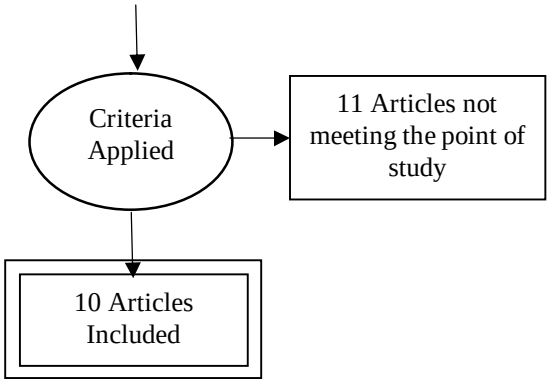


Fig. 1. Selection of study process

From the reviews, most studies had been conducted in Europe which is 15 studies [3-5, 8-19] followed by USA which is nine studies [2], [20-27], Korea [28, 29], and South East Asia [30-33] had been handled 3 studies respectively, while China has 2 studies [34, 35] and Turkey [36] and Brazil [37] and Japan [38] had one paper respectively. The papers had been published in the early 2000s until the present. The papers had been published in several journals that are from health, technology, and education. From several aspects, we can combine to be one topic that related to previous studies.

The previous study and investigation have shown that healthy and technology have close associated which means it important to help the user to improve or assist their daily routine. Another study that evaluates the augmented reality games as a supportive technology application that has been used for hand motor-impaired user [3], [15], [19], [28]. Besides that, there is a study that used another device which is exoskeleton technology for hand motor impaired users' [10], [4], [25], [27]. However, there are some studies that introduce an augmented reality technology has used for various category such as advertising, tourism and so forth [12], [23], [32], [33]. There also has studied the survey about an augmented reality that focused on education [20]. This is show that supportive technology for an augmented reality is applicable in many fields of studies but their focus is not relatable with the criteria of this review study.

According to the quality of methodologies of this review, the majorities of the studies focused on hands motor-impaired users' and the supportive technology that has been used in the studies respectively.[3, 8-10], [4], [15], [17], [18], [24-26, 28], [34], [35], [37].

The Table I display all the findings from the selected review paper. The result show that the existing of supportive technologies was considered to contribute a positive effect.

Table I. Synthesis of the research papers included the review

Paper	Objectives	Sample	Outcomes
Paper 1[27]	1)To determine the impact of repetitive task-specific practice (RTP) integrating electrical stimulation and behavioral supports on upper extremity (UE) impairment, gross manual dexterity, and paretic UE amount and quality of use in chronic stroke survivors exhibiting moderate, stable UE deficits.	9 persons who experienced a stroke.	The results suggest the integrate RTP regimen is a promising technique for increasing the amount and quality of UE movement in the moderately impaired stroke survivor population.
Paper 2 [10]	1)Evaluate in which order of magnitude AHSP may improve in sub-acute stroke patients with moderately to severely affected arm-hand. 2)Assess the clinical usability of the dynamic hand orthosis combined with electrical stimulation.	Eight sub-acute stroke patients	As the results, 75% of the sub-acute stroke patients improved on their capacity to use their affected arm in daily activities between the start of the training and follow-up. The improvements in arm-hand skill performance may also be attributable to other factors
Paper 3 [9]	Propose as an alternative a low-cost system for the automated assessment of the upper limb UPDRS tasks Finger Tapping (FT), Opening-Closing (OC), Pronation-Supination (PS) at home.	The PD upper limb motor tasks as specified by the Unified Parkinson's Disease Rating Scale (UPDRS)/ PD patients	A self-managed system for the automated assessment of Parkinson's disease at home is presented. The system interface allows gestural interactions with visual feedback, providing a system management suitable for motor impaired users in home monitoring of Parkinson's disease.
Paper 4 [35]	Evaluate the potential efficacy of intention-driven robot-assisted fingers training.	Participants (6 to 24 months post-stroke) were randomly assigned into two groups: robot-assisted (robot) and non-assisted (control) fingers training groups.	The potential efficacy of robot-assisted fingers training for hand and fingers rehabilitation and its feasibility to facilitate early rehabilitation for a wider population of stroke survivors; and hence, can be used to complement constraint-induced movement therapy (CIMT).
Paper 5 [4]	Evaluated the system from a neuroimaging perspective, showing that the device can elicit EEG brain patterns typical of natural hand motions.	Two users who suffered from spinal cord injuries.	The hand exoskeleton designed to assist and restore hand functions of people who suffered with motor disabilities during activities of daily living (ADL). The results showed that the device represents an ecological solution aimed at promoting sensorimotor recovery.

Paper	Objectives	Sample	Outcomes
Paper 6 [38]	Facilitate the use of the hemiparetic upper extremity (UE) in daily life by combining integrated volitional control electrical stimulation with a wrist splint.	Twenty patients with chronic hemiparetic stroke.	The combination between hand splint and volitional and electrically induced muscle contraction may offer promising option for the management of paretic UE in patients with stroke.
Paper 7 [3]	1) Evaluating the speed and goal-directedness of movements within the individually determined interaction space. 2) Adaptation of hand opening to objects of different sizes. 3) Obstacle avoidance in healthy individuals	10 patients with Parkinson's Disease and 10 stroke patients by implement three AR games to evaluate these key aspects of motor function.	The potential of patient tailored AR games for assessing motor impairments in patients with neurological conditions and provides starting points for further improvement. The rapid technical developments will lead to higher accuracy of contactless hand tracking and to improvements in some aspects.
Paper 8 [24]	Compare four different free hand gestures for pointing and selecting 2D targets on productivity, usability, preference, and comfort.	Eighteen participants evaluated four different ray-casting hand gestures and three snapback thresholds while selecting 2D targets of different sizes.	There were no significant differences between snapback thresholds on productivity, error or preference. However, there was a trend for shorter completion time, lower number of incorrect targets, and higher preference for more snapback when using the index click gesture.
Paper 9 [19]	Explore the potential of augmented reality (AR) using free hand and body tracking to develop engaging games for a uniform.	20 patients (10 Parkinson's Disease patients and 10 stroke patients)	The different sensors of devices have further improved of hand tracking and get a higher of the position of the joints. Video See-Through HMD have more precise alignment of the virtual hand with the real hand. Besides that, it provided the patients do not get dizzy while wearing it.
Paper 10 [15]	Evaluate potential interaction methods for motor-impaired individuals, specifically those who use wheelchairs.	A total of 18 wheelchair users participated	Augmented reality technology has the potential to be a useful tool for people with mobility impairments to encourage and support independence in their daily routines and activities.

IV. DISCUSSION

The person who is dealing with low or decrease the functionality of their hands al-ways had a difficult time to grip or hold the object. There are many reasons that cause hand motor-impaired to people. For example, stroke, accident, arthritis, and Parkinson's disease. From the reviews, there are a lot of researchers found out that there are a few supportive technology or therapy for them to increase their functionality of hand gestures.

Among the supportive technologies to assist hand motor-impaired user is exoskeleton. This technology has been studied by [35], [25], [4]. From their study, the device has been developed for stroke user. This disease remain the leading cause of severe long-term disabilities worldwide, with hemiplegia connected with abnormal muscle activation and coordination, muscle weaknesses,

spasticity, and loss of dexterity and precision being the major contributors to the disabilities [35], [22]. The device use to assist hands and fingers functions training. Based on the result, the user has showed better improvement of fingers dexterity. This show the device has promote positive effect such as pinching, grasping and do other natural hand motions. But due to several limitation, more training sessions should be considered in future studies.

The next supportive technology is electrical stimulation. Electrical stimulation is one such intervention that has the potential to improve motor outcomes and such, potentially lead to increased activity performance and participation after stroke [39]. This technology has been researched by [10]. From the study, the result has been displayed only little improvement in their capacity to perform daily activities for stroke patients, seem to benefit from training with a dynamic arm orthosis in combination with electrical stimulation. Although the result give a positive effect to the user, the future investigation is still need to obtain optimum recovery for hand motor-impaired user.

The other disease that involves the functionality of hand is Parkinson's disease. Parkinson's disease (PD) is a disease that has been categorized as a chronic neurodegenerative which gives impacts to motor functions [40]. The user who has been affected with PD were advised doing physical activity that allows them to improve the condition of the disease. The previous researcher has developed a self-managed system as a supportive technology for the automated assessment of the PD upper limb motor tasks. The system interface allows gestural interactions with visual feedback, providing a system management suitable for motor impaired users in home monitoring of Parkinson's disease [9]. Therefore, the result of this study shows a positive feedback where the technology used is effective to the user.

Besides that, the previous researcher has discovered augmented reality technology as a supportive technology tool to assist the hand performance. Augmented reality (AR) is a user interface technology in which a camera-recorded view of the real world is augmented with computer-generated content such as annotations, graphics, animations, and three-dimensional (3-D) models [29]. Much work over the past few decades has brought the use of virtual reality (VR) and augmented reality (AR) to the fields of gaming, rehabilitation, therapy, and skill training [26]. From the previous research, they found that AR games are more interesting than computer games plus this game required them to make a move to complete the task. It gives motivation to them to do exercises while playing the game. This exercise game concept gives the idea or inspiration for future investigation to make this innovation and initiative for the disabled person, especially those who encounter low functionality of hand motor-impaired. Another study has developed and designed an augmented reality for a motor-impaired user to evaluate their potential interaction [15]. This technology helps them to be more independent and motivate them as we know their struggle to obtain ability the performance of daily activities. Besides that, the user interface plays an important role as well. It gives an effect of the user's control and emotion that can be seen from the user's face will give the information needed to be considered in game development [30].

V. CONCLUSION

Different supportive technologies for different diseases have been discovered to help the user to improve the functionality of their movement especially their hand gestures. Nowadays there are so many alternative ways to increase the function of hands that they can do on their own at home or self-therapy. It can save cost, avoid the time constraints which is they no need to set an appointment with expert and it is user-friendly. However, they still need to consult with the expert if they have a problem. Nevertheless, more evidence and alternative are needed regarding the positive feed-back from the patient according to the application or technology that assist them to recover or enhance their capacity of the movement.

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REFERENCES

[1] Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., MacIntyre, B.J.I.c.g., and applications: "*Recent advances in augmented reality*", 2001, 21, (6), pp. 34-47

[2] Raghavan, P.: "*The nature of hand motor impairment after stroke and its treatment*", Current treatment options in cardiovascular medicine, 2007, 9, (3), pp. 221-228

[3] Bank, P.J.M., Cidota, M.A., Ouwehand, P.E.W., and Lukosch, S.G.: "*Patient-Tailored Augmented Reality Games for Assessing Upper Extremity Motor Impairments in Parkinson's Disease and Stroke*", J Med Syst, 2018, 42, (12), pp. 246

[4] Randazzo, L., Iturrate, I., Perdikis, S., and Millan, J.d.R.: "*mano: A Wearable Hand Exoskeleton for Activities of Daily Living and Neurorehabilitation*", IEEE Robotics and Automation Letters, 2018, 3, (1), pp. 500-507

[5] Kirk, P., Grierson, M., Bodak, R., Ward, N., Brander, F., Kelly, K., Newman, N., and Stewart, L.: "*Motivating Stroke Rehabilitation Through Music*". Proc. Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI '162016 pp. Pages

[6] Zeng, Q., Burdet, E., Teo, C.L.J.N., and repair, n.: "*Evaluation of a collaborative wheelchair system in cerebral palsy and traumatic brain injury users*", 2009, 23, (5), pp. 494-504

[7] Reinkensmeyer, D.J., and Boninger, M.L.: "*Technologies and combination therapies for enhancing movement training for people with a disability*", Journal of neuroengineering rehabilitation 2012, 9, (1), pp. 17

[8] Bachmann, D., Weichert, F., and Rinkenauer, G.: "*Review of Three-Dimensional Human-Computer Interaction with Focus on the Leap Motion Controller*", Sensors (Basel), 2018, 18, (7)

[9] Ferraris, C., Nerino, R., Chimienti, A., Pettiti, G., Cau, N., Cimolin, V., Azzaro, C., Albani, G., Priano, L., and Mauro, A.: "*A Self-Managed System for Automated Assessment of UPDRS Upper Limb Tasks in Parkinson's Disease*", Sensors (Basel), 2018, 18, (10)

[10] Franck, J.A., Smeets, R., and Seelen, H.A.M.: "*Evaluation of a functional hand orthosis combined with electrical stimulation adjunct to arm-hand rehabilitation in subacute stroke patients with a severely to moderately affected hand function*", Disabil Rehabil, 2019, 41, (10), pp. 1160-1168

[11] Harborth, D., and Pape, S.: "*Exploring the Hype: Investigating Technology Acceptance Factors of Pokémon Go*". Proc. 2017 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)2017 pp. Pages

[12] Martínez-Graña, A., Goy, J., González-Delgado, J., Cruz, R., Sanz, J., Cimarra, C., and de Bustamante, I.: "*3D Virtual Itinerary in the Geological Heritage from Natural Areas in Salamanca-Ávila-Cáceres, Spain*", Sustainability, 2018, 11, (1)

[13] Montero, A., Zarraonandia, T., Diaz, P., and Aedo, I.: "*Designing and implementing interactive and realistic augmented reality experiences*", Universal Access in the Information Society, 2017, 18, (1), pp. 49-61

[14] Pantano, E., and Gandini, A.: "*Exploring the forms of sociality mediated by innovative technologies in retail settings*", Computers in Human Behavior, 2017, 77, pp. 367-373

[15] Rashid, Z., Pous, R., and Norrie, C.S.: "*An independent shopping experience for wheelchair users through augmented reality and RFID*", Assist Technol, 2019, 31, (1), pp. 9-18

[16] Siekański, P., Michoński, J., Bunsch, E., and Sitnik, R.: "*CATCHA: Real-Time Camera Tracking Method for Augmented Reality Applications in Cultural Heritage Interiors*", ISPRS International Journal of Geo-Information, 2018, 7, (12)

[17] Vaitkevičius, A., Taroza, M., Blažauskas, T., Damaševičius, R., Maskeliūnas, R., and Woźniak, M.: "*Recognition of American Sign Language Gestures in a Virtual Reality Using Leap Motion*", Applied Sciences, 2019, 9, (3)

[18] Ibrahim, Z., and Money, A.G.: "*Computer mediated reality technologies: A conceptual framework and survey of the state of the art in healthcare intervention systems*", J Biomed Inform, 2019, 90, pp. 103102

[19] Cidota, M.A., Lukosch, S.G., Bank, P.J.M., and Ouwehand, P.W.: "*Towards Engaging Upper Extremity Motor Dysfunction Assessment Using Augmented Reality Games*". Proc. 2017 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct)2017 pp. Pages

[20] Billinghurst, M.: "*Augmented reality in education*", New horizons for learning, 2002, 12, (5), pp. 1-5

[21] Borrel, A., and Fourches, D.: "*RealityConvert: a tool for preparing 3D models of biochemical structures for augmented and virtual reality*", Bioinformatics, 2017, 33, (23), pp. 3816-3818

[22] Dobkin, B.H.: "*Strategies for stroke rehabilitation*", The Lancet Neurology, 2004, 3, (9), pp. 528-536

[23] Lee, K.: "*The Future of Learning and Training in Augmented Reality*", 2012, 7, pp. 31-42

[24] Lin, J., Harris-Adamson, C., and Rempel, D.: "*The Design of Hand Gestures for Selecting Virtual Objects*", International Journal of Human–Computer Interaction, 2019, pp. 1-7

[25] Triolo, E.R., Stella, M.H., and BuSha, B.F.: "*A force augmenting exoskeleton for the human hand designed for pinching and grasping*". Proc. 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)2018 pp. Pages

[26] Wiederhold, M.D., Crisci, M., Patel, V., Nonaka, M., and Wiederhold, B.K.: "*Physiological Monitoring During Augmented Reality Exercise Confirms Advantages to Health and Well-Being*", Cyberpsychol Behav Soc Netw, 2019, 22, (2), pp. 122-126

[27] Page, S.J., Levine, P.G., and Basobas, B.A.: '*"Reps" Aren't Enough: Augmenting Functional Electrical Stimulation With Behavioral Supports Significantly Reduces Impairment in Moderately Impaired Stroke*', Arch Phys Med Rehabil, 2016, 97, (5), pp. 747-752

[28] Ku, J., Kim, Y.J., Cho, S., Lim, T., Lee, H.S., and Kang, Y.J.: "*Three-Dimensional Augmented Reality System for Balance and Mobility Rehabilitation in the Elderly: A Randomized Controlled Trial*", Cyberpsychol Behav Soc Netw, 2019, 22, (2), pp. 132-141

[29] Laine, T.H., and Suk, H.J.: "*Designing Mobile Augmented Reality Exergames*", Games and Culture, 2016, 11, (5), pp. 548-580

[30] Ahmad, I., Abdullasim, N., Suaib, N.M.J.I.J.o.E., and Technology: "*Usability Testing on Game Interface Design using Video-based Behavior Analysis*", 2018, 7, (2.15), pp. 142-145

[31] Hou, H.-T., and Lin, Y.-C.: "*The Development and Evaluation of an Educational Game Integrated with Augmented Reality and Virtual Laboratory for Chemistry Experiment Learning*". Proc. 2017 6th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI)2017 pp. Pages

[32] Nazri, N.I.A.M., Rambli, D.R.A., and Tomi, A.: "*A mobile augmented reality game design approach for on product advertising*". Proc. Proceedings of the 12th International Conference on Advances in Computer Entertainment Technology - ACE '152015 pp. Pages

[33] Tahyudin, I., and Surya Saputra, D.I.: "*A Response Analysis of Mobile Augmented Reality Application for Tourism Objects*", International Journal of Electrical and Computer Engineering (IJECE), 2017, 7, (6)

[34] Chen, P., Hu, Y., and Yang, F.: "*A conformal geometric algebra method for virtual hand modeling and interaction*", EURASIP Journal on Image and Video Processing, 2018, 2018, (1)

[35] Susanto, E.A., Tong, R.K., Ockenfeld, C., and Ho, N.S.: "*Efficacy of robot-assisted fingers training in chronic stroke survivors: a pilot randomized-controlled trial*", J Neuroeng Rehabil, 2015, 12, pp. 42

[36] Akçayır, M., and Akçayır, G.: "*Advantages and challenges associated with augmented reality for education: A systematic review of the literature*", Educational Research Review, 2017, 20, pp. 1-11

[37] Guarnieri, R., Crocetta, T.B., Massetti, T., Barbosa, R.T.A., Antao, J., Antunes, T.P.C., Hounsell, M.D.S., Monteiro, C.B.M., Oliveira, A.S.B., and Abreu, L.C.: "*Test-Retest Reliability and Clinical Feasibility of a Motion-Controlled Game to Enhance the Literacy and Numeracy Skills of Young Individuals with Intellectual Disability*", Cyberpsychol Behav Soc Netw, 2019, 22, (2), pp. 111-121

[38] Fujiwara, T., Kasashima, Y., Honaga, K., Muraoka, Y., Tsuji, T., Osu, R., Hase, K., Masakado, Y., Liu, M.J.N., and repair, n.: *"Motor improvement and corticospinal modulation induced by hybrid assistive neuromuscular dynamic stimulation (HANDS) therapy in patients with chronic stroke"*, 2009, 23, (2), pp. 125-132

[39] Howlett, O.A., Lannin, N.A., Ada, L., and McKinstry, C.: "*Functional electrical stimulation improves activity after stroke: a systematic review with meta-analysis*", Arch Phys Med Rehabil, 2015, 96, (5), pp. 934-943

[40] Pal, G., and Goetz, C.G.J.F.i.n.: "*Assessing bradykinesia in parkinsonian disorders*", 2013, 4, pp. 54