

Classification and Review of Neck Rehabilitation Devices

Sarah-Maria MAREȘ

Transilvania University of Brasov, Romania, sarah.mares@unitbv.ro

Andrea DEACONESCU

Transilvania University of Brasov, Romania, deacon@unitbv.ro

Abstract

The aim of this study is to provide a general insight into the causes that lead to cervical spine disorders and different types of pathologies of the neck joint, while also providing insight into how the respective condition can be ameliorated or even treated. For the scope of this study, the only treatment methods considered were the ones using rehabilitation devices based on different types of equipment, as opposed to classic methods, such as kinesiotherapy. Where available, a comparison between the two is provided. To create a clearer picture of the different types of rehabilitation devices, a classification method is introduced, which is based on the following aspects: the interaction of the device with the patient, the type of actuation and its stiffness. Different examples are also provided along with available specifications. Furthermore, the study compiles data on the development of rehabilitation devices, emphasises the effectiveness and adaptiveness of said devices, and highlights the importance of additional research in this field.

Keywords

neck rehabilitation equipment, electrical devices, neck disorders

1. Introduction

The cervical spine, located in the neck area, is known for its role in providing balance to the body. Among the most well-known pathologies, considered to be the main ones affecting the neck joint, are: acute and chronic neck pain, fractures, cervical postural syndrome, nerve root pain/cervical radiculopathy, torticollis and whiplash. All these have different causes. For example, acute or chronic neck pain is due to muscle spasms or strains, and torticollis has a similar cause. Cervical fractures can occur from car accidents or falls to the ground, and whiplash is also due to car accidents, while cervical postural syndrome is caused by poor posture.

According to the latest studies in the field, it was found in 2019 that neck pain occurs in 27 cases per 1000 inhabitants, with the most cases reported in Norway and Finland (6151.2 and 5750.3 cases per 100,000 inhabitants). It was also shown that women had more incidents involving neck pain, and the number of years they lived with disabilities was higher compared to men [1].

The neck joint allows motions in the three anatomical planes: frontal, sagittal and transverse, as shown in Figure 1. The angular amplitudes of these motions are presented in Table 1.

Noticeably, the neck joint is highly complex. Each of the numerous muscles involved has a specific role in moving and stabilizing this joint. The rehabilitation procedures of this joint have to address the motor state (muscle tonus), the sensorial state (proprioception) as well as the patient's psycho-social and professional status.

Dysfunctionalities caused by trauma to the neck joint have a high rate of functional recovery, and thus allow for a swift reintegration of patients into everyday professional or home life. The development of effective methods of therapy has improved the duration of recovery and reduced the failure rate of treatment. A significant role in achieving swift patient recovery is the deployment of dedicated equipment for the rehabilitation of the very complex neck joint.

Repetitive movements are known to have a positive impact on improving muscle force and motion coordination in patients with neurological and/or orthopaedic disorders. In the case of manual rehabilitation, the performance is difficult to quantify, and the physical therapist's assessment of patient progress during sessions is often subjective. This is one of the reasons for deploying mechanized methods in physical recovery therapy.

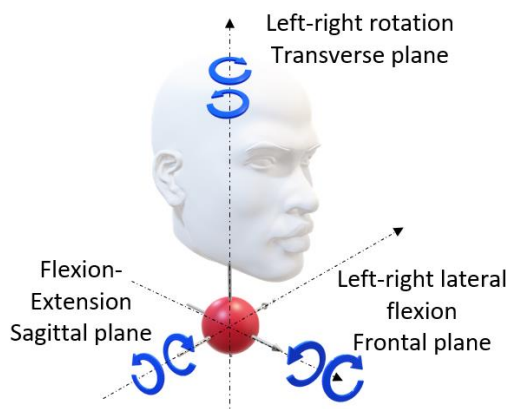


Fig. 1. Motions of the biomechanical model of the neck joint

Table 1. Motions and motion limits of the neck

	Motions	Angular limits
Sagittal plane	Flexion	50°
	Extension	60°
Frontal plane	Lateral flexion to the left	45°
	Lateral flexion to the right	45°
Transverse plane	Rotation to the left	80°
	Rotation to the right	80°

An alternative for manual rehabilitation is robot-assisted recovery. Robotic rehabilitation systems allow the exact measurement of various parameters, like duration of the exercise, forces, torques, etc. Thus, these systems allow an objective evaluation of patient progress. Because of the interaction with humans, the concept of such robots has to meet a set of requirements completely different from industrial robots that operate in structured environments. These requirements include safety, conformity, gentle and easy deployment.

Further on a review is presented of the main neck joint rehabilitation devices currently available on the marketplace.

2. Rehabilitation Equipment

Both neck pain and cervical spine problems are dysfunctions that affect the patient's life, regardless of their cause. For this reason, in recent years, more and more equipment has been developed to eliminate or reduce neck pain. The equipment is made either for use by patients, at home, or in specialist clinics under the guidance of a physiotherapist.

2.1. Jaw occipital belt traction rehabilitation devices

This type of equipment, as the name suggests, is based on rehabilitation through the cervical traction method. This method has proven effective over the years, and currently the best options are being researched in order to make a better rehabilitation possible, depending on the patient's position. According to Wong et al. [2], the use of the sitting and the inclined position was compared so that their impact on the patient could be observed, measuring the anterior and posterior intervertebral position, demonstrating that the inclined position could lead to a better result than the one in sitting position.

Such equipment can be observed in Figure 2, available in various, merely slightly different variants, the power source being a reduction motor. At this time, no detailed information was found on the manufacturer's website. Articles based on the use of this equipment are also not available.

2.2. "TENB" (Traction Exercise Neck Brace) devices

This type of equipment is used to improve the curvature of the cervical spine and helps to eliminate neck pain. The advantage of using this equipment is that the traction angle is aligned with the direction

of the traction force due to maintaining the position of the head and neck at 20° anteflexion. This stage, whereby the head and the neck are stabilized before and after using the equipment, can be observed in Figure 3. A wide variety of equipment of this kind is available on the marketplace, made by different manufacturers, but they are not different from a functional point of view. The operating principle of the equipment relies on the stabilization of the neck, after which the pulling movement is performed repeatedly for a period of time. This is described in Figure 2.



Fig. 2. Example devices for jaw occipital belt traction [3]

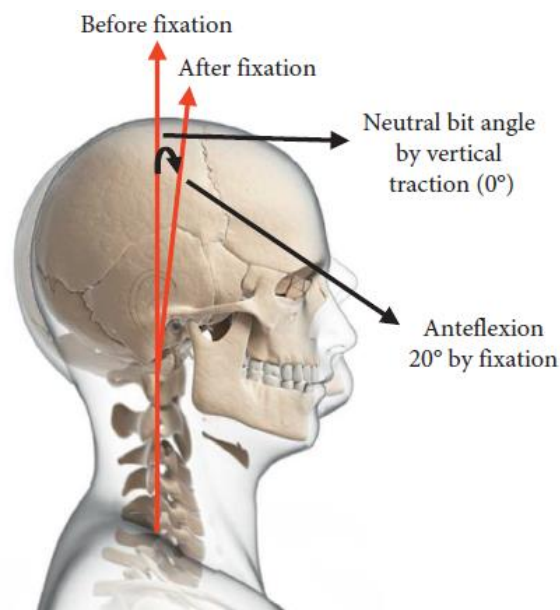


Fig. 3. Operation of TENS [4]

This type of equipment has the advantage that it can also be used at home, and the price is affordable, being much easier to purchase, compared to the previously described equipment. In patients diagnosed with cervical spondylotic radiculopathy (CSR), it has been shown that the use of this type of equipment alleviates the compression of the nerve root, and it contributes to the relaxation of the neck and shoulder muscles, according to article [4].

2.3. “MCU (Multi-Cervical Unit)” devices

Compared to the previously presented pieces of equipment, this type of device (Figure 4) is used for rehabilitation in all three existing planes, thus performing flexion, extension, rotation and lateral flexion.

What differentiates this type of equipment from those described previously is that it can only be used under the guidance of a physiotherapist, in a special rehabilitation center.



Fig. 4. Example of equipment use [5]

This electrically actuated equipment has been improved over the years, being discussed in various research papers that have demonstrated its effectiveness. One of them pointed out that according to the collected data, it was concluded that a ten-week use of the MCU equipment achieved a greater increase in the isometric strength of the muscles in the cervical area compared to the use of Thera-Band strips for the same period [6].

The advantage of this equipment is that it has software installed that ensures a good traceability of each individual patient's evolution, by saving the values obtained for each patient and relating them to the reference values.

2.4. "Necks level" devices

In recent years, a new patented product has appeared [7], shown in Figure 5, which puts forward a new rehabilitation method. It has the advantage of being usable even at home by the patient, without the need for the physiotherapist's follow-up, and it has an affordable price.

This equipment has a different functionality compared to the rest of the equipment available on the marketplace, because it uses a mechanical traction method by supporting the patient's head on a slide.

Based on "Necks level" a device called "Pro Clinic Bundle" [8] was developed, shown in Figure 6. It consists of the combination of two devices, the „NecksLevel Glide Pro" and the special support for fastening on the walls.

The benefit of purchasing such equipment is that it offers training videos conceived by a clinician, as well as the explanation of the protocols of the equipment in video format, so that it can be used by patients at home. Furthermore, it can be used in all motion planes, and the resistance bands offer different levels from 0.5 kg up to 3.7 kg, according to the technical data of the equipment [9].



Fig. 5. The patented "Necks level" equipment with an example of operation [9]



Fig. 6. "Pro Clinic Bundle" device; example of using the device [8]

2.5. Pneumatic devices

While the previously presented equipment is driven either manually or, in most cases, electrically, another rehabilitation equipment variant that we looked at was the one with pneumatic actuation. There are extremely few pieces thereof available, since this kind of equipment is rather at the prototype level. Kolar D.K. et al. discuss in [10] the development and improvement of a pneumatically operated cervical traction equipment (Figure 7). The improved traction equipment around the neck deploys a pneumatic cylinder. Its novelty is the possibility of controlling the air pressure in the device. That is, even by applying pressure on one side of the person's neck with unilateral traction, it can be rotated, so that the patient can control the amount of traction required. This newly developed equipment was analyzed on an age group of 21- to 45-year-old patients. The study points out that the new traction equipment is easier to handle and much more comfortable, and can be used to treat conditions such as cervical spondylosis, cervical disc bulges and cervical compression syndrome.

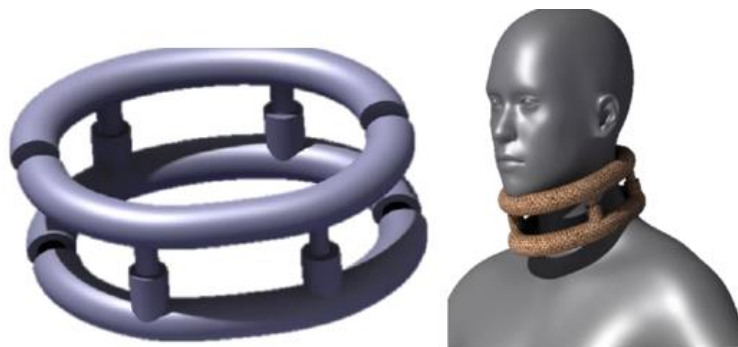


Fig. 7. Example of use of pneumatically operated equipment [10]

Various models of cervical collars produced by different manufacturers are available on the marketplace, all of them functionally similar. Two such examples are the Twinkleepoch cervical traction device fitted with an electric air pump (Figure 8) [11], and the “Ludwig Katrin” cervical brace (Figure 9) [12], respectively. The role of these pneumatic device is to fix the cervical spine and ensure its vertical elongation.



Fig. 8. Twinkleepoch cervical traction device [11]



Fig. 9. “Ludwig Katrin” cervical brace [12]

3. Conclusion

The main purpose of this paper was to present the equipment available on the marketplace that helps treating various pathologies in the neck area. Research has shown that these conditions are treatable with existing rehabilitation devices, which play an important role in returning the patient to a normal life. The development of the devices used for the neck area has seen many advances from one year to the next, due to the development of new methods which make it possible to improve the rehabilitation method and the ease of use of the equipment.

Further research is needed in the development of pneumatically driven rehabilitation devices in order to obtain a better care device that the patient can use in everyday life. Moreover, the development of pneumatically operated rehabilitation devices used in the rehabilitation of different parts of the human body, such as the limbs, demonstrates that these kinds of equipment can offer a better alternative to the classic ones.

References

1. Kazeminasab S., Nejadghaderi S.A., Amiri P. et al. (2022): *Neck pain: global epidemiology, trends and risk factors*. BMC Musculoskelet Disord, ISSN 1471-2474, Vol. 23, art. 26, <https://doi.org/10.1186/s12891-021-04957-4>
2. Wong L.K.F., Luo Z., Kurusu N. (2014): *Dynamic Simulation of Cervical Traction Therapy: Comparison between Sitting and Inclined Positions*. IEEE International Conference on Robotics and Biomimetics (ROBIO 2014), ISBN 978-1-4799-7397-2, pp. 167-172, DOI: 10.1109/ROBIO.2014.7090325
3. http://www.xiangyumedical.com/product/74/#c_portalResProduct_list-16570875030279884-1
4. Xiao L.X., Liu C.S., Zhong S.Z., Huang W.H. (2021): *Effect of a Traction Exercise Neck Brace on Cervical Spondylopathy Radiculopathy: A Clinical Study and Finite Element Analysis*. Evidence-Based Complementary and Alternative Medicine, eISSN 1741-4288, Vol. 2021, Art. ID 8825150, <https://doi.org/10.1155/2021/8825150>
5. Salo P.K., Häkkinen A.H., Kautiainen H., Ylinen J.J. (2010): *Effect of neck strength training on health-related quality of life in females with chronic neck pain: a randomized controlled 1-year follow-up study*. Health and Quality of Life Outcomes, eISSN 1477-7525, Vol. 8, is. 1, art. 48, <https://doi.org/10.1186/1477-7525-8-48>
6. Burnett A., Naumann F., Price R., Sanders R. (2005): *A comparison of training methods to increase neck muscle strength* Work. WORK: A Journal of Prevention, Assessment & Rehabilitation, eISSN 1875-9270, Vol. 25, is. 3, pp. 205-210, <https://ro.ecu.edu.au/ecuworks/2802>

7. Dickenson S. (2023): *Physical therapy device*. Patent US 11,547,902 B2, <https://worldwide.espacenet.com/patent/search?q=Physical%20therapy%20device%2C%20Dickenson>
8. Pro Clinic Bundle – NecksLevel
9. <https://neckslevel.com/?srsltid=AfmBOoplNFlh5DUrdG4BvfjyYu60e38jangEOujwIB2fZZ6GFj1JlMb> (Premium neck strengthening for neck pain & posture)
10. Kolar D.K., Tejas G., Raju Bahubalendruni R.V.A. (2020): *Design and Development of a Novel Pneumatic Cervical Traction Device*. International Journal of Performability Engineering, eISSN 2993-8341, Vol. 16, is. 4, pp. 520-527, <https://www.ijpe-online.com/EN/10.23940/ijpe.20.04.p3.520527>
11. <https://m.media-amazon.com/images/I/71k8Co9B49L.SL1500.jpg> (Twinkleepoch Cervical Neck Traction Device with Electric Air Pump, Neck Pain Relief and Relaxation)
12. <https://www.red-dot.org/project/ludwig-katrin-58478> (Neck Support-Ludwig Katrin. Manufacturer: Guangzhou New-Design Biotechnology Co., Ltd., Guangzhou, China)