International Journal of Advanced Research in Medicine 2022; 4(2): 88-93

E-ISSN: 2706-9575
P-ISSN: 2706-9567
IJARM 2022; 4(2): 88-93
Received: 27-05-2022
Accepted: 29-06-2022

Konstantinos Chandolias
Ph.D. Doc Researcher, Department of Physiotherapy, University of Thessaly, Lamia, Greece

Vasiliki Stefanouli
Ph.D. Cand, Department of Physiotherapy, University of Thessaly, Lamia, Greece

Aristi Tsokani
Ph.D. Cand, Department of Physiotherapy, University of Thessaly, Lamia, Greece

Eleni-Argyroula Tsounia
Ph.D. Cand, Department of Physiotherapy, University of Thessaly, Lamia, Greece

Anthi Kellari
Ph.D. Cand, Department of Physiotherapy, University of Thessaly, Lamia, Greece

Corresponding Author:
Konstantinos Chandolias
Ph.D., Doc Researcher, Department of Physiotherapy, University of Thessaly, Lamia, Greece

The use of surface electromyography (sEMG) wearable sensors on land and underwater during hydro-rehabilitation: A review

Konstantinos Chandolias, Vasiliki Stefanouli, Aristi Tsokani, Eleni-Argyroula Tsounia and Anthi Kellari

DOI: https://doi.org/10.22271/27069567.2022.v4.i2b.412

Abstract
Introduction: Surface electromyography (sEMG) equipment technological advancements are opening more and more new options for the use of this technology in many medical areas and rehabilitation, including physiotherapy on land and in the water environment.
Objective: The purpose of this study is to investigate the use of electromyography (EMG) wearable sensors in hydro-rehabilitation and to analyze the use of surface electromyography in the rehabilitation of various diseases on land and in the water environment
Methods: Studies were searched for on the Pub-Med, Science direct, and Google Scholar databases using the following descriptors: "sEMG rehabilitation", "sEMG physiotherapy", "surface electromyography physiotherapy", "sEMG hydrotherapy", resulting in 57,200 citations in total. After reviewing for inclusion criteria – methodological quality assessment using the Physiotherapy Evidence Database (PEDro) scale and consistency with the theme of systematic review – 152 studies remained in the analysis.
Results: A total of 153 articles were found in 3 databases searched, only 30 were included and classified with good methodological quality by Pedro because they were related to surface electromyography, physiotherapy on land and hydrotherapy.
Conclusion: The role of EMG sensors to measure muscle activity is extremely important for the physiotherapist to monitor and evaluate the clinical process and the effectiveness of hydro-rehabilitation as a treatment method. More research is needed in order to find a functional and reliable way of use.

Keywords: Electromyography, wearable sensors, hydro-rehabilitation, sEMG, dynamic electromyography (DEM), and aquatic

Introduction
With technology, there have been many medical advancements, especially in treating health conditions that have long been a significant concern for medical practitioners. Different medical conditions in the healthcare field have long called for hydro-rehabilitation as a treatment measure. For many centuries, medical experts have incorporated the use of hydro-rehabilitation, otherwise known as hydrotherapy, in the treatment of extreme physical injuries or significant medical conditions that have been associated with severe pain. The reason for the Department of Physical Medicine and Rehabilitation to approve the employment of this treatment method is because of the soothing and relaxing feeling that is associated with water and therefore explains why it is recommended as a treatment in these circumstances. One of the trending technologies in the healthcare sector is wearable technology. According to Zyukov (2017) [30], over the last decade, one notable innovation has been the electromyography (EMG) sensors incorporated by different professions as an assistive measure applied in other therapies, including hydrotherapy rehabilitation. The first attempt at EMG sensors can be dated back to the 1950s. Since its generations, scholars and scientists have incorporated improving technology to advance the design and the functionality of the sensors. The extensive development that has been made on EMG since its creation has increased its usefulness in the healthcare sector. For instance, the EMG sensors are now wireless, facilitating easier portability and enhancing their sphere of usage (Zhao *et al.*, 2020) [29]. In this aspect, they can be used both on land and in water during hydro rehabilitation to facilitate the monitoring aspects of the patient's therapy session.

The principal non-invasive method for recording the electrical impulses of muscles during vigorous exercises is surface electromyography (sEMG) (Agostini *et al*., 2020) [2]. Among the most essential aspects of daily life is walking (ADL) (Krogstad, 2015) [12]. In hospitals, examining muscle function during movement is crucial in treating patients with a range of orthopedic, neurological, and peripheral vascular illnesses that change gait rhythms. Engineered gait analysis generates objective knowledge regarding time-distance factors, joint movements, and joint moments and strengths, which is important in therapeutic practice (Horsak, nd). Simple, "user-friendly" gait assessment approaches, such as those relying on accelerometric sensors, have substantially affected the literature over the previous year. Furthermore, dynamic electromyography (EMG) measures muscle timing and activity, which helps define a patient's gait patterns and provides an empirical foundation for determining the practical explanation of a gait problem (Abu-Faraj, 2015) [1]. Dynamic electromyography (DEM) describes the muscle activation that regulates joint motion precisely. While movement and moment estimates can infer the general activity of muscle units, muscle specificity necessitates a more selective approach (Kaufman, 2016) [10]. To ensure weight-bearing strength, shock resistance, and advancement over the supporting leg during the stride and to drive the limb in movement, walking hinges on selected timing and strength of relevant muscles at every joint (Herbert-Copley, 2015) [8]. Just the muscles that are best positioned for each action are activated, and wherever possible, velocity and passive connective tension are used instead of direct muscle action. The muscles work in groups throughout this series of functions. The lower limb's primary motions occur in the sagittal plane (Sanz-Merodio, 2014) [22]. To improve single-limb stability and body motions, many activities in the additional two planes (coronal and transverse) are also present (Northeast *et al*., 2018) [16]. The position of each muscle along the joint or joints it crosses determines its three-dimensional (3D) effect.

Furthermore, most muscles belong to two or more physiological categories. This redundancy ensures 3D equilibrium and makes integrating adjacent joint motion easier (Zhang, 2019) [28]. The relative strength of a muscle's activity is governed by its function currently dominating. As a result, simply comprehending normal function necessitates a thorough examination of individual muscle movement. Such data can also determine the impact of orthotics, muscle training routines, and other treatments. Dynamic electromyography allows you to link muscle movement to a singular purpose with pinpoint accuracy (Parziale, 2020) [18]. Various factors might cause the usual, complicated walking pattern to be disturbed. Muscles can become weaker due to inactivity, pain, or a direct injury (Steele *et al*., 2014) [24]. Passive mobility may be limited by fibrotic tissue stiffness. Orthoses inhibit nearby mobility by accident while shielding the area of attention on intent (Leclairetal. 2018). Brain and spinal cord damage can disrupt the basic motor-sensory and feedback channels. According to Yeh (2016) [27], Spastic paralysis, stroke, and head injuries pose the biggest diagnostic problem because muscle performance affects multiple levels. Spasticity typically leads clinical testing to diverge significantly from the muscular pattern employed during movement (Papavasiliou, 2009) [17]. Even minor motor neuron injuries can lead to a variety of unexpected outcomes. Individuals maintain their capacity to walk by replacing to the degree their selective control permits. Other movements and muscle activities are adopted to circumvent the limits imposed by the disease. Individuals' ability to substitute differs significantly. As a result, the individual's walking gait is a combination of primary functional impairment and compensatory efforts (Knarr *et al*., 2013) [11]. Inadequate, excessive, poorly timed, or out-of-phase muscular activation are all possible outcomes. It is critical to understand muscle activity rather than presume it to effectively devise retraining procedures, optimize orthotic aid, or arrange a proper reconstructive surgical operation. Dynamic electromyography is required for this procedure.

Comparing gait using electromyography in water and on land

The physical and physiological benefits of exercising in water habitats have made it a popular choice for therapy and improved function. People unable to handle the mechanical stress of dry-land exercise can benefit from aquatic training and generate biological and behavioral reactions that will improve their health or physical performance (Severin *et al*., 2017) [23].

Physiotherapists promote water exercise because of hydrostatic pressure, induced drag, and velocity benefits. According to Garcia-Hernandez (2019) [7], muscle activation varies in strength and amount of engagement based on the routines and training utilized due to the buoyant force operating in the opposing plane of gravitational force and induced drag going in the opposite plane of body mobility in water. As a result, knowing the degree of muscle activation in water during different activities and workouts would be helpful in determining a suitable aquatic therapy program. Similarly, there exists a shortage of knowledge on muscle activation in aquatic activities for application in sports and physiological activity, including aqua-fitness and leisure swimming, which are beneficial for upholding or enhancing physical condition without putting undue strain on the spine and extremities (Das *et al*., 2016) [5].

Aquatic treatment is commonly utilized in pediatrics, sports medicine, rheumatology, neuroscience, and other fields. Particularly in neurological recovery, aquatic treatment has a significant hands-on aspect (Centeno, 2015) [3]. Aquatic therapy is often only a minor element of rehabilitation in these individuals, which is varied and complex. Even so, where any diagnosis is small in quantifiable terms, this may play a significant role in the lengthy effects of rehabilitation. As a result, there hasn't been enough focus on measuring the effectiveness of water therapy. As a result, gaining a more excellent knowledge of muscle action while exercising in water could be the first start toward developing an efficient water-based exercise treatment program (Raffaelli *et al*., 2016) [20]. There is much variation in recording muscle function from surface electromyography impulses in the research on water training and action. This diversity is related to various factors, including pool deepness and water temperature, aquatic activity training, exercise frequency control, and so on. Some discoveries about muscular strength and recruitment tendencies are inconsistent.

Assessing muscle movement during water training is challenging and typically avoided because most devices are unsuitable for this kind of setting and are thus unpredictable or invalid (Pettee *et al*., 2009) [19]. Quantitation of muscle action using electromyography [EMG] methods during mobility in water, for instance, is complicated due to the difficulty of avoiding indirect water in the capturing of a muscle's electrical impulse and, for security reasons, with reverence to the absorption of electrical constituents in aquatic, for example, electrocution. There may also be some minor difficulties with the EMG response; the most likely explanation is that the buoyancy influence on the neuromuscular systems is still unknown (Masumoto *et al*., 2008) [14].

Since these exercises are not comparable, there are differences in muscle movement while moving in the water vs. moving on land. The most frequent method of standardizing EMG data for inter-individual comparability is Maximal Voluntary Contraction [MVC]. While there is a defined procedure for dry training, it is uncertain if the EMG data collected from the dry workouts should be corrected for water (Cuesta-Vargas *et al*., 2020) [4]. Three studies looked at MVC on land and water and discovered that the setting did not influence the value as long as the muscle activity was controlled similarly. Two investigations looked at the knee, two just at the shoulder, and another at the lumbar area regarding anatomical sections.

There have been many studies into surface EMG in the water during the last few years. When MVC is conducted in water instead of dry land, EMG appears lower. It's unknown why EMG is lesser in water at this moment, although variations in muscle movement may be linked to response and fluid variations brought on by submerging. The authors concluded that the environment had no significant effect on sEMG and force in research that monitored sEMG responses with isometric strains on the ground and in water (Cuesta-Vargas *et al*., 2020) [4]. The results of this investigation could be valuable in illustrating the functional mobility activity in the water, which could assist clinicians in making better decisions in aquatic therapy procedures. There were no variations in force output in the second study examining knee muscular isometric activity; however, there was less muscle activation via sEMG. Less muscular activation in the lower limb possibly will permit effective execution of the muscle action for patients with decreased leg power. Still, greater trunk action is needed to manage the motion.

Waterproofing EMG wires is a severe concern of recording muscle function in water (Cuesta-Vargas *et al*., 2020) [4]. The following are the two primary techniques for measuring muscle activity utilizing surface EMG in water motility: creating a waterproof cover around the wires and creating a watertight structure across the body by individuals donning a dry suit. Assessing the neuromuscular reactions in water necessitates overcoming the constraints and limitations of sEMG. A literature survey shows that measuring muscle activity during aquatic movement is a hot topic.

Dynamic electromyography allows the physician or research scientist to determine the timing and strength of a particular muscle function during walking and other operational tasks. When the equilibrium of passive and active stresses is disrupted by disease, moment estimations can become erroneous. Wire electrodes offer a more accurate characterization of both timing and strength of muscle activity than surface electrodes due to their insertion within the targeted muscle. Still, they do necessitate needle piercing of the skin. The benefit of surface electrodes is their portability. A description of muscle activity measurement during various aquatic exercises and activities. Muscle activation is lower in water-based activities than in land-based training, but further investigation is necessary to figure out why.

Methodology

The method used in the collection of data used for the development of this article is the qualitative data collection method. The primary source of this article is the analysis of thirty peer-reviews journals. The thirty peer-reviewed articles used in this study include information related to the topic. Most of the articles were obtained through extensive research on different search engines Pub-Med, Science Direct, and Google Scholar databases. For additional information used to build u the content of this study paper, different secondary sources were explored through different medical databases including the National Centre for Biotechnology Information (NCBI). To ensure that the secondary sources contained information liable for this study the method incorporated the use of keywords to search. The keywords were useful to narrow down the results available on search engines such Pub-Med, Science Direct, and Google Scholar databases. For instance, inputting “electromyography wearable sensor" brought up 32,000 results in just under 0.4 seconds. There were no notable results linking electromyography to hydro rehabilitation which called for an analysis of the available data to assess the implications that will develop the topic. The search for hydro-rehabilitation brought up 77,000 results in under 0.4seconds. Uses of EMG brought 25,200 results in just under 0.04 seconds. To maintain relevance, the sources were narrowed down to articles written between 2014-2022. The keywords in this aspect were Electromyography, wearable sensors, and hydro-rehabilitation, sEMG, Dynamic electromyography (DEM), and aquatic.

Results

One of the most important uses of EMG wearable sensors in hydrotherapy is their ability to generate accurate and reliable signals that can be used to monitor the effect of therapy on individuals. The technology behind the EMG wearable sensors allows them to derive information about the patient using bio-signals. Using Surface EMG sensors on land allows the therapist to monitor and assess the progress of patients using comparative analysis of the patient’s vital entries on land and while in the water. Using this information, a therapist can determine the effectiveness of the hydro rehabilitation by checking for any positive notable changes experienced during physical activity. According to Fantozzi *et al.* (2022) [6], inertial measurements are considered to be one of the most used variables in the determination of physical activity in both therapy and sport activity. Physiotherapists, therefore, use the information provided by the software used in EMG sensors to interpret a patient's physical well-being using accurate variables.

According to Cuesta-Vargas *et al*., (2020) [4], the relationship between physical activity on land and underwater is extremely important in hydrotherapy. While it is complex to notice slight movement using the physical eye, the EMG sensors have been notably useful in providing a media for noticing even small changes that could be noticed through changes in the heart rate or slight muscle movements. These small developments can be crucial for patients suffering from intense physical conditions. EMG wearable sensors have been incorporated by physiotherapists to measure even the slightest of changes in the electrical potential between two points of a muscle. The EMG wearable sensors have been made waterproof to enhance their usefulness in this aspect. As mentioned earlier, water has been established to have a soothing and relaxing effect. Based on a study conducted by Yokoyama *et al*., (2021) [26] pain is a contributing factor to the slow treatment of patients with locomotive difficulties. It can therefore be complex to assess the real degree of injuries or the actual level of a medical condition if a patient's ability to show actual developments is inhibited by pain. However, using hydro-rehabilitation has been made possible. It is important to note however that physical monitoring of physical activities under water can be extremely hard which makes EMG wearable sensors of much importance in this field.

Based on the analysis of Mazzetta *et al*., (2019) [15], the most important feature of the EMG wearable sensor is its non-invasive nature. This element of technology has made it highly preferred by medical practitioners as it has lowered the cases of bacterial infections caused by other traditional methods of measuring physical activity. According to a study conducted by Tam *et al*., (2019) [25], the scholars deduced that while the EMG sensors are externally placed on the patient's body, they can send electrical signals all over the human body. The information retrieved from the signal is important to therapists as they utilize it to generate an analysis of the muscle activity as a measure of evaluating the patient's muscle status. According to Yokoyama *et al.* (2021) [26], the evolution of EMG sensors is completely dependent on their design development over the years. At their creation stage, EMG sensors were extremely cumbersome and bulky with a lot of wires that had invasive electrodes. The current designs are more noninvasive, less bulky, and have been guaranteed to be safe enough to ensure no bacterial infections during procedures.

Discussion

According to the findings generated from the evaluation of the seven articles. It was discovered that the EMG sensors do not promote the improvement of skeletal muscle activities in patients with severe injuries or those suffering from medical conditions. The usefulness of the EMG wearable sensors was in monitoring the activities of the muscles from two points which in this case is on land and underwater. The role played by EMG sensors to measure muscle activity is extremely important for the physiotherapist to monitor and evaluate the clinical process and the effectiveness of hydro-rehabilitation as a treatment method. Most of the articles also show that the EMG wearable sensors are designed to be applied remotely and provide technical abilities for monitoring and controlling any rehabilitation exercises that are aimed to improve motor abilities (Cuesta-Vargas *et al*., 2020) [4]. This technology has therefore been determined to be a functional integration in hydrotherapy as a treatment method in the healthcare sector.

During the research of this study, it was established that there are limited research materials on the uses of EMG wearable sensors on land and underwater in hydro-rehabilitation. Based on the effectiveness of both methodologies and their contributions to the medical sector, it is important that more studies are conducted, and human samples used to determine the actual effectiveness and usefulness of both methodologies when incorporated together to enhance the medical well-being of patients suffering from muscle injuries and muscle-related disease. The findings of this article are based on assumptions generated through the application of the hypothesis generated from the 7 articles. It is however impossible to determine the facts behind the findings as there are no evidence-based articles that have been submitted to support the concepts generated in this article.

Conclusion

In conclusion, it is important to understand that the application of wireless and wearable technologies has become a norm and a necessity in modern rehabilitation. And while this article focuses on the use of EMG sensors in hydro-rehabilitation, different studies have explored the importance of this technology in different other treatments for patients with muscle problems and also those with heart conditions. There have been a lot of developments concerning EMG sensors. These developments are aimed at maximizing the uses of this technology. There has been a great increase in the medical conditions of the human population. The traditional concept of medical conditions such as Parkinson's disease affecting elder people is slowly fading as young people continuously show signs of being victims. Young children are also showing signs of medical conditions that affect their physical movement. These kinds of situations are increasing the demand for EMG sensors as their contribution to hydro-rehabilitation has been proven to be of high importance. This study is considered to be important for both medical practitioners' especially physiotherapists and also for the general public as they can understand the importance of integrating these two methodologies that have made a difference in the medical sector due to their effectiveness in patient treatment

Acknowledgement

Not available

Author’s Contribution

Not available

Conflict of Interest

Not available

Financial Support

Not available

References

1. Abu-Faraj ZO, Harris GF, Smith PA, Hassani S. Human gait and clinical movement analysis. Wiley Encyclopedia of Electrical and Electronics Engineering; c2015. p. 1-34.
2. Agostini V, Ghislieri M, Rosati S, Balestra G, Knaflitz M. Surface electromyography applied to gait analysis: how to improve its impact in clinics? Frontiers in Neurology. 2020;11:994.
3. Centeno JG. Assessing services with communicatively impaired bilingual adults in culturally and linguistically diverse neurorehabilitation programs. Journal of Communication Disorders. 2015;58:58-73.
4. Cuesta-Vargas Á, Martín-Martín J, Pérez-Cruzado D, Cano-Herrera CL, Güeita Rodríguez J, Merchán-Baeza JA, *et al*. Muscle activation and distribution during four

test/Functional tasks: A comparison between dry-land and aquatic environments for healthy older and young adults. International Journal of Environmental Research and Public Health. 2020;17(13):4696. https://doi.org/10.3390/ijerph17134696

5. Das KK, Roy RK, Singh HK, Bezboruah T. An embedded system for monitoring pulse rate during indoor exercise. Advance Res Electric Electron Eng. 2016;3(5):354-357.
6. Fantozzi S, Borra D, Cortesi M, Ferrari A, Ciacci S, Chiari L, Baroncini I. Aquatic therapy after incomplete spinal cord injury: Gait initiation analysis using inertial sensors. International Journal of Environmental Research and Public Health. 2022;19(18):11568. https://doi.org/10.3390/ijerph191811568
7. Garcia-Hernandez N, Garza-Martinez K, Parra-Vega V. Alvarez-Sanchez, A., & Conchas-Arteaga, L. Developing an EMG-based exergaming system for isometric muscle training and its effectiveness in enhancing motivation, performance, and muscle strength. International Journal of Human-Computer Studies. 2019;124:44-55.
8. Herbert-Copley A. Design and Evaluation of a Variable Resistance Orthotic Knee Joint (Doctoral dissertation, Université d'Ottawa/University of Ottawa; c2015.
9. Horsak B. Advancements in biomechanical research in gait analysis and motor rehabilitation.
10. Kaufman MT, Seely JS, Sussillo D, Ryu SI, Shenoy KV, Churchland MM. The largest response component in the motor cortex reflects movement timing but not movement type. Eneuro. 2016,3(4).
11. Knarr BA, Reisman DS, Binder-Macleod SA, Higginson JS. Understanding compensatory strategies for muscle weakness during gait by simulating activation deficits seen post-stroke. Gait & posture. 2013;38(2):270-275.
12. Krogstad JR, Hjorthol R, Tennøy A. Improving walking conditions for older adults. A three-step method investigation. European Journal of aging. 2015;12(3):249-260.
13. Leclair J, Pardoel S, Helal A, Doumit M. Development of an unpowered ankle exoskeleton for walking assist. Disability and Rehabilitation: Assistive Technology; c2018.
14. Masumoto K, Shono T, Hotta N, Fujishima K. Muscle activation, cardiorespiratory response, and rating of perceived exertion in older subjects while walking in water and on dry land. Journal of Electromyography and Kinesiology. 2008;18(4):581-590.
15. Mazzetta I, Zampogna A, Suppa A, Gumiero A, Pessione M, Irrera F. Wearable sensors system for improved analysis of freezing of gait in Parkinson's disease using electromyography and inertial signals. Sensors. 2019;19(4):948. https://doi.org/10.3390/s19040948
16. Northeast L, Gautrey CN, Bottoms L, Hughes G, Mitchell AC, Greenhalgh A. Full gait cycle analysis of lower limb and trunk kinematics and muscle activations during walking in participants with and without ankle instability. Gait & posture. 2018;64:114-118.
17. Papavasiliou AS. Management of motor problems in cerebral palsy: a critical update for the clinician. european journal of pediatric neurology. 2009;13(5):387-396.
18. Parziale A, Senatore R, Marcelli A. Exploring speed-accuracy tradeoff in reaching movements: A neurocomputational model. Neural Computing and Applications, 2020;32(17):13377-13403.
19. Pettee KK, Storti KL, Ainsworth BE, Kriska AM. Measurement of physical activity and inactivity in epidemiologic studies. Epidemiological methods in physical activity studies; c2009. p. 15-33.
20. Raffaelli C, Milanese C, Lanza M, Zamparo P. Water-based training enhances both physical capacities and body composition in healthy young adult women. Sport Sciences for Health. 2016;12(2):195-207.
21. Rosati S, Agostini V, Knaflitz M, Balestra G. Muscle activation patterns during gait: A hierarchical clustering analysis. Biomedical Signal Processing and Control. 2017;3(1):463-469.
22. Sanz-Merodio D, Cestari M, Arevalo JC, Carrillo XA, Garcia E. Generation and control of adaptive gaits in lower-limb exoskeletons for motion assistance. Advanced Robotics. 2014;28(5):329-338.
23. Severin AC, Burkett BJ, McKean MR, Wiegand AN, Sayers MG. Quantifying kinematic differences between land and water during squats, split squats, and single-leg squats in a healthy population. PloS one. 2017;12(8):e0182320.
24. Steele J, Bruce-Low S, Smith D. A reappraisal of the deconditioning hypothesis in low back pain: a review of evidence from a triumvirate of research methods on specific lumbar extensor deconditioning. Current medical research and opinion. 2014;30(5):865-911.
25. Tam S, Bilodeau G, Brown J, Gagnon-Turcotte G, Campeau-Lecours A, Gosselin B. A wearable wireless armband sensor for high-density surface electromyography recording. 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); c2019. https://doi.org/10.1109/embc.2019.8857750
26. Yokoyama H, Kato T, Kaneko N, Kobayashi H, Hoshino M, Kokubun T, Nakazawa K. Basic locomotor muscle synergies used in land walking are finely tuned during underwater walking. Scientific Reports. 2021;11(1). https://doi.org/10.1038/s41598-021-98022-8
27. Yeh CH, Young HWV, Wang CY, Wang YH, Lee PL, Kang JH, Lo MT. Quantifying spasticity with limited swinging cycles using a pendulum test based on phase-amplitude coupling. IEEE Transactions on Neural Systems and Rehabilitation Engineering. 2016;24(10):1081-1088.
28. Zhang W, Wang J, Han G, Zhang X, Feng Y. A cluster sleep-wake scheduling algorithm based on 3D topology control in underwater sensor networks. Sensors. 2019;19(1):156.
29. Zhao S, Liu J, Gong Z, Lei Y, OuYang X, Chan CC, Ruan S. Wearable physiological monitoring system based on electrocardiography and electromyography for upper limb rehabilitation training. Sensors. 2020;20(17):4861. https://doi.org/10.3390/s20174861
30. Zyukov IM. The effectiveness of the methods for combined hydro rehabilitation to develop selected locomotor functions in the patients presenting with an infantile cerebral paralysis. Russian Journal of Physiotherapy, Balneology and Rehabilitation.

2017;16(4):211-215. https://doi.org/10.18821/1681-3456-2017-16-4-211-215.

How to Cite This Article
Konstantinos Chandolias, Vasiliki Stefanouli, Aristi Tsokani, Eleni-Argyroula Tsounia and Anthi Kellari. Suicidal behavior among Iranian psychiatric patients. International Journal of Advanced Research in Medicine. 2022;4(2):88-93.

Creative Commons (CC) License
This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.