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Preventing Foot Drop and Venous Thrombosis While Maintaining Muscle Function in a Portable Orthosis

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Keywords

orthosis, foot drop, venous thrombosis, Muscle contraction.

Abstract

Background: Intensive care is the treatment of patients who are suffering from illnesses that pose a significant risk to their lives. These patients are looked after by the most highly trained medical professionals using the most cutting-edge medical technology and services. Intensive care encompasses all aspects of protocol that are associated with the patient's natural life. Foot drop, deep vein thrombosis, atrophy, and diminished muscular strength are among possible problems that might arise from being hospitalized in a distinctive ward. The goal of this research is to find ways to treat foot drop, deep vein thrombosis, muscle atrophy, and a decrease in overall muscular endurance. Methods: The heading and presentation of the assignment were developed with input from the director after a review of scholarly journals and books yielded the starting point. After that, a prototype of the gadget was created in corporation with the graphic and mechanical engineers at Fianccy. The engineers themselves came up with the proper equipment. Results: The findings of the current research as well as the findings of other studies would be one of the most efficient methods to avoid ankle foot drop, the distortion of the toes, muscular atrophy, enhance blood circulation from the bottom towards the top, monitor heart rhythm, and preserve the endurance of the foot muscles. This research was conducted in the conjunction with other studies. Furthermore, utilizing orothesis might lessen it greatly. Moreover, it is advised to make adjustments to the preventative measures, such as the production of equipment (e.g., portable orthosis).Conclusion:This system is a cost-effective strategy, and by using this device, it is possible to prevent the occurrence of the mentioned problems so that patients do not suffer from secondary problems.

1. Introduction

The World Health Organization (WHO) considers wellness to be the scientific knowledge of disease control, the availability of healthcare systems for early recognition, therapy, and promotion in order to solve challenges. The provision of a risk-free environment for patients is among the highest priorities of healthcare outcomes (1). As a result, the precision and efficiency of therapy, as well as patient happiness, are all enhanced when the standard of service is raised (2). Hospitalization is the medical treatment of patients who are suffering from conditions that pose a significant risk to their

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lives. This kind of care is administered by highly trained medical professionals using cutting-edge technology and infrastructure, and it encompasses all aspects of protocol that are directly connected to the human body (3-4). The treatment method puts a lot of work into providing the finest services possible to its patients while still keeping costs reasonable. Intensive care units (ICUs) have a special position in the medical system because of the enormous human and monetary expenditures they may impose (5-6). Patients who have issues like diabetic ketoacidosis, hypertensive illness, non-incidental self-poisoning, heart failure, ischemic heart illness, cerebrovascular illness, and respirational disorders might be highlighted (7-8-9). Countless investigations have been conducted to determine the reasons contributing to the rising death rates of patients hospitalized in intensive care units. Death rates in intensive care units are impacted by a variety of conditions, including bacterial distress, advanced time of life, smoking, and nosocomial poisons (10-11). The death rate of new cases admitted to intensive care units in UK hospitals was around 20.6%, according to a thorough survey of those facilities (12), whereas the risk of dying of the same patients in Singapore medical centers was 9.4%(13). An estimated 20–30% of stroke survivors experience foot drop; thus approximately 240,000– 360,000 people might be living with it in the UK alone (27). Foot drop, deep vein thrombosis, and muscular atrophy are just some of the difficulties that might arise from being hospitalized in the Intensive Care Unit. It is estimated that VTE-related conditions like deep vein thrombosis (DVT) and pneumothromboendarterectomy (PTE) cause 250000 hospitalizations annually in the US. But then again, between one hundred and fifty thousand individuals are admitted to hospitals annually owing to a non-life-threatening condition that can be treated, but these patients end up dying from thromboembolism, albeit their deaths may be avoided with preventative measures (18).Patients are more likely to get this condition if they are sedentary or have a history of paralysis, malignancy, a myocardial infarction, respirational failure, surgical procedure, distress, fatness, or a blood clotting issue passed down through the family (19). "Foot drop" is an additional issue that might arise when a patient is hospitalized. People with foot drop or prolapse cannot complete the dorsiflexion joint function effectively because their frontal tibialis muscle or further muscles arising from the peroneal nerve are underdeveloped or paralyzed. Foot drop may affect either one or both feet simultaneously. When this problem occurs, it can occasionally be accompanied by symptoms like discomfort, lethargy, and tingling (20). Medical assessment is all that is required to make an easy identification of this problem; however, using such scanning tools and electromyography may also be helpful in gaining a more in-depth understanding of this issue (21). There are a variety of therapies currently available for the management of foot drop, and taking into account the underlying reason for this problem is necessary in order to choose the most effective therapeutic strategy. Some of the most shared dealings for foot drop are physiotherapy, electrotherapy, and teaching. These are also some of the treatments that can be used to prevent and fix foot drop with ankle foot orthoses (22). Additional risks of a stay in the healthcare setting comprise muscular atrophy (15), bed sores, and other such things. Another strategy to avoid and lessen difficulties in healthcare settings is to develop and employ a mobile orthosis that may minimize foot prolapse and deep vein thrombosis while also maintaining muscular contraction, given the desired study. What follows is an examination of its underlying framework. This concept has been licensed with the Iranian Patent Organization with the number 103769.

2. Methods

A novel research concept served as the impetus for the creation of this project. Because of this research, the project's subject and proposal were drafted with the help of the advisor's input. The device's layout was afterwards created in partnership with graphic and mechanical experts Fianccy. The primary instrument was created by the investigator. With the help of a mechanical engineer and Solid works software, the design of this instrument with specialized software with academic-theoretical proposal scientists(Mahmoudi et al) about making a tool to stop foot drop, distortion of toes, muscles atrophy, development of blood coming back from distal to proximal body parts and preserve the function of vain valves, the evaluation of heart rhythm and retain the power of foot solid muscles

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and inhibition from muscels atrophy. This concept was conceptualized via software, and the resulting design data was then brought to the laboratory by a researcher and a mechanical engineer for use in hardware development and maquette creation. Orthotic structures were debated in terms of their morphology from every viewpoint, as well as their standardization in figure measuring, and were then recreated using software experts when these parameters had changed once again. This portable orthosis, which is capable of averting foot drop, maintaining the action of the vain valve, and evaluating the patient's symptoms, is fabricated by a variety of various components, including the following: mechanical lock (3×2 cm), body (40 cm length), pulse sensor (0.5× 0.5 cm), pulse oximeter sensor (0.5× 1 cm), inflatable inner layer R (12 cm), outer layer R (15 cm), electrical message transmitter leads (R: 1cm), insole (25 cm), removable hinge (R: 2cm), connector between internal layer and air pump (R:2 cm). Once the foot has been correctly located (positioned) inside the orthosis, the top and bottom portions are mechanically linked together (see Fig. 1-2). A cable separates the viewscreen from the orthosis and connects it to the first detachable hinge (see Fig. 7-11) to allow foot movement within its range of motion (ROM). An on-screen application will do all canonical foot movements (dorsal flexing, sole flexing, invertion, and overtion) by selecting every single action. A signal will be conveyed to the detachable hinge (see Fig. 3-11) through a wire, and using shifting the orthosis, the foot will travel in the intended way and given the instruction that was provided to the software. The foot holds the appropriate stance for the allotted amount of time, which in this case is five seconds, before returning to its original position. The four foot motions (foot's dorsal flexing, foot's sole flexing, invertion, and overtion) are performed by a code that is stored on the panel database using a detachable hing. This code also determines the length of time spent performing every single foot motion, the number of periods it is performed, and the duration of foot rest that is required before the robot does the subsequent foot motion. Initially, a removable tiny air compressor (see Fig. 6-1) that is currently on the market is linked to the connection between air compressor (see Fig. 2-4) and expandable internal layer (see Fig. 3-8) using an air tube. Whilst also transferring air from compressor to expandable internal layer, the operation of inflation, and thereafter emptying, actually occurs. This is done so as to avoid deep vein thrombosis (DVT) and preserving the performance of the one-way valve. Obviously, the frequency and force of the airflow are both determined by the screen (see Fig. 2-6), which itself is located on the compressor's core (see Fig. 6-1) and is applied with the foot; this results in the normal atmospheric pressure of 17 mm Hg being applied to the one-way valve. It does so by ensuring continuity, so aiding cardiovascular system, and preventing a decline in the performance of one-way valves.

Additionally, wiring connections (see Fig. 1-3) are linked to the required place (see Fig. 5-5) by means of a wire. It creates electrical currents in muscles and avoids muscular failure and atrophy following linking to tennes machine (impulse producer engine) via creating shocks. Voltage intensity, length of muscle stimulation, and number of stimulations are regulated and conducted through a monitor (see Fig. 5-2), thus activities are planned. The number of dorsal pedis pulses are detected and displayed on the monitor in accordance with the placement of the detector in the top section of the orthosis (see Fig. 4-10). As demonstrated in Fig. 4-9, a pulse oximeter detector may also be used to display an individual's level of oxygen level on a monitor. Muscle contraction, atrophy, and foot drop are all decreased thanks to adjustable orthosis as well as structural and muscular electrotherapy. This has the effect of preserving valve performance, and the quantity of oxygen level is examined using a dorsal pedis pulse detector as well as a pulse oximeter sensor. Furthermore, it has the potential to reduce the incidence and mortality rates associated with a wide range of illnesses.

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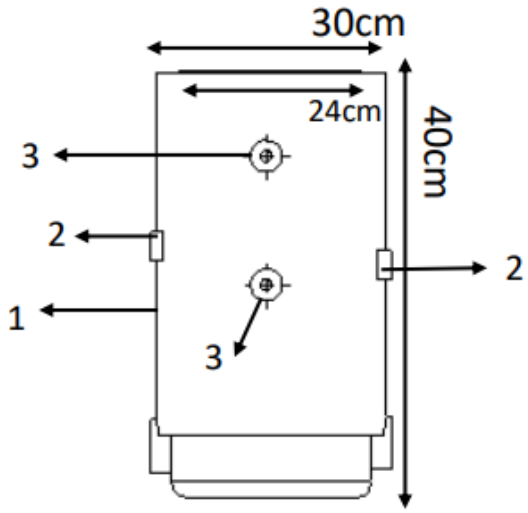

Figure 1

In keeping with Figure 1:

1-Orthotic body

2-Power-driven padlock

3- Electrical leads

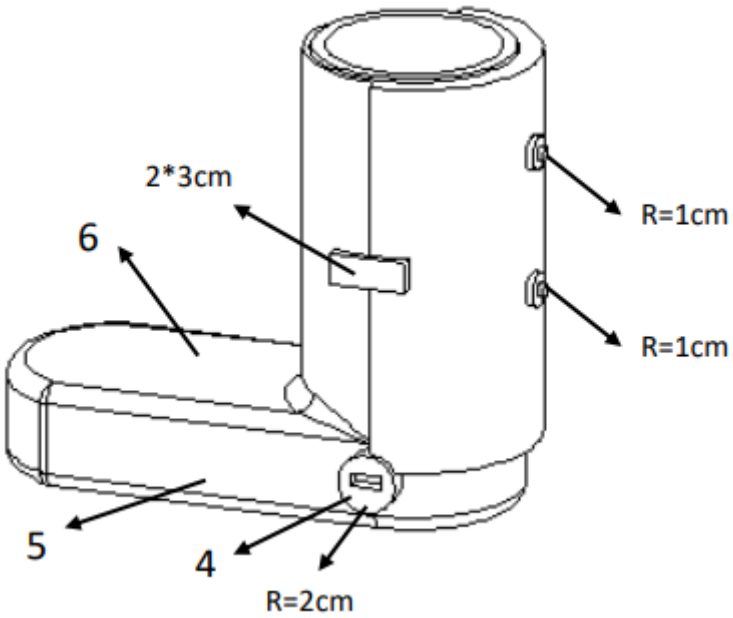

Figure 2

In keeping with Figure 2:

4- Connector

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5- Orthotics insole

6-Upper part of orthosis

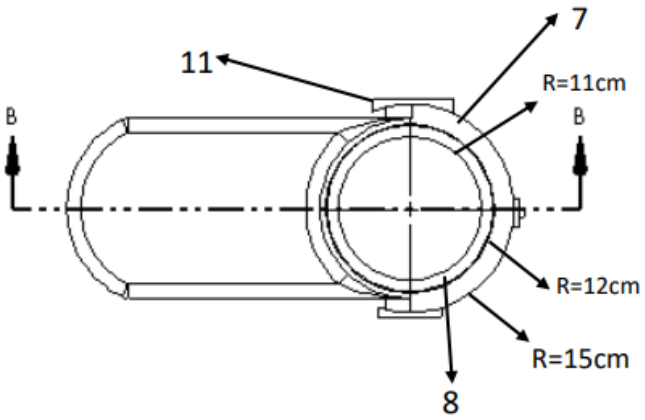

Figure 3

In keeping with Figure 3:

7- external layer of orthosis

8- internal layer of orthosis

11- Portable hinges

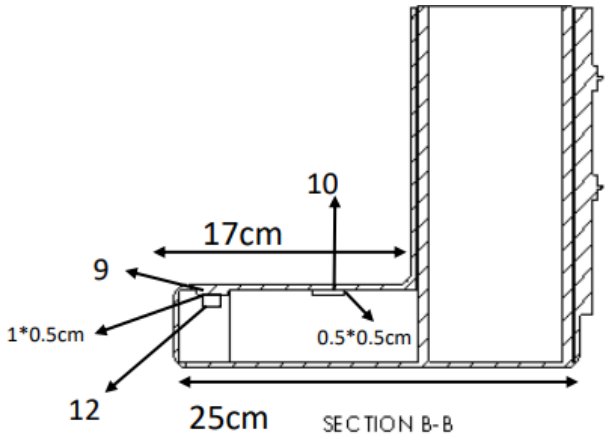

Figure 4

In keeping with Figure 4:

9- pulse Oximeter detector

10- Pulse detector

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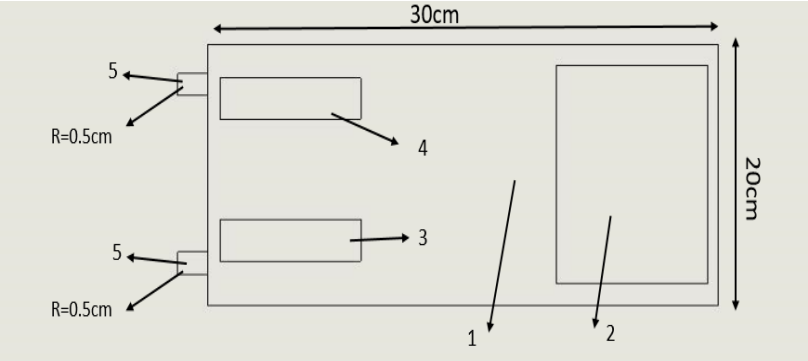

Figure 5

In keeping with Figure 5:

1- Tens devices

2- LCD

3- Power on

4- Power off

5- Wire connection position

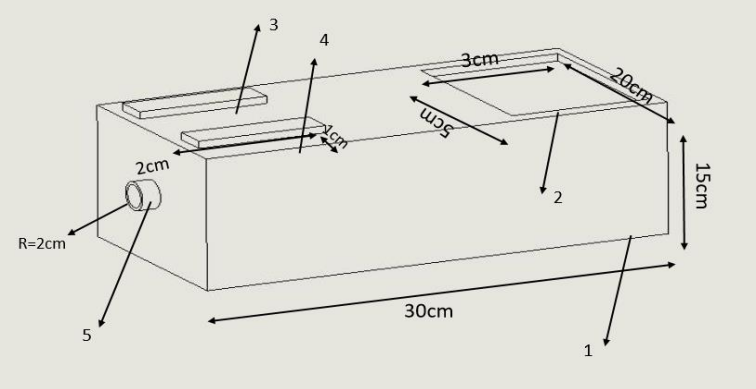

Figure 6

In keeping with Figure 6:

1- Air compressor
2- LCD
3- Power on
4- Power off
5- Joint with interface

3. Discussion

This investigation has been carried out in the health care science and clinical procedure. Given the size of the foot drop and Deep vein thrombosis while delivering hospital attention, using preventative tools is necessary to avoid this issue. In order to avoid ankle foot drop, distortion of toes, muscular

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atrophy and enhance cardiac output from the lowest to the highest, this device develops a new structure to keep track of heart rhythm and preserve the power of the muscular endurance. Shifting the foot in four directions (the rear flexing of the foot and the sole flexing of the foot, inverting, and monitoring) is one of the benefits of such a design. Other benefits consist of the aptitude to organize the number and duration of actions, monitor heart rhythm in, minimize the decrease of contractility muscle, prevent blood stagnation in the lower limbs, and avoid atrophy and muscle loss. According to the research of Mahmoudi et al (2021) (26), Preventive devices have been presented as one of the ways to prevent the disease.Besides, on the basis of several research projects conducted by Esfandiari et al. (2017) (23), Alnajar et al. (2020) (24), Prenton et al. (2018) (25), and this research, it is proposed that the use of preventative tools be used in order to avoid ankle foot drop, toe distortion, muscular atrophy, boosting cardiac output from the lowest to the highest and preserving pigeonhole valve function, as well as evaluating heart rhythm and keeping leg muscular endurance.

4. Results

Preventing ankle foot drop, toe distortion, muscular atrophy, improving cardiac output from the lowest to the highest extremities, monitoring heart rhythm, and maintaining foot muscular endurance may be one of the most efficient strategies to use the findings of this and other studies. It may be considerably reduced by employing orothesis as well. Furthermore, altering preventative strategies such as creating equipment such as removable orthoses is advocated. We are willing to collaborate with all organizations and people in the domains of the economy, teaching, science, healthcare, and entrepreneurship for this initiative. If you prefer, you can reach us at masoudmahmoudi515@ymail.com.

5. Conclusion

Patients suffer from foot drop which is one of the side effects of long hospitalization, if they hospitalize for long time and failure to provide proper care by medical team. Many people suffer from foot drop that causes secondary problems in patients (27). Ways to treat and prevent foot drop in hospitals are using retaining boards, physiotherapy, medications, orthosis and brace. However, the best way to prevent this problem is prevention. Using orthosis and AFO to prevent this problem has been effective based on researchers and their results (28-29). In this article we presented primary sample to prevent foot drop, blood stasis in lower organs and keep muscle`s contraction, which is through a device, which is like an orthosis and Tens device, inflatable engine that prevent this side effect. This system can easily be put on the market and be used as a prevention from mentioned side effects instead of common methods.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Refrences

[1] Marin HF. Improving Patient Safety with Technology. Int JMed Inform 2004; 73(7-8): 543-546.

[2] Armstrong KJ, Laschinger H. Structural empowerment, magnet hospital characteristics, and patient safety culture: making the link. Journal of Nursing Care Quality 2006; 21(2): 124-32.

[3] Abbasi S, Mahjobipoor H, Kashefi P, Massumi G, Aghadavoudi O, Farajzadegan Z, et al. The effect of lidocaine on reducing the tracheal mucosal damage following tracheal intubation. J Res Med Sci 2013; 18(9): 733-8.

[4] Zandieh M, Falehgari G, Salavsti M, Borzoo SR. Study of applying proposed infection control standards in ICU. J Shahrekord Univ Med Sci. 2005;6.

[5] Kahn JM, Angus DC. Reducing the cost of critical care: new challenges, new solutions. Am J Respir Crit Care Med. 2006;174(11):1167-8. DOI: 10.1164/rccm. 200609-1388ED PMID: 17110650.

[6] Affolter RH, Groves S, Betterton WJ, Benzel W, Conrad KL, Swanson SM, et al. Geochemical database of feed coal and coal combustion products (CCPs) from five power plants in the United States. US Geological Survey Data Series. 2011;635.

ISSN: 2309-5288 (Print)
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Journal of Coastal Life Medicine

[7] Downing H, Scott C, Kelly C. Evaluation of a dedicated short-stay unit for acute medical admissions. Clin Med (Lond) 2008;8(1):18–20.

[8] James NJ, Hussain R, Moonie A, Richardson D, Waring WS. Patterns of admissions in an acute medical unit: priorities for service development and education. Acute Med 2012;11(2):74–80.

[9] Kellett J, Deane B. The diagnoses and co-morbidity encountered in the hospital practice of acute internal medicine. Eur J Intern Med 2007;18(6):467–73.

[10] Garkaz O, Taghdir M, Sepandi M. The Analytical study of the Main Causes of Mortality of Patients in the ICU Section of the Selected Military Hospital between 2012 - 2017. hrjbaq. 2019; 4 (3) :129-136. URL: http://hrjbaq.ir/article-1-340-fa.html.

[11] Khan U, Menezes CN, Govind N. Patterns and outcomes of admissions to the medical acute care unit of a tertiary teaching hospital in South Africa. Afr J Emerg Med. 2021 Mar;11(1):26-30. doi: 10.1016/j.afjem.2020.11.006. Epub 2020 Dec 8. PMID: 33318914; PMCID: PMC7725673.

[12] Singer M, Little R. ABC of intensive care: Cutting edge. BMJ. 1999;319(7208):501-4.

[13] 13 Lim BL, Chan YW. Audit of 2431 admissions to the surgical intensive care unit, Singapore hospital. Ann Acad Med Singapore. 1998;27(3):314-7.

[14] Mahjobipoor H, Rahimi-Varposhti M, Shetabi H, Heidari S. Predictive factors of deep vein thrombosis in patients admitted to intensive care unit. Tehran Univ Med J. 2021; 78 (12) :828-834.
URL: http://tumj.tums.ac.ir/article-1-11067-fa.html

[15] ZAND SOLEYMAN, RAFIEI MOHAMMAD. CAUSES AND DURATION OF HOSPITALIZATION AND MORTALITY RATE IN INTENSIVE CARE UNITS IN CENTRAL PROVINCE. IRANIAN JOURNAL OF CRITICAL CARE NURSING (IJCCN). 2010 [cited 2021September24];3(2):63-67. Available from: https://www.sid.ir/en/journal/ViewPaper.aspx?id=176991.

[16] McLeod AG, Geerts W: Venous thromboembolism prophylaxis in critically ill patients. Crit Care Clin 2011;27(4):765–780.

[17] Sharif-Kashani B, Mohebi-Nejad A, Abooturabi SM. Estimated prevalence of venous thromboembolism in Iran: Prophylaxis still an unmet challenge. Tanaffos 2015;14(1):27.

[18] Gordon RJ, Lombard FW. Perioperative venous thromboembolism: a review. Anesth Analg 2017;125(2):403-12.

[19] Spyropoulos AC, Anderson Jr FA, FitzGerald G, Decousus H, Pini M, Chong BH, et al. Predictive and associative models to identify hospitalized medical patients at risk for VTE. Chest 2011;140(3):706-14.

[20] Deberg L, Taheri Andani M, Hosseinipour M, Elahinia M. An SMA passive ankle foot orthosis: Design, modeling, and experimental evaluation. Smart Materials Research. 2014; 1–11. doi: 10.1155/2014/572094

[21] Lamkin-Kennard K. Design of a pneumatically actuated robotic assist device for patients with foot drop [PhD dissertation]. Rochester: Rochester Institute of Technology; 2010.

[22] Bosch PR, Harris JE, Wing K. Review of therapeutic electrical stimulation for dorsiflexion assist and orthotic substitution from the American congress of rehabilitation medicine stroke movement interventions subcommittee. Arch Phys Med Rehabil. 2014;95(2):390–6.

[23] Esfandiari E, Arazpour M, Saeedi H, Ahmadi A. [Literature Review of the Effect of Ankle-Foot Orthosis on Gait Parameters After Stroke (Persian)]. Archives of Rehabilitation. 2017; 18(2):164-179.
http://dx.doi.org/10.21859/jrehab-1802160.

[24] Gil-Castillo, J., Alnajjar, F., Koutsou, A. *et al.* Advances in neuroprosthetic management of foot drop: a review. *J NeuroEngineering Rehabil* **17,** 46 (2020). https://doi.org/10.1186/s12984-020-00668-4.

[25] Prenton S, Hollands KL, Kenney LPJ, Onmanee P. Functional electrical stimulation and ankle foot orthoses provide equivalent therapeutic effects on foot drop: A meta-analysis providing direction for future research. J Rehabil Med. 2018 Feb

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CODEN: JCLMC4
Journal of Coastal Life Medicine

13;50(2):129-139. doi: 10.2340/16501977-2289. PMID: 29227525.

[26] Mohammad Masoud Mahmoudi, Asghar karbord, Amirhossein Jafari Yeganeh, Parastoo Ghadamabadi, and Mahyar Mahmoudi. Invent a safe Anti Needle stick Protector Device, J. New Medical Innovations and Research, 2(3): DOI: 10.31579/jnmir/012.

[27] Nori SL, Stretanski MF. Foot Drop. 2022 Apr 21. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan–. PMID: 32119280.

[28] Prenton S, Hollands KL, Kenney LPJ, Onmanee P. Functional electrical stimulation and ankle foot orthoses provide equivalent therapeutic effects on foot drop: A meta-analysis providing direction for future research. J Rehabil Med. 2018 Feb 13;50(2):129-139. doi: 10.2340/16501977-2289. PMID: 29227525.

[29] Intercollegiate Stroke Working Party. National clinical guidelines for stroke. Fifth edition. London: Royal College of Physicians (RCP). 2016 [cited 2017 Feb 24]. Available from:https://www.strokeaudit.org/SupportFiles/Documents/Guidelines/2016-National-Clinical-Guideline-forStroke-5t-(1).aspx.