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*Titolo articolo / Article title:*

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*Autori / Authors:* Cristina Turco, Sara Zago, Marianna Cavinato.

*Pagine / Pages:* 38-57, N.2, Vol.7 - 2023
***Submitted***: 17 May 2023 – ***Revised:*** 8 July 2023 – ***Accepted***: 27 October 2023 – ***Published***: 20 December 2023

*Contatto autori / Corresponding author:* Cristina Turco,

cristina.turco451@gmail.com



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OPEN ACCESS JOURNAL
http://www.ojs.unito.it/index.php/jbp
ISSN 2532-7925

Journal of Biomedical Practitioners
JBP

A Scientific, Technical and Professional Practice Journal for Biomedical Practitioners

# Neurophysiology Technologist in neurorehabilitation and scientific research: an observational study of employment on the Italian national territory.

**Cristina Turco[1], Sara Zago[2], Marianna Cavinato[3]**

[1] *Azienda Ospedaliero - Universitaria Città della Salute e della Scienza di Torino, Torino (TO)*

[2] *IRCCS San Camillo Hospital, Lido di Venezia (VE)*

[3] *Unità di Riabilitazione, Dipartimento di Neuroscienze, Università di Padova, Padova (PD)*

Corresponding author: Cristina Turco – cristina.turco451@gmail.com - ORCID: 0000-0002-0736-4443

N. 2, Vol. 7 (2023) – 38:57
Submitted: 17 May 2023
Revised: 8 July 2023
Accepted: 27 October 2023
Published: 20 December 2023

Think green before you print

## ABSTRACT

### Introduction

The professional figure of the Neurophysiology Technologist (TNFP) has always been related to the diagnostic field. However, the number of technologists employed in the scientific research, or in the neurorehabilitation field, is increasing. Indeed, there are various brain stimulation methods used for neurorehabilitation which can be performed by the TNFP (repetitive Transcranial Magnetic Stimulation - rTMS, transcranial Direct Current Stimulation – tDCS). Furthermore, different recording techniques (Magnetoencephalography - MEG, high density Electroencephalogram - hd-EEG, BCI) allow this professional figure to be included in the field of scientific research.

### Objective

This study aims to know the current state of employment of Italian TNFP in the neurorehabilitation and scientific research.

### Materials and Methods

A questionnaire was distributed via e-mail by the Neurophysiology Technologists Registry (TSRM PSTRP Orders) and by the Italian Association of Neurophysiology Technologists (AITN) throughout the national territory.

### Results

49 of the 91 TNFP participants of the study, carry out activities in neurorehabilitation and/or scientific research. The largest number of participants, 19 out of 49 (39%) is employed in public facilities; the most frequent type of contract is permanent employment (32 technologists out of 49). When asked about the training they received, 13 respondents out of 49 reported that their current place of employment did not provide an adequate training, 21 that they had limited training, 10 considered their training as sufficient, 5 answered that they had been adequately prepared during their university bachelor degree course.

### Discussion

Most of the TNFP in the study work in public facilities. The data could indicate how the Italian National Health System is investing in neurorehabilitation and how the TNFP figures are increasingly involved in the scientific development. 66% of the TNFPs (32 technologists) are employed with a permanent contract, of these, 17 are working in Scientific Institues of Health Research and Development, affiliated to public or private: the employment of TNFP is becoming so significant as to lead the aforementioned centers to assign permanent contracts, rather than scholarships or project contracts. On the other hand, 69% (34 technologists) of the participants defined themselves as untrained or with limited grounding, respect to a possible future employment in the neurorehabilitation and/or research field.

**Conclusion**

The need of more training addressed to neurorehabilitation and research could upgrade Neurophysiology technologists' skills and consequently increase job opportunities.

**Keywords:** neurophysiology technologist; neurorehabilitation; research; employment.

## INTRODUCTION

The professional profile of the Neurophysiology Technologist (TNFP) was outlined in Italy by the Decree of the 15th March 1995, n. 183 (Regulation concerning the identification of the figure and related professional profile of the Neurophysiology Technologist). In the Decree, the technologist is defined as "the healthcare operator who [...] carries out his/her activity in the diagnosis of pathologies of the nervous system, directly applying, on medical prescription, the specific diagnostic methods in neurological and neurosurgical fields (electroencephalography, electroneurography, polygraphy, evoked potentials, ultrasound)" [1].

Afterwards, with the Law of the 10th August 2000, n. 251, art. 3, paragraph 1, the specific aspects of the degree in Neurophysiology Techniques have been further defined. The TNFP has been described as the health profession operator, in the technical-diagnostic area, who independently carries out the functions identified by the professional profile (Ministerial Decree n.183 /1995 and subsequent amendments and additions), and by the specific code of ethics [2].

Returning to the technical-diagnostic field, the TNFP has always been classified as the healthcare professional able to perform a variety of methods for purely diagnostic purposes. Over the last few years, however, various non-invasive brain stimulation techniques have been developed and spread (Non Invasive Brain Stimulation – NIBS), where the term "non-invasive" refers to the methodic of stimulation applied and not to the effect determined by it. In fact, these are transcranial techniques, i.e. delivered via electrodes/coils on the head, as opposed to invasive procedures which require the intervention of a neurosurgeon to implant an impulse generator and electrodes (such as Deep Brain Stimulation, DBS, or epidural motor cortex stimulation, EMCS) [3].

NIBS include repetitive Transcranial Magnetic Stimulation (rTMS) and transcranial Electrical Stimulation (tES), widely used in neurology and neurorehabilitation, which can be performed by suitably trained TNFPs. Furthermore, different techniques for recording brain signals (Magnetoencephalography - MEG; High Density EEG - HD-EEG; Brain Computer Interface – BCI) are increasingly used in the context of scientific research and can be practiced by the figure of the technologist. The use of all these methods leads to an unavoidable process of evolution and updating of the professional profile of the TNFP (in accordance with the positioning document of the FNO TSRM and PSTRP, concerning the evolution of professional profiles) [4].

Below a brief description of the different stimulation and recording methods that can be performed by TNFP is provided, as well as its role in the different applications.

## NIBS

Among the non-invasive brain stimulation techniques used in neurorehabilitation, there are the repetitive transcranial magnetic stimulation (rTMS) and the transcranial electrical stimulation (tES), the most used of which is transcranial direct current stimulation (tDCS).

### repetitive Transcranial Magnetic Stimulation - rTMS

In rehabilitation the rTMS is used to stimulate certain areas of the cerebral cortex with trains of impulses at different frequencies, through a coil placed on the subject's head [5]. The precise positioning of the coil can be ensured by an optic navigation system, a tool which allows for accurate positioning at the target during the stimulation, permitting the impulses to reach specific anatomical structures [6]. rTMS indirectly recruits cortical neurons through a synaptic activation by horizontal interneurons, inducing a modulation of cortical excitability through long-term potentiation or depression (after effect LTP, LTD) [7].

The therapeutic implications of this method concern depression, migraine and obsessive-compulsive disorder (applications approved by the FDA respectively in 2008, 2013 and 2018) [8, 9, 10], in drug addiction cases, eating disorders, sleep and post-stroke rehabilitation (motor and aphasic deficits) [11, 12, 13, 14]. rTMS cannot be used on patients with metal implants, defibrillators, Baclofen perfusion pumps and on patients with history of seizures.

The TNFP who performs rTMS carries out neuronavigation, appropriately places the coil, sets the stimulation protocols, and presides over the stimulation session.

### transcranial Direct Current Stimulation – tDCS

Unlike rTMS, tDCS does not induce action potentials, but modifications of the synaptic function (excitatory post-synaptic potentials or subthreshold inhibitors), NMDA-receptor activity and axonal hyper/depolarization [15]. tDCS uses constant, low direct current delivered by two or more transcranial electrodes (high density tDCS), previously soaked in a saline solution and sprinkled with electroconductive gel over the target area at 1-2 mA for a pre-established time (10-30 minutes). Because of the large size of electrodes (from 5 to 9 cm), the 10-20 system is mostly used to identify the target. The identification of target area, application of electrodes, settings and treatment can all be performed by the TNFP.

For therapeutic uses, although the method has not been approved by the FDA, many researchers have highlighted how, based on the specific stimulated areas, tDCS can improve working memory, increase brain plasticity in stroke patients, modify the perception of pain, affect depression and addictions [16].

As described, it is clear that TNFP can be involved in the use of these stimulation techniques. In a recent article of 2021 [17], Fried et al. have elaborated various recommendations for a correct execution of NIBS, suggesting specific training divided into three classes, based on the skills of different professionals: technologists, clinicians, scientists. In the paper, EEG or EMG technologists are mentioned as the most appropriate figures for performing rTMS and tDCS for experimental or clinical sessions, after an appropriate training.

In a work by Rich et al. of 2019 [18], some investigators unfamiliar with performing head-specific 10/20 EEG measurements underwent a short period of training conducted by the "Registered Electroencephalographic Technologist (REEGT)", to correctly locate C3 and C4 in the tDCS montage. After the training, the standard error of several inter-rater and intra-rater measurements (SEM) was calculated. The results showed low SEM values, ranging between 0.34 cm and 0.58 cm. These data, collected after the training performed by a TNFP, validate his work for a correct performance of transcranial stimulations.

## HD-EEG - BCI

High-density EEG (HD-EEG) is recorded using headset consisting of 128/256 electrodes (some up to 512 sensors). The high spatial resolution guaranteed by these electrodes allows a precise and accurate exploration of the brain regions. All HD-EEG headset are pre-wired and the electrodes disposed (or positioned by the technologist in specific locations) according to the international 10-10 system. These techniques are mainly used in rehabilitation/research facilities that require long recording sessions (>30 minutes).

The Neurophysiology Technologist not only deals with the maintenance of the headset, the preparation of subject, the recording and the quality control of the signal, but very often actively participates in the pre-processing and analysis of the signal recorded. Numerous studies have demonstrated the usefulness of the information conveyed by the HD-EEG in the localization of the epileptic focus in surgical candidates [19-28]. HD-EEG is also used to investigate the origin of the cortical signal (through appropriate source analysis software) in Parkinson's disease, cerebral ischemia, psychiatric pathologies and in patients treated with DBS [29, 30]. Some centers have begun to use HD-EEG as a tool to further investigate the neurophysiology of sleep [31].

The HD-EEG can also be used in the Brain Computer Interface (BCI), a method which employs brain signals to control external devices and leads the subject to voluntarily activate his own rhythms. This allows the TNFP to record sessions in neurorehabilitation and/or scientific research field.

### MEG

Magnetoencephalography (MEG) records the magnetic fields generated by the post-synaptic intracellular ionic currents of neurons, using extremely sensitive devices, the SQUIDs ("Superconductive Quantum Inference Devices"), positioned inside a helmet containing numerous sensors (up to 500). SQUIDs are able to transform a very weak magnetic field (femtotesla unit of measurement - fT) into a proportional and easily recordable voltage. They operate at a temperature of 4.2ºK (-230ºC) and for this reason they must be immersed in a cryogenic structure containing liquid helium, called "dewar". To attenuate the environment magnetic noise (108 fT) the MEG is positioned inside magnetically shielded room; no metal object must be placed inside of this magnetic free environment because it would affect the quality of the recorded signal.

According to Mason et al. [32], the technologist employed in a MEG laboratory should receive adequate training to be able to perform various tasks, including patient preparation, application of MEG/EEG electrodes and polygraphic channels, recognition of artifacts, correct use of devices for evoked fields recording, identification of epileptic activity. These listed skills are prerogatives of the graduate in Neurophysiology Techniques. In fact, already in 2011 the guidelines of the American Clinical Magnetoencephalography Society defined the REEGT or the Registered Evoked Potential Technician (REPT) as the preferable technologist for the assignment [33]. Furthermore, the technologist is responsible for the matters concerning the liquid helium refill and can be involved in the preprocessing and analysis of the obtained signal.

MEG is used for the localization of the epileptic focus (preoperative evaluation in patients' candidate for epilepsy surgery), for the analysis of the cortical signal and its origin, in numerous pathologies such as autism, schizophrenia, stroke, head trauma and in drug administration monitoring [34]. Furthermore, MEG signals can be analyzed in terms of functional connectivity among different brain areas for the study of numerous neurological disorders, obtaining even more precise results than HD-EEG.

## OBJECTIVE

Given the growing use of different methods that can be performed by a suitably trained technologist, the study aims to know the current state of employment of TNFPs in neurorehabilitation and scientific research fields, on the Italian national territory. The result will provide an overview of the occupation status of what could become an important job opportunity for this professional figure.

## MATERIALS AND METHODS

A questionnaire was created using SurveyHero®, generated by the Swiss company © 2007 - 2023 Enuvo GmbH, in compliance with GDPR UE/2018/1725, Regulation 2016/679-GDPR, directive 2016/680, which set the rules applicable to the processing of personal data and privacy in Europe. The survey, circulated from the 18th December 2022 to the 1st February 2023, was administered via e-mail and social channels by the professional commissions of Neurophysiology Technicians (TSRM PSTRP Orders) throughout the national territory and by the Italian Association of Neurophysiology Technologists (AITN). No recruitment of subjects was envisaged: the participants were informed about the aims of the study and joined on a voluntary basis by giving their consent to data processing. The ethical principles enshrined in the Declaration of Helsinki have been respected. No compensation was paid for participation.

The questionnaire was divided into four sections (see appendix): demographic characteristics, education, employment information, neurorehabilitation/research employment. The first two sections defined demographically the participants (gender; year of birth) and the level of education (location of the bachelor degree course; attainment of a first level master course, second level master course, master degree, doctorate). The third section involved the technologist's employment status (working region; type of contract; type of work structure; years of service performed in neurorehabilitation/research field). The last section identified the specific methods used in neurorehabilitation (tDCS; tACS; tRNS; rTMS), in scientific research (MEG; hd-EEG; BCI; Other) and any related publications. Finally, a judgment regarding the training received during the degree course was requested and whether specific post-graduate courses had been attended to deepen one's skills.

### Statistical analysis

Statistical analyses were conducted with PythonTM software version 3.11.2.

## RESULTS

91 participants, 22 men (28-64 years, 42 ± 10), 69 women (24-60 years, 38 ± 11) filled out the questionnaire. Among those, 62 technologists answered all the questions submitted, the remaining 29 did not complete the questionnaire, leaving the forth section empty (8 men, 28-52 years, 36 ± 9; 21 women, 26-60 years, 40 ± 11 ). Of the participants who completed the survey, 13 were excluded (13 women, 24-60 years, 40 ± 14) because it appeared they were not employed in neurorehabilitation or scientific research, therefore not falling within the scope of the investigation. A total of 42 technologists were finally excluded, 8 men and 34 women, who graduated between 1984 and 2021 (2008 median value). Of these, 6 technologists obtained a master degree (2 men, 4 women), 12 a first level Master course (3 men, 9 women), 1 a second level Master course (1 man).

The Neurophysiology Technologists who completed the survey and actually carry out activities in neurorehabilitation and/or scientific research are 49.

The demographic characteristics analyzed highlight the participation in the study of 14 men (30-64 years; 46 ± 9); 35 women (24-57 years; 36 ± 11). The 49 participants graduated in Neurophysiology Techniques, or obtained a Qualifying Diploma, between 1986 and 2022 (2009 median value). *Figure 1* shows the different degree course headquarters, associated with the absolute number of TNFPs who attended these universities.

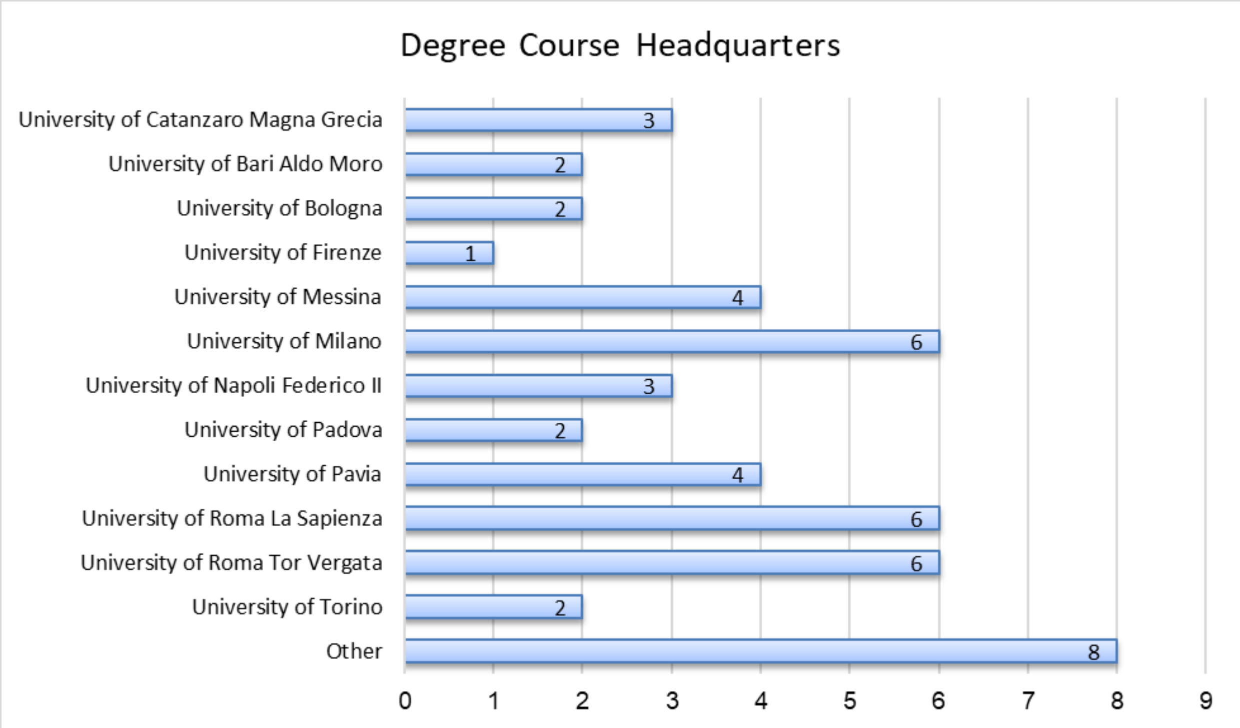


*Figure 1. Absolute number of TNFPs divided by each Degree Course headquarters attended. "Other" refers to technologists in possession of a diploma enabling the profession, prior to the establishment of the Degree Courses in 2001.*

39 technologists continued their studies: 17 obtained a master degree (9 men, 8 women); 19 obtained a first level Master course (8 men, 11 women), 2 a second level Master course (1 man, 1 woman). Only one technologist holds a PhD (1 woman).

From the answers provided in the third section of the questionnaire, relating to the state of employment, it was possible to observe that on the national territory the largest number of neurophysiology technologists employed in neurorehabilitation and/or scientific research field works in Lombardia (9 TNFPs/49, 18 .4%), followed by Lazio (7 TNFPs/49, 14.3%), Piemonte (5 TNFPs/49, 10.2%), Emilia Romagna (4 TNFPs/49, 8.2%), in Liguria (4 TNFPs/49, 8.2%), in Veneto (4 TNFPs/49, 8.2%), in Calabria (3 TNFPs/49, 6.1%), in Sicilia (3 TNFPs/49, 6 .1%), in Abruzzo (2 TNFPs/49, 4.1%), in Puglia (2 TNFPs/49, 4.1%), in Umbria (2 TNFPs/49, 4.1%), in Campania ( 1 TNFP/49.2%), in Molise (1 TNFP/49.2%), in Toscana (1 TNFP/49.2%), in Trentino Alto-Adige (1 TNFP/49.2%). Figure 2 shows an overview of the absolute frequencies on the employment status of the 49 TNFPs in all Italian regions. In Figure 3 an overview of the percentage frequencies divided by region.

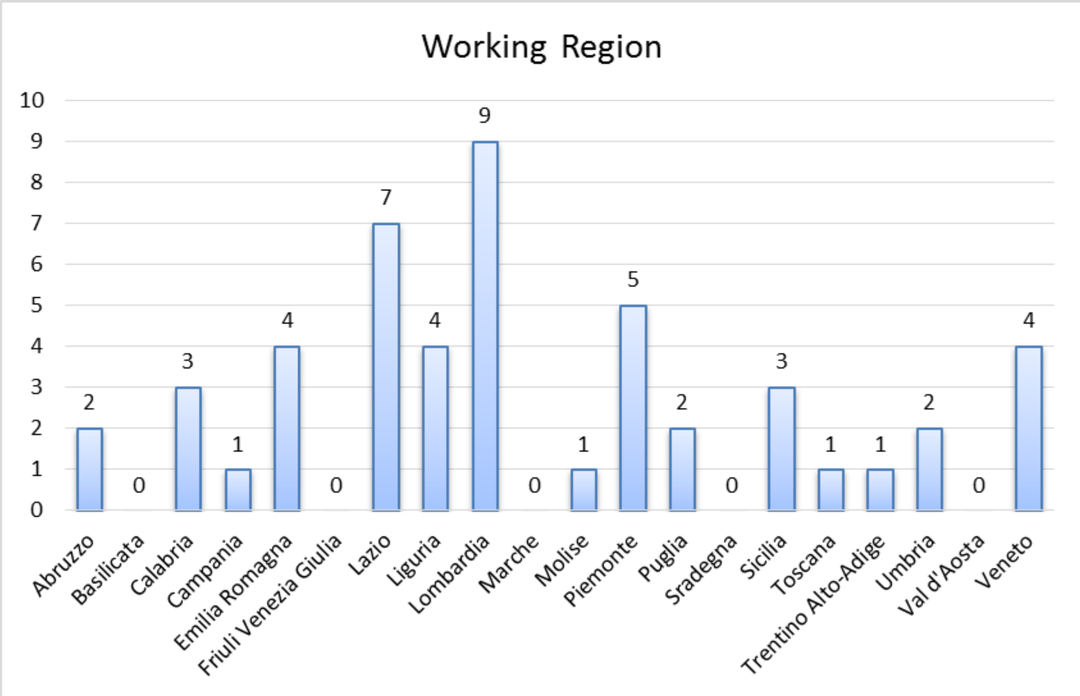


*Figure 2. Absolute frequencies of TNFPs employed in neurorehabilitation and/or scientific research divided by working region.*


*Figure 3. Percentage frequencies of TNFPs employed in neurorehabilitation and/or scientific research divided by working region.*

Most of the 49 TNFPs are employed with a permanent contract (32/49, 66%), followed by freelancers (6/49, 12%), scholarship (4/49, 8%), fixed-term contracts (2/49, 4%), project contracts (2/49, 4%), research grants (2/49, 4%) and collaborations (1/49, 2%). Figure 4. 19 out of 49 technologists work in a public structure of the Italian National Health System (39%), 16 in a Scientific Institute of Health Research and Development (33%), 7 in private structures (14%), 7 in facilities affiliated with the Italian National Health System (14%). Figure 5.

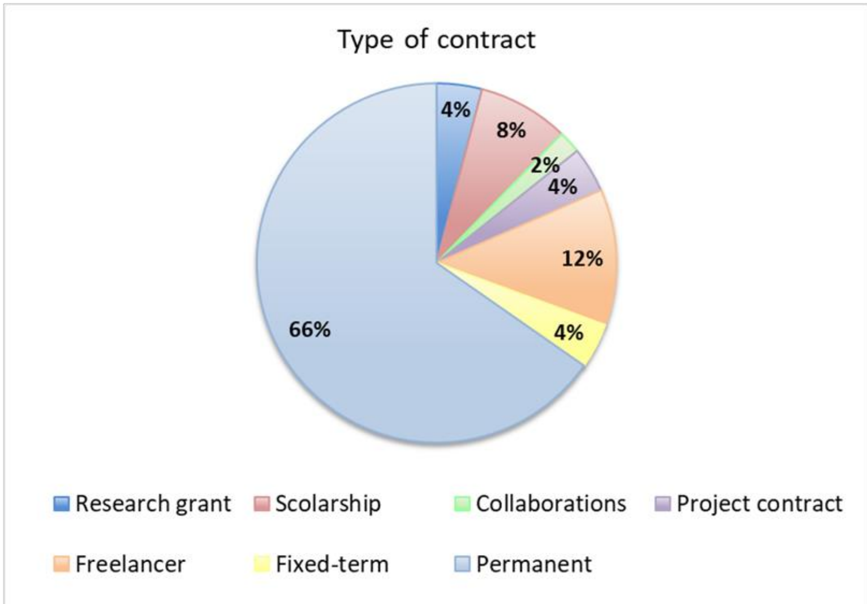


*Figure 4. Pie chart showing different types of TNFPs' employment contracts.*

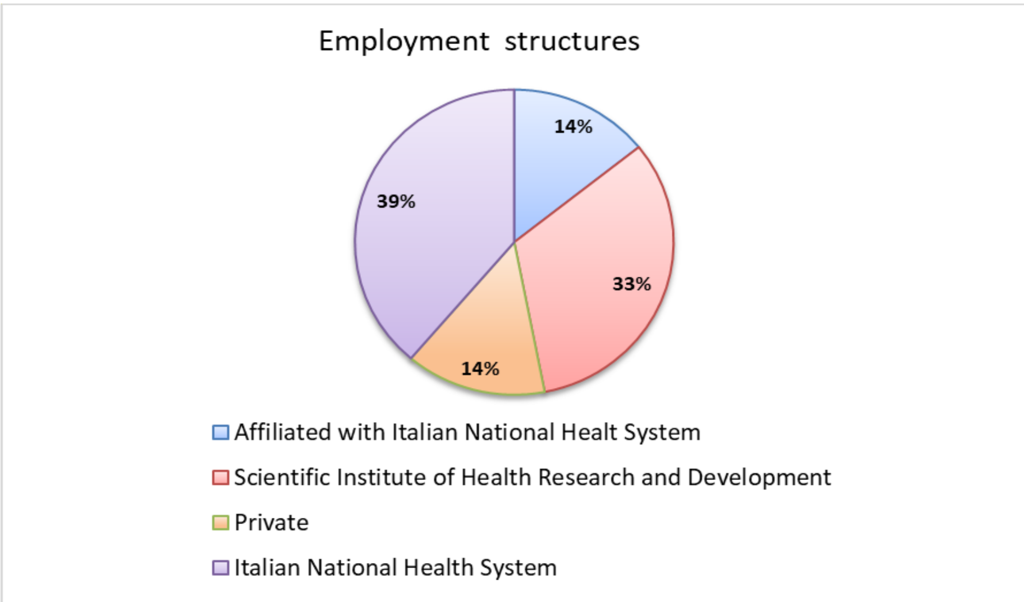


*Figure 5. Pie chart highlighting the different employment structures.*

15 of the 32 technologists with permanent contracts are working in public structures, 12 in Scientific Institute of Health Research and Development, 3 in structures affiliated with the Italian National Health System, 2 in private structures. 4 of the freelancers work in private structures, 1 in a structure affiliated with the Italian National Health System and 1 in a public structure. Two of the TNFPs working with scholarship are employed in public structures, 2 in Scientific Institute of Health Research and Development. Fixed-term contracts are 1 in a public facility and 1 in a facility affiliated with the Italian National Health System. The 2 project contracts both work in structures affiliated with the Italian National Health System. Research fellows work 1 in a Scientific Institute of Health Research and Development, 1 in a facility affiliated with the Italian National Health System, the only TNFP with a collaboration contract works in a Scientific Institute of Health Research and Development. Then, the years of work in the neurorehabilitation and/or scientific research fields were analyzed over 49 TNFPs. Since the data are not homogeneous, the modal value was calculated giving the result of 4 years (Figure 6).

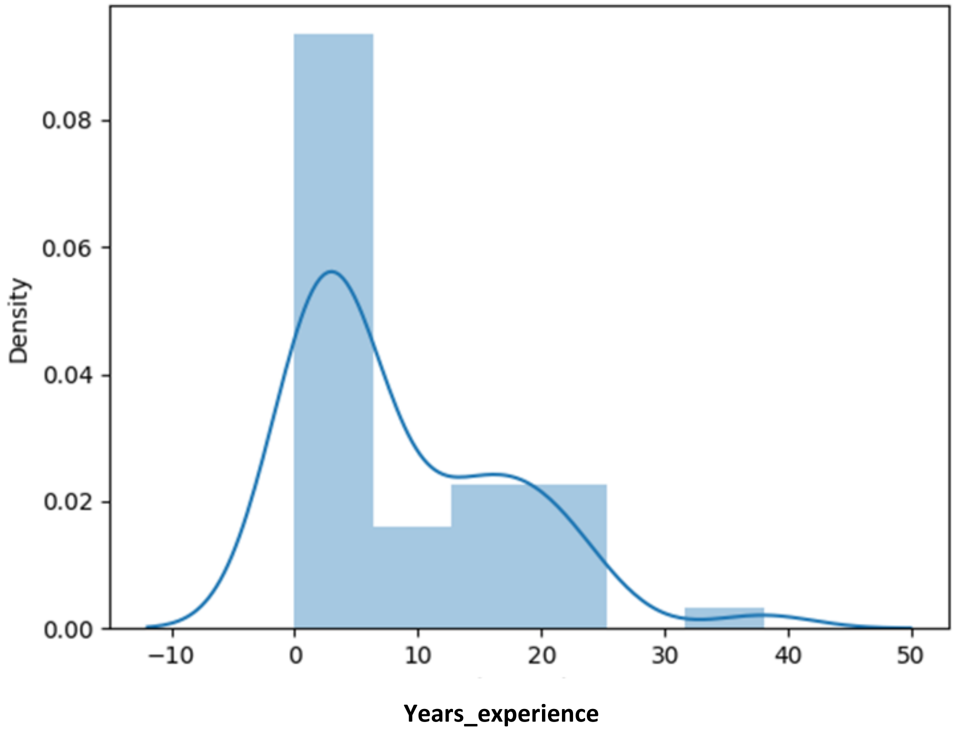


*Figure 6. Years of experience in neurorehabilitation and/or scientific research unimodal distribution.*

Participants were then divided into classes, based on the number of years of declared work experience in neurorehabilitation and/or research field. 28 out of 49 TNFPs have 3 months to 5 years of experience, 2 TNFPs from 6 to 10 years, 8 TNFPs from 11 to 15 years, 7 TNFPs from 16 to 20, 4 TNFPs have more than 21 years of experience. For each class, the number of TNFPs performing non-invasive brain stimulation techniques for neurorehabilitation or researching neurophysiological techniques was also calculated (Table 1).

22 technologists carry out several methods (either in neurorehabilitation field, or in research, or both), for this reason the total number of cells exceeds the total number of 49 participants in the study.

| | | Neurorehabilitation | | Research | | | |
|---|---|---|---|---|---|---|---|
| **Years of experience** | **n° TNFP** | **tDCS** | **rTMS** | **HD-EEG** | **BCI** | **MEG** | **Other** |
| Class I: 0-5 | **28** | 13 | 10 | 13 | 2 | 2 | 6 |
| Class II: 6-10 | **2** | 1 | 1 | 1 | 0 | 0 | 0 |
| Class III: 11-15 | **8** | 2 | 5 | 4 | 2 | 1 | 3 |
| Class IV: 16-20 | **7** | 4 | 4 | 3 | 1 | 0 | 1 |
| Class V: ≥ 21 | **4** | 1 | 2 | 1 | 1 | 0 | 1 |

*Table 1. TNFPs divided into classes according to the declared number of years of experience in neurorehabilitation and/or scientific research.*

30 of the 49 TNFPs work only in neurorehabilitation field, i.e. they perform rTMS and tDCS, 19 only carry out scientific research activities, 15 deal with both. 9 of the total 34 technologists working in research deal with HD-EEG, BCI, MEG, 15 carry out studies on rTMS and tDCS, 10 other methods (one quantitative EEG with analysis in Matlab, one MRgFUS, 4 gait analysis, 2 polysomnographies, 2 electromyography, 2 intraoperative neurophysiological monitoring, 1 integrated EEG for amplitude in rare pediatric syndromes). 33 TNFPs have published scientific papers as first name, last name or other author.

19 of the 49 TNFPs specified the name of their work structure thus providing a more precise and indicative national overview of employment in these sectors. Those involved in non-invasive brain stimulation techniques and/or research work are listed in the belonging facilities.

**- Italian National Health System:** University of Genova (1 TNFP performs HD-EEG), Rizzoli Orthopedic Institute of Bologna (1 TNFP carries out research in intraoperative neurophysiological monitoring), S. Maria of Terni Hospital (1 TNFP carries out research in EEG, Electromyography and Evoked Potentials), Policlinico Tor Vergata in Roma (2 TNFPs perform rTMS);

**- Structures affiliated with the Italian National Health System:** Casimiro Mondino Neurological Institute Foundation in Pavia (1 TNFP performs HD-EEG), Pederzoli Hospital in Peschiera del Garda (1 TNFP performs tDCS), San Pietro Fatebenefratelli Hospital in Roma (1 TNFP performs tDCS); Agostino Gemelli University Hospital of Roma (1 TNFP performs HD-EEG), S. Anna Institute of Crotone (1 TNFP performs rTMS and HD-EEG).

**- Private centres:** Don Carlo Gnocchi Foundation in Milano (1 TNFP carries out tDCS and rTMS), Brain and Care in Torino (1 TNFP carries out rTMS);

**- Scientific Institute of Health Research and Development:** Istituto Auxologico Piancavallo of Verbania (1 TNFP performs research in gait analysis and polysomnography), IRCCS Carlo Besta of Milano (1 TNFP performs research in MRgFUS), IRCCS Ca' Granda Foundation Ospedale Maggiore Policlinico of Milano (2 TNFP perform tDCS and rTMS), ICS Maugeri of Pavia (1TNFP performs HD-EEG), IRCCS San Camillo of Lido di Venezia (1 TNFP performs tDCS and MEG), IRCCS Neuromed of Pozzilli (1 TNFP performs tDCS).

The ratio between these 19 technologists and the total number of technologists working in the same structures, including those who perform diagnostic tests, was then calculated (Table 2). The total of TNFPs working in the centers mentioned above is 102. The ratio between technologists who have specified the name of their work structure and those who are employed in neuro-rehabilitation and/or research field, compared to the total number of technologists employed in the same centers is therefore approximately 1:5 (19%).

| Employment structure's name | TNFP study | TNFP tot |
|---|---|---|
| S. Maria of Terni Hospital | 1 | 5 |
| Brain and Care in Torino | 1 | 1 |
| Don Carlo Gnocchi Foundation of Milano | 1 | 2 |
| IRCCS Ca' Granda Foundation Ospedale Maggiore Policlinico of Milano | 2 | 10 |
| Casimiro Mondino Neurological Institute Foundation of Pavia | 1 | 12 |
| ICS Maugeri of Pavia | 1 | 2 |
| IRCCS Carlo Besta of Milano | 1 | 15 |
| IRCCS Neuromed of Pozzilli | 1 | 12 |
| IRCSS San Camillo of Lido di Venezia | 1 | 3 |
| Istituto Auxologico Piancavallo of Verbania | 1 | 3 |
| Istituto Ortopedico Rizzoli of Bologna | 1 | 3 |
| Istituto S. Anna of Crotone | 1 | 2 |
| Pederzoli Hospital of Peschiera del Garda | 1 | 4 |
| San Pietro Fatebenefratelli Hospital of Rome | 1 | 3 |
| Policlinico Tor Vergata of Roma | 2 | 9 |
| Policlinico Universitario Agostino Gemelli of Roma | 1 | 15 |
| University of Genova | 1 | 1 |
| Total | 19 | 102 |

*Table 2. Number of TNFPs included in the study, working in the corresponding employment structure they specified (TNFP study) and total number of TNFPs working in the same centre, including those involved in diagnostic tests (TNFP tot). Data refer to responses of the study participants.*

Participants were finally asked for an opinion on the training provided during the degree course, on neurorehabilitation techniques or on scientific research. 13 technologists out of 49 declared that they had not received adequate training in these areas; 21 said they received limited training; 10 defined the foundations provided by the degree course as sufficient; 5 answered that they had been adequately prepared during the three-years degree. 14 participants out of 49 attended specific post-graduate courses or carried out internships in specific structures in order to deepen their skills; among them, 10 have followed training courses to be able to carry out rTMS and tDCS.

## DISCUSSION

There are about 2200 Neurophysiology Technologists regularly registered in the TSRM PSTRP Order (data provided by the President of the Commission of Neurophysiology Technologists of Milan, as well as President of the AITN), the technologists who answered the questionnaire were 91. It is well understood how the limit of this study lies in the uncertainty that the questionnaire was actually viewed by all the Italian TNFPs employed in neurorehabilitation and/or scientific research. The scarcity of adherence to the survey could also be attributed to the lack of knowledge of the topic by the population concerned. Of the TNFP participants in the study, 29 did not complete the questionnaire, leaving the “performed methods” section blank; 13 completed the survey but were excluded because the answers provided showed that they were not involved in neurorehabilitation or scientific research. For instance, they indicated an inexperience in these areas or they answered 0 years to the question "years of experience". Therefore, 42 subjects out of 91 were excluded, i.e. 46% of the participants: these data could be explained by a lack of knowledge of the different fields (research and neurorehabilitation) where the TNFP can be involved. Indeed, they completed the questionnaire up to the "methods performed" section and then either paused or continued to the end, likely with the purpose to grasp the survey's topic techniques, and then, realizing their lack of experience in neurorehabilitation or scientific research and so indicating their absence of expertise. This data is significant as it highlights the limited familiarity of healthcare professionals with the study's methods, despite their potential relevance to their work sectors.

The state of employment in the Italian territory shows that most of the 49 TNFPs work in Lombardia (18%) and in Lazio (14%). These data, associated with those related to the universities attended, could imply that the TNFPs trained in these universities have continued their career in the same region. In fact, 6 technologists out of 49 graduated from the University of Milano, 4 from the University of Pavia, 6 from the University of Roma "Tor Vergata" and 6 from the University of Roma "La Sapienza", for a total of 10 TNFPs in Lombardia and 12 TNFPs in Lazio, respectively 20.4% and 24.5% of the graduates participating in the questionnaire.

39% of the 49 TNFPs work in a public structure: this interesting evidence could indicate how much the Italian National Health System is investing in neurorehabilitation and how the TNFP figures are increasingly involved in scientific development. 66% of the 49 TNFPs work with a permanent contract, of these 15 are employed in public structures, 12 in Scientific Institute of Health Research and Development, 3 in structures affiliated with the Italian National Health System and 2 in private structures. These results show that the employment of TNFPs is of considerable importance in the research laboratories and private or affiliated structures, offering permanent contracts, rather than scholarships or project contracts. Furthermore, there are 33 technologists who have published scientific papers, further confirmation of the inclusion of this professionals within the scientific research sector.

28 TNFPs out of 49, 57% of the participants, have an experience ranging from 3 months to 5 years, confirming the idea of how recently the employment of the Neurophysiology Technologists is in these fields is.

Given the small sample size analyzed in this study (49 TNFPs out of 2200), a more representative comparison was made between the TNFPs participating in the survey, who specified their work structure, and the total number of technologists from the same centers (19 TNFPs out of 102). In any case, data provided highlight how low is the number of TNFPs dedicated to performing non-invasive brain stimulation techniques and/or scientific research compared to colleagues employed in diagnostics. In fact, among the centers specified in the study, only 1 out of 5 TNFPs (19%) perform non-invasive brain stimulation techniques or methods applicable in scientific research field.

As regards to the training received during the degree course, the knowledge related to neurorehabilitation or scientific research methods was considered limited by 21 technologists out of 49, and inadequate for 13 technologists. Overall, 69% of the study participants defined themselves as untrained or with limited preparation for a possible future employment in neurorehabilitation and/or research field. This is demonstrated by the need for 14 TNFPs to resort to specific post-graduate courses or internships aimed at completing their training, in particular in correlation to the most recent non-invasive brain stimulation methods in neurophysiology, tDCS and rTMS.

## CONCLUSION

Neurophysiology Technologists employed in neurorehabilitation or scientific research field are still decidedly reduced compared to colleagues employed in technical-diagnostic field (1:5 ratio of the specified centers participating in the study). However, in the light of the results of this study, it is clear that the professional figure of the TNFP is becoming increasingly involved in neurorehabilitation and research in recent years. This is demonstrated by the greater number of permanent contracts stipulated in this sector and the interest in employment by the National Health System. Furthermore, greater training by universities, internship periods and specific post-graduate courses could increase the skills of Neurophysiology technologists, bring them ever closer to these areas and increase job opportunities for the profession.

### Acknowledgements

We sincerely thank Dr. Miryam Bartoli, Data Scientist, for her collaboration in data analysis.

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# APPENDIX

## Survey

| Demographic characteristics | |
|---|---|
| 1. Gender | Female<br>Male |
| 2. Year of birth | |
| **Education** | |
| 3. Graduation Course Headquarters | |
| 4. Graduation year | |
| 5. Have you obtained a first level Master Course? | Yes<br>No |

| | |
|---|---|
| 6. Have you obtained a Master Degree? | Yes<br>No |
| 7. Have you obtained a second level Master Course? | Yes<br>No |
| 8. Have you obtained a PhD? | Yes<br>No |
| **Job information** | |
| 9. Working region | |
| 10. Type of contract | Collaborations<br>Freelancer<br>Project contract<br>Research grant<br>Scholarship<br>Fixed term<br>Permanent |
| 11. Type of structure | Italian National Health System<br>Private<br>Agreement with Italian National Health System<br>Scientific Institute of Health Research and Development<br>Home therapy |
| 12. Years of work in neurorehabilitation/research | |
| **Employment in neurorehabilitation / research** | |
| 13. Methods used (more than one selectable answer) | tDCS, tACS, tRNS<br>rTMS<br>HD-EEG<br>BCI |

| | |
|---|---|
| | MEG<br>Other |
| 14. Based on your experience, has the training received during the Degree course, relating to the methods used in neurorehabilitation/research, provided adequate preparation for entering this sector? | |
| | Yes<br>Sufficiently<br>Limited<br>No |
| 15. For training in these fields, have you attended specific post-graduate courses? | |
| | Yes<br>No |
| 16. Have you written scientific articles (first name, last name, other author) about your work in neurorehabilitation or research? | |
| | Yes<br>No |