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Preface

The publication process of the 'Inspiring Technologies and Innovations (INOTECH)' journal is continuing with the decision numbered 261 taken at the session of the Senate of Kastamonu University dated 2.12.2021 and numbered 26, and with the coordination of Kastamonu University Technology Transfer Office.

Our journal named 'Inspiring Technologies and Innovations (INOTECH)', which is a pioneer because it prioritizes R&D and innovation issues in multidisciplinary fields, is a peer-reviewed, open access, free publication policy and periodical research journal by Kastamonu University twice a year.

Aiming to develop in the way of presenting qualified works to national and international readers with the principle of scientific publishing, this first issue of our journal includes 5 original research and 1 review research articles from different disciplines and research fields.

We would like to thank all the academicians who contributed by sending their works, and all the referees who contributed in the evaluation process of these works;

We hope that the interest and support for our journal from the national and international community will increase.

Regards.

Prof. Dr. Kasım YENİGÜN

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Inspiring Technologies and Innovations

<https://dergipark.org.tr/tr/pub/inotech>**Research Article** RFID Cartesian Smart Parking Lot SystemSabri UZUNER^a Fatih Mert CELEBI^b^aDuzce University, Engineering Faculty, Mechatronics Engineering, TÜRKİYE^bDuzce University, Engineering Faculty, Mechanical Engineering, TÜRKİYEORCID^a: 0000-0002-9099-1324ORCID^b: 0000-0002-1945-9343Corresponding Author e-mail: sabriuzuner@duzce.edu.tr<https://doi.org/10.5281/zenodo.10119423>**Received** : 01.09.2023 **Accepted** : 13.11.2023 **Pages** : 21-25

ABSTRACT: In recent years, smart products in different fields that have come to the market continue to exist and increase. Smart products, which we hear about in every sector, allow us to make life easier, save time, and even allows us to protect nature. In this study, the smart parking lot system aims to provide security, save space, save time, and reduce the carbon emitted while searching for a parking space with the vehicle. In the present study, Arduino MEGA 2560 was used as the controller, DC motor with reducer to provide movement, encoder to count the steps of the moving motors, servo motor to place the cars on the shelves, MFRC522 card reader to read RFID cards, 20x4 LCD screen for information and 12V DC adapter to provide the power required by the system. The car park has 3 rows and 4 columns and 12 parking spaces. The vehicle arriving at the car park is parked in the car park by reading any RFID (13.56MHz) card. If there is no free space, the warning "There is no space in the parking lot!" is given. In the realized system, integrating RFID security standards into parking lot automation may provide advantages in terms of security and time.

KEYWORDS: Arduino, Smart parking lot, Encoder, RFID, Automation**1. INTRODUCTION**

Technology has entered almost every aspect of human life today (Anli and Taş, 2018; Meral, 2018). The innovations brought by technology facilitate people's daily lives and contribute to their adaptation to changing world conditions (Davey et al., 2018; Yam and İlhan, 2020). New inventions from the past to the present have brought new problems, such as where these inventions will be used (Seferoğlu, 2015), the areas where they will be stored (Sağlık, 2021), the storage conditions, and so on. For example, the telephone was invented and brought features such as a battery for carrying (Beyzanur, 2020; Şükran and Güngör, 2021), a charger for charging, and even wireless charging, which has recently become widespread (Aydın, 2020; İspir, 2020).

As the invention of the car has added many requirements to the car, parking lots have become widespread as safe areas where the car will be kept. With the increase in city life, parking lots were not enough and were replaced by multi-story parking lots (Haldenbilen et al., 1999). The disadvantages of multi-story parking lots include being unable to find the car due to many floors, theft of valuables in some parking lots without cameras, and, of course, the time lost while parking and picking up the vehicle (Cheng and Nian, 2021). These disadvantages of parking garages have pushed parking lots to become smart (Güngör and Öztürk, 2017).

There are many different automation systems integrated into parking lots. Bingöl et al. (Bingöl et al., 2010) studied a PLC-controlled automatic parking garage system. In their study, a three-story, three-row parking lot system with a total capacity of nine vehicles was designed. In a study by Yardım and Ağrıklı (Yardım and Ağrıklı, 2005), automatic parking garages used worldwide were examined, and their contribution to the solution of the parking problem in Turkey was evaluated. A study by İçer (İçer, 2019) aimed to develop smart car parks with controlled charging stations that are centralized and collected at certain points instead of individual or scattered uncontrolled charging stations. By calculating the power requirement for vehicle charging in the parking lot, an effective PLC-based energy control automation has been developed to ensure efficient use of energy resources by considering the grid power demand density. Can and Ilıcalı (Mesut and Ilıcalı, 2019) introduced the mechanical lift, which is a semi-automatic and fully automatic parking system which have been used for a long time in developed countries where the construction of traditional open or closed parking lots is inefficient or does not meet the needs in terms of capacity and operating conditions.

There are RFID systems used for different purposes in parking lots. Pala and Inanc (Pala and Inanc, 2008) carried out parking lot entrance and exit controls with RFID readers, tags, and barriers. In the study by Winter and Goel (Winter and Goel, 2021),

an RFID tag is attached to the vehicle for parking lot occupancy detection, and information about the vehicle, such as brand, model, and license information, is stored in the memory of this tag. Moreover, when the vehicle enters the range of the reader placed in the parking lot, the reader detects the tag, reads the stored data, identifies the vehicle, and determines whether it is parked.

In the present study, an automation system for smart car parks that can be entered and exited with an RFID system has been developed. The developed system is presented as a solution to the problem of finding a parking space, which is one of the problems experienced in urban parking. At the same time, the vehicle can be dropped off and picked up with any RFID-enabled card used in daily life (bus card, student card, credit card, etc.) without requiring an RFID card registered in the car park. paragraph.

2. MATERIAL and METHOD

Arduino MEGA 2560, geared DC motor, encoder, servo motor, MFRC522 card reader, 20x4 LCD screen, and 12V DC adapter were used in the present study. The system is designed to provide automatic parking management and layout.

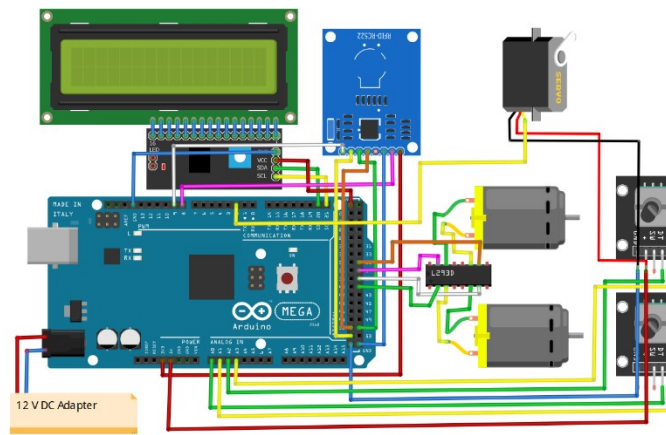


Figure 1. Experimental Setup

Control and management were coordinated through the Arduino MEGA 2560 microcontroller. Arduino Mega 2560 is an electronic control board with Atmel's ATmega2560 microcontroller. There are 15 PWM outputs among the 54 input-output pins on it. It also has 16 analog inputs on it (Kayaalp and Özkorucuklu, 2015).

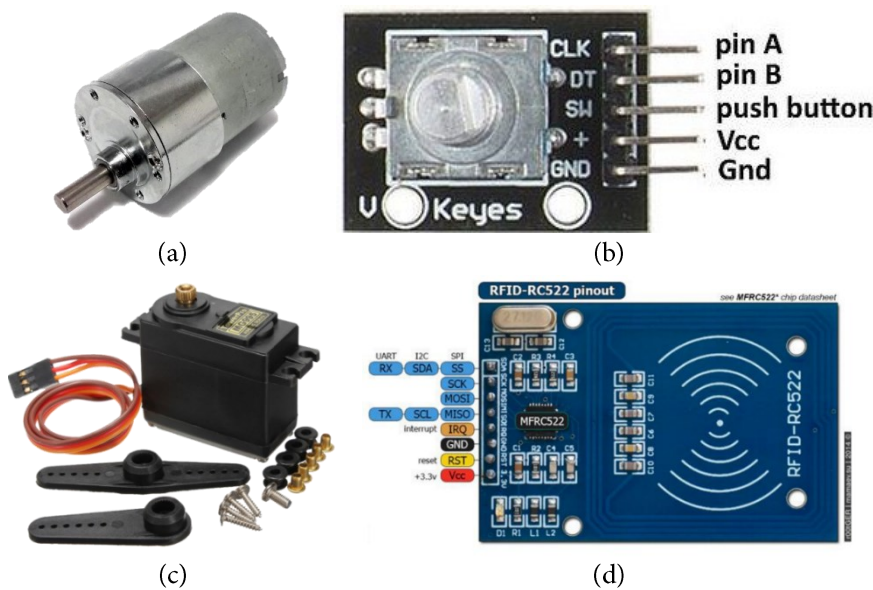


Figure 2. (a) Geared DC Motor, (b) HW-040 Encoder, (c) Servo Motor, (d) MFRC522 RFID Module

Preferred DC motors with gearboxes that transmit motion ensured smooth and precise movement of parked vehicles. Gearboxes are gear systems that change the speed-to-torque ratio of a rotary motion with the help of gears. They are closed-gear assemblies designed to convert the high rotational speeds of motors into the torque required for machines (Erkan, 2014). The Gearmotor DC motor consists of a reducer and a motor (Figure 2a). HW-040 encoders accurately tracked these motors' movement steps to determine the parked vehicles' position. The encoders in question, shown in Figure 2b, a rotary encoder, also called a shaft encoder, are electromechanical devices that convert the angular position of an axle into analog or digital output signals (Salur et al., 2021). The HW-040 model encoders used in this study can count 30 steps in 1 circular revolution. The task of shelf arrangement and placement of vehicles in the car park was undertaken by servo motors. MG995 servo motor, shown in Figure 2c, was used in this study. The servo was an automatic device that controlled the functioning of any mechanism with the help of a feedback device by detecting errors and eliminating errors. It is the most widely used motor type in robot technology. As the DC motor in the servo moves, the potentiometer rotates, and the control circuit compares the motor's position with the desired position and drives the motor (Saraltın, 2017). MFRC522 card reader is used to read RFID cards in the system so that vehicles and parking spaces can be uniquely identified. The MFRC522 RFID Reader module shown in Figure 2d generates a 13.56MHz electromagnetic field to communicate with RFID tags (Süzen and Taşdelen, 2018). The RFID reader comprises a Radio Frequency module and an antenna that generates a high-frequency electromagnetic field. The RFID tag is a passive RFID device. The feature that allows it to operate without energy is that it contains a microchip that stores and processes information and an antenna for receiving and transmitting a signal. The tag is placed within range of a reader, and the reader generates an electromagnetic field that allows electrons to pass through the tag's antenna and then power the chip to read the information encoded on a tag (Karakoç et al., 2021). The system is directed according to the information in the read RFID card. In addition, a 20x4 LCD screen was integrated into the system to provide users with operational status and instant information presentation. This screen instantly displayed the parking spaces' status, occupancy rates, and guidance information. As a result, users can quickly and easily obtain information about the car park's status. A 12V DC adapter supported the system to provide uninterrupted and sufficient power. This adapter was selected considering the energy requirement of the Gearmotor DC motors that provide movement in 2 axes. The car park has a 3x4 matrix structure and has 12 parking spaces. Incoming vehicles are directed to empty parking spaces by reading their RFID cards. However, when all parking spaces are full, the system warns the users, "There is no space in the car park!". This feature aims to help prevent time loss for vehicle owners and optimize car park management.

3. RESULTS and CONCLUSION

Initially, it was planned to arrange the shelves in a cylindrical arrangement. As a result of the research, it was determined that when the cylindrical parts are arranged side by side, there are gaps between them, which cannot be used. Since one of the most important goals of this study was to save space, geometric shapes that are compatible with each other were emphasized. Hexagonal parts can be arranged side by side like a honeycomb without leaving any space between them. However, the corners cannot be used since the motor will move the system from the center to the middle during the usage phase.

The square and rectangle were emphasized. Since it will be an example, the number of parks was determined as 12, and the design was started to be made accordingly. The design was made in 3x4 (3 rows, 4 columns). Then, the shelves were converted into a Cartesian (x,y) system. Using 2 motors, the mechanism movement was realized in x (vertical) and y (horizontal) planes. DC motors provided this movement. At the end of the DC motor is a 20-tooth pulley and an encoder with the same axis as this pulley. The pulley at the end rotates the encoder, and the position information of the encoder is transmitted to the Arduino. In this way, the position control of the DC motor can be easily done.

A demonstration study was conducted to assess the system's performance. Initially, the encoder lacked positional information when the system was first initiated due to the absence of a zero setting. A limit switch was employed to determine the zero positions of the motors responsible for moving the axes to address this issue. In the software developed for this purpose, all motors automatically align with the predefined zero point upon program initiation. This zero point is also where vehicles are picked up and placed.

When considering inter-axis movements, we initially opted for a double steel bar layout but subsequently realized that a single bar could effectively resolve the issue. The drawback of using double rods lies in the additional compressive load imposed on the system, resulting in a doubled weight. Instead of the bolt initially used to transmit linear motion for vehicle parking, we explored the possibility of employing the 3D printer Z-axis bolt as a more favorable alternative. However, this would necessitate using a

more powerful motor, presenting a trade-off between time and cost. If speed is a priority, opting for the 3D printer bolt with a higher-powered motor is advisable, with cost considerations taking a secondary role. When contemplating axis movements, one can envision a configuration where the motor and steel rods responsible for the x-axis motion are mounted on the y-axis. This approach may offer advantages in terms of aesthetic design and expedited results.

In conclusion, this study successfully developed an RFID-based smart car park automation system to alleviate urban parking issues. It accommodates various RFID-enabled cards for vehicle access, eliminating the need for dedicated cards. The design evolved from cylindrical shelving to a space-efficient 3x4 grid, controlled by DC motors with encoders in a Cartesian system. A limit switch ensured zero position alignment for motors. The choice between single and double steel bars, as well as the consideration of a 3D printer Z-axis bolt, balanced speed and cost factors. The study's innovative axis configuration proposes mounting x-axis components on the y-axis for potential efficiency and aesthetics. This work provides valuable insights for future automated parking projects and optimization efforts.

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Research Article **Pv/T Systems For Energy Efficiency By Using Advanced Deep Neural Network (DNN) And Nanofluid In Solar Systems**

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ABSTRACT: Today, solar energy is a very popular alternative energy source due to its enormous availability in nature. In this study, focusing on the electro-mechanical production industry of advanced PV/T solar panels, studies carried out on the development of new methodological methods for the efficiency of existing asset management practices of the infrastructure of this industry and the optimal improvement. For this, it is to integrate a power-generating PV/T panel and a solar thermal heating panel within the same collection surface. PV/T systems are one of the subjects that scientific studies have focused on in recent years. The main reasons for this are to increase the electricity generation performance of PVs, as well as to obtain thermally hot fluid from the system. In this research, it was implemented using a new roof-mounted PV/T multi-reflection panel, which not only increases the power output of the PV/T panel, but most importantly, the aesthetic aspect is a major barrier to large-scale uptake of PV/T. In this study, we developed a new advanced MPPT (maximum power point tracking) algorithm such as Deep Neural Network (DNN) controller especially for photovoltaic system. The proposed DNN based MPPT algorithm is developed PV/T voltage, current and corresponding duty cycle.

KEYWORDS: PV/T, MPPT, DNN, Türkiye, İran, Nanofluid

1. INTRODUCTION

In the near future, the demand for electrical energy is expected to increase rapidly due to world population growth and industrialization. Solar Photovoltaic PV/T systems are one of the most promising renewable energy sources that convert solar energy into electrical energy in a way that is compatible with the environment. However, the efficiency of these systems is low and their relative costs are high. In order to overcome these disadvantages, a grid-connected PV energy system is needed to meet the load requirement requirements. The proposed microgrid system and its controller block diagram are shown in figure -1.

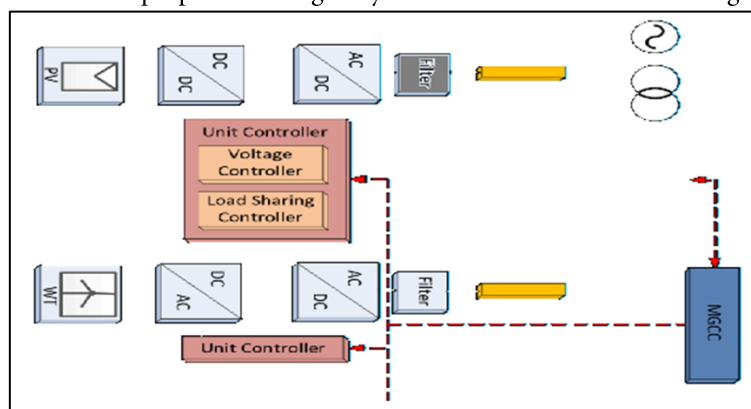


Figure 1. Micro Grid System and Controller Block Diagram

The amount of electricity produced in Turkey, one of the developing countries, does not meet the energy needs. More than half of our energy needs go to neighboring countries (Russia, Bulgaria, Iran, etc.) we need in a connected country. Decarbonized coal, lignite, oil and natural gas are among the domestic energy sources. Approximately 97% of the grid electricity in Turkey is

produced from fossil fuels that emit harmful CO₂ gases into the atmosphere. In the energy sector, CO₂ emissions can be reduced by increasing the share of renewable energy sources among electricity suppliers [1-5]. Based on what is expected from this model and what the existing software is, the best software that can be used for modeling has been developed by scanning the literature, and the necessary data and the necessary data analysis have been carried out step by step. In the near future, it is expected that the world's population increase and the demand for electrical energy will increase rapidly due to industrialization. This increase in energy demand requires electricity companies to increase their production. Nowadays Iran, Turkey, Europe, Asian and European have focused on both useful and advanced innovation of ergonomic systems for renewable energy systems. Recent scientific research shows that world net electricity production increased from 17.3 Gwh in 2005 to 24.4 Gwh in 2015 and to 33.3 Gwh in 2030 (92.5%)[6-10].According to the results of the Turkey National Energy Plan study, electricity consumption is expected to reach 380.2 TWh in 2025, 455.3 TWh in 2030 and 510.5 TWh in 2035.In 2023, 34.6% of our electricity production will come from coal, 22.2% from natural gas, 20.6% from hydraulic energy, 10.8% from wind, 4.7% from solar, 3% from solar energy, 3% obtained from geothermal energy and 3.7% from other sources. As of the end of July 2023, our country's installed power has reached 105,135 MW (Republic of Turkey Ministry of Energy and Natural Resources-2023) [10-12].

2. MATERIAL AND METHODS

2.1. Deep Neural Network for PV/T

It is a new advanced maximum power tracking algorithm developed as deep neural network controller for photovoltaic systems PV/T. The proposed DNN-based MPPT algorithm developed using 80000 data such as PV/T voltage, Current and corresponding duty cycle, as shown in Deep and Artificial Neural Network based Figure -2 [13-17]. The algorithm of PV system simulation model developed and Matlab. The proposed simulation model was used with a 50 Kw [18-22].

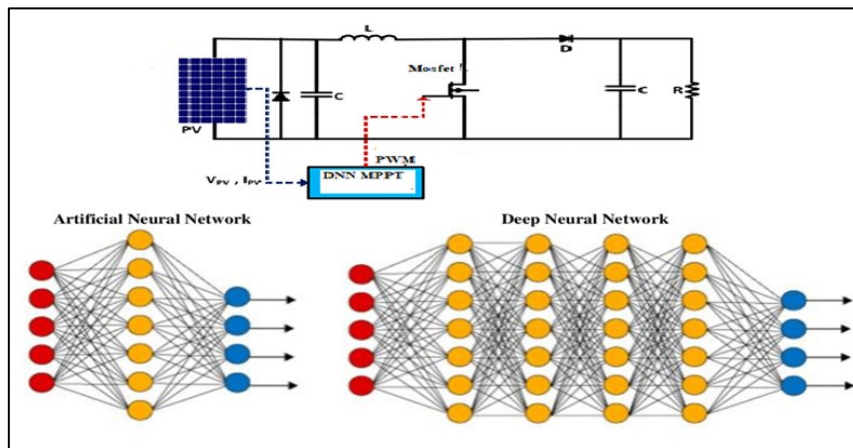


Figure 2. Deep and Artificial Network Based Maximum Power Tracking [23-25].

2.2 Artificial Neural Network(ANN)

ANN is a numerical representation of the ANN in an individual's brain, consisting of a large number of nerve cells called interconnected neurons [25-30]. Communication between neurons is established by short-term interactions of electrical signals produced by the mass of cells, called Decays. Information is transmitted from one neuron to another as electrochemical intersections called neurotransmitters, and these intersections, called dendrites, which carry the signals, are located on the branches that connect them to the body of the cell. Information is transmitted from one neuron to another as electrochemical assemblies called neurotransmitters. These junctions are located in the branches that connect them to the cell, transmit the signals it receives from a large number of neurons to the nerve cell. For analytical explanation, a simple many-layer feedforward ANN is given,

$$n1 = F1(w1x1 + b1) \tag{2.1}$$

$$n2 = F2(w2x2 + b2) \tag{2.2}$$

$$n3 = F3(w3x3 + b3) \tag{2.3}$$

$$n4 = F4(w4x4 + b4) \tag{2.4}$$

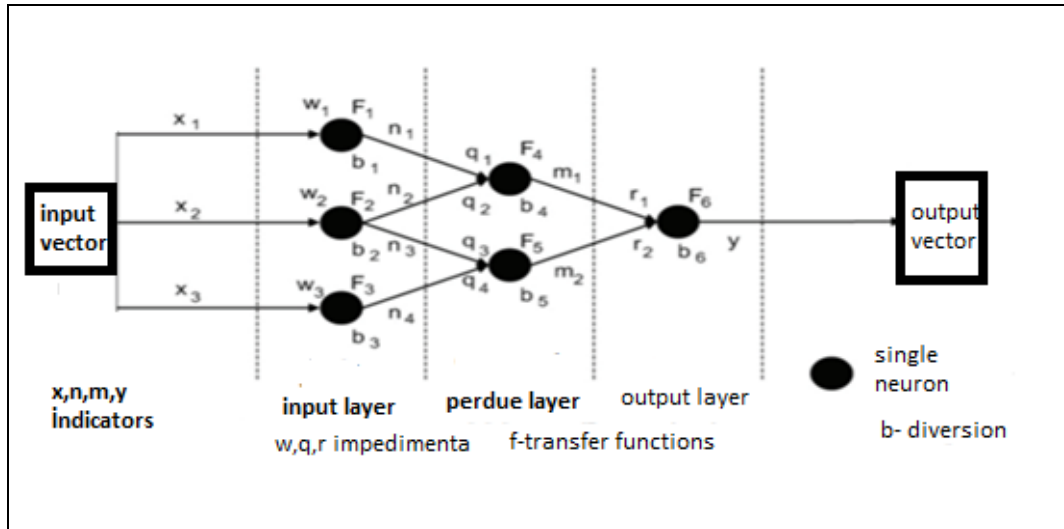


Figure 3. Advanced Feed Deep Neural Network with Single Neuron Model [27-32].

2.3 Measurement of the PV/T

The base fluid and hybrid nanofluid for different thermal physical properties calculated. The specific heat value of the hybrid nanofluid as follow,

$$Cp_{hna} = \frac{\rho_{Fe_2O_4} Cp_{Fe_2O_4} + (1 - \Phi) \rho_{pure\ water} Cp_{pure\ water}}{\rho_{hna}} \tag{2.5}$$

where Cp_{hna} is the specific heat of the hybrid nanofluid, $\rho_{Fe_2O_4}$ is the density of Fe_2O_4 nanoparticles, $\rho_{Fe_2O_4}$ is the density of Fe_2O_4 nanoparticles, $\rho_{pure\ water}$ is the density of the base liquid, ρ_{hna} is the density of the hybrid nanofluid, $Cp_{Fe_2O_4}$ is the specific heat [27-32]. The calculated thermophysical properties of the hybrid nanofluid are given in Table 1.

Table 1. Thermophysical Properties of Hybrid Nanofluid [5-8].

Hybrid Nanofluid	Density (kg/m ³)	Specific heat (J/Kg K)	Thermal conductivity (W/m K)
(Fe ₂ O ₄)/water	5.326	702.3	120.3

The necessary theoretical analysis was carried out using the data, recorded as experimental results. The heat production of PV/T panels can be expressed as follows:

$$\dot{Q}_{PVT} = \dot{m}_{PVT} c_p (T_{PVT,o} - T_{PVT,i}) \tag{2.6}$$

3. RESULTS and CONCLUSION

The study carried out in the climatic conditions of simulation results and experimental discussed for the implementation of the model, Matlab 2021a. The maximum surface temperature difference is 14°C, it observed that the cooling of the panel reached to a significant degree. In the PV/T system, the cooling amount increased by using different fluids, water, and hybrid nanofluid. It give to figure- 4 and figure-5. The variation of inlet and outlet temperatures of serpentine with time, according to the type of fluids used in the cooling circuit. Mains water primarily used as the cooling fluid in the experiments carried out according to the values measured at certain times of the day [7-10].

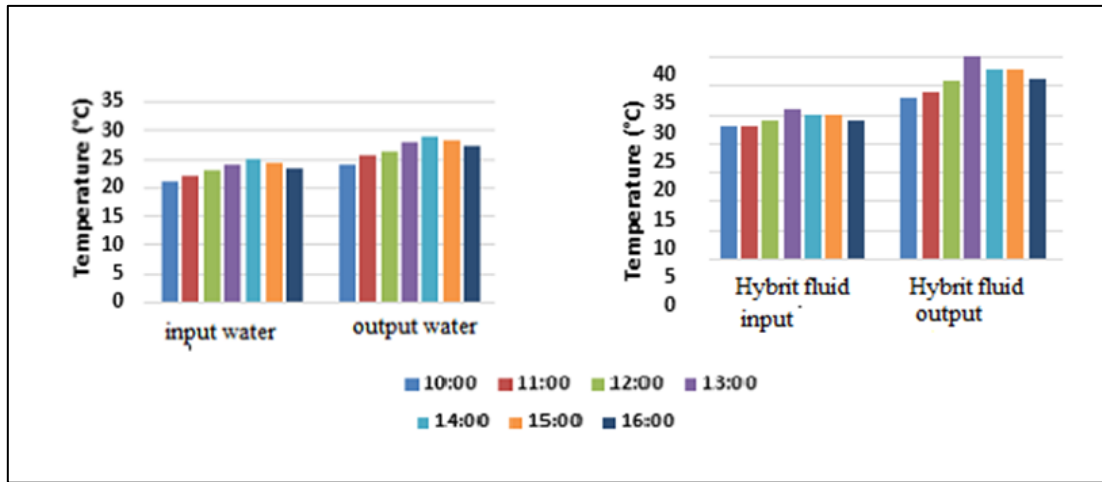


Figure 4. I/O temperature according to the fluids by using cooling circuit.

As shown in figure 5, there are three launch capacities that are often used. It has been shown that NNs with ReLU initiation capacities are much superior to other enactment capacities in terms of execution. Due to the non-linearity of the calculations, the necessary elements can be determined and the result can be calculated from the contributions.

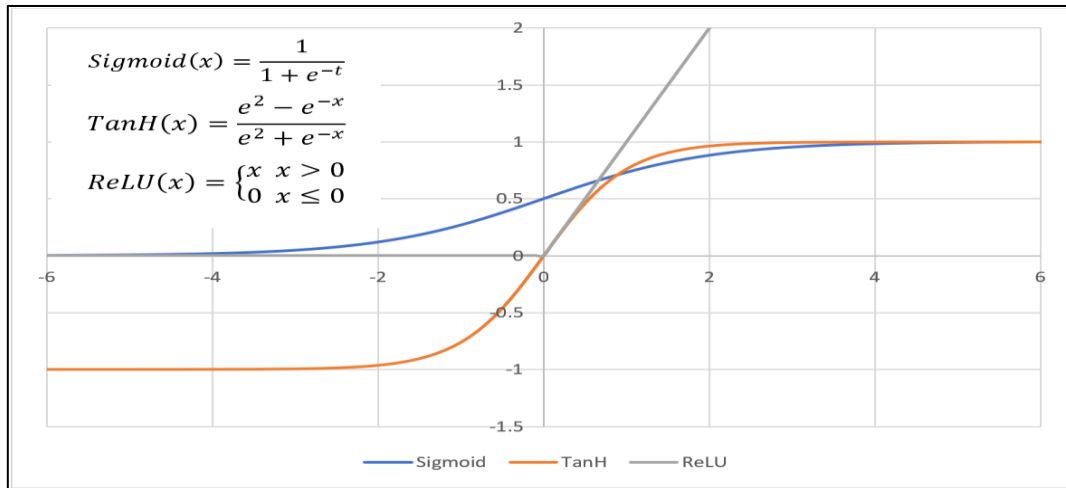


Figure 5. The Activation Function of Neurons [27-32].

In this study, investigating of providing electricity from PV/T systems connected to the electricity grid for Iran and Turkey. The most important feature and originality of our study was that until this time the studies required numerical. The fact that the obtained hot fluid has many application areas such as space heating, heating of greenhouses, use in drying systems, use as a heat source in heat pumps also causes PV/T systems to gain importance. The installation of the photovoltaic power system and its integration with the electric grid have become more common [30-35]. In this study, it can be concluded that the hybrid nanofluid containing nanometer-sized Fe_2O_4 particles is aimed to replace pure water with properties such as high thermal conductivity and heat transfer coefficient. The aim of this thesis is to analyse the operation, design and performance of a grid-connected PV system and to present the modeling of PV module behavior and characteristic features based on a mathematical model equivalent circuit based on the Matlab-Simulink 2021a version. In addition, cooling the system by using a hybrid system (water + nanofluidics) instead of water, which is traditionally used, in a certain environment, and how the output parameters and energy efficiency are affected have been experimentally studied. Considering the climatic conditions and energy needs of Turkey and Iran, successful development of the proposed system have significant economic impact and help global investment achieve the target of reducing emissions as required by both Turkish and Iranian governments. Hybrid PV/T modules with thermal units PV/T are heat-releasing systems that are installed together with a solar cell. In addition to increasing the electricity production performance of PV systems, the importance of PV/T systems is to obtain thermally hot fluid from the system. The importance of the PV/T system has also increased due to the wide application area of the produced hot fluid, which can be used as an energy source in heat pumps in industrial drying systems and for heating rooms/areas and greenhouses [33-35].

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Review Implication of Quantum Molecular Resonance Devices in Surgical Applications

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ABSTRACT: Today, studies in the field of quantum physics have provided the explanation of many unknown points about the source of vital energy of living organisms. Accordingly, quantum molecular resonance devices have been developed for surgical applications for the treatment of many diseases, especially cancer diseases.

In our study, important current studies on these devices used in surgery were compiled and the results were evaluated.

According to the results we obtained, quantum molecular resonance devices used in surgical applications have a significant effect on prolonging the life span of human beings and increasing the quality of life.

KEYWORDS: Surgical applications, quantum, molecular resonance.

1. INTRODUCTION

The peregrination of the medical world that started in macroorganisms, tissues, cells, molecular medicine, nano medicine, has shrunk to the quantum world in the microcosm today, and quantum energy has been used more frequently in the diagnosis and treatment of diseases.

In an article by Martin Riegler published in European Surgery, the importance of quantum physics in surgery was mentioned, and it was stated that "life is a quantum genetic-based self-reproducing cytohumoral information orchestration, while dead matter does not have quantum genetics". It has been emphasized that diseases arise in humans, humans are in the universe, the universe is under the influence of space-time and gravitational force, and therefore quantum physics and surgery are directly related. In the quantum world, fields consist of particles and waves as small as 10^{-66} cm². It has been reported that these waves and particles (planck quanta) used in diagnosis and treatment form the basis of the technology of machines such as magnetic resonance imaging (MRI), computerized tomography (CT), positron emission tomography (PET-CT), quantum magnetic resonance (QMR) devices. One of the most interesting phenomena in the quantum world is the observation that physicists are unable to obtain information about particles smaller than 10^{-33} . This is because the energy applied during the measurement increases the mini spacetime to form a mini black hole. In this case, no additional information can be get out from the system. This is because the light entering the mini black hole cannot escape from the black hole. Because black holes are very dense masses that increase gravity and curve spacetime. In the quantum world of humans, these mini black holes are thought to be effective in quantum genetics and have a role in the development of pathological events such as cancer and inflammation [1].

In a study by Wang et al., it was reported that devices such as bipolar cautery, monopolar cautery, ultrasonic energy-based devices, and LigaSure should be used with care in thyroid surgery, and that nerve recurrence should not be approached more than 2 mm, otherwise nerve damage may occur [2]. In this respect, QMR devices have advantages over traditional methods. In a study conducted by Tseng et al. on the safety of QMR bipolar scissors and unipolar unit in 8 pig models that underwent intraoperative neuromonitoring on 16 nerve recurrences, they reported that adverse EMG changes did not occur in both activation and cooling stages, and that these devices could be used safely in thyroidectomy surgeries [3]. In a study by Ricciarduello et al., they reported that they had excellent results in 281 allergic and nonallergic inferior turbinate hypertrophy patients who were treated with QMR, especially in nonallergic patients [4].

Devices with QMR technology are being used more and more effectively in cancer treatment. In an experimental study by Thöni et al., it was shown that quantum-based nuclear magnetic resonance therapy increased the expression of HIF-1 α , decreased hypoxia permanently by inducing glycolysis in mammalian cells, and prevented the increase in mitochondrial respiration after

acute hypoxia, thus reported that it can be used for the treatment of diseases such as ischemia [5]. In a clinical study by Kumar et al., 51 cancer patients in the terminal stage were treated with the CYTOTRON QMR device for 1 hour a day for 28 days, the patients' quality of life, overall survival and tumor stability were recorded using RECIST v1.1, and the patients were followed for 12 months. According to the results obtained in the study, an improvement in Karnofsky Performance Scala and Quality of Life score was found in 71% of the patients, and a statistically significant increase in overall survival was found [6]. The QMR coagulation device was successfully used by Yazama et al. for bleeding control in tumor resection in a case of glomus tympanicum [7]. The theranostic liposome integrated with quantum dots, superparamagnetic iron oxide, and cilengitide were successfully used to target the tumor in a glioma patient who underwent surgical resection under magnetic targeting by Xu et al. [8]. In a study by Blank et al., it was emphasized that there is a quantum leap in photobiomodulation in new generation beam-based treatments in cancer and some other complex diseases, and they reported that it can be used successfully as a cost effective especially in elderly and sensitive populations [9]. In a study by Jeong et al., it was reported that the patient was successfully treated with a QMR device and an insulated monopolar radiofrequency device in a case of injection-induced refractory filler granuloma [10].

In an experimental study by Bang et al., in an animal model, it was stated that conventional laparoscopic bipolar cautery devices cause excessive tissue damage and produce more smoke because they operate at high energy frequencies. compared to their devices; It has been reported that it is more effective, produces less smoke and causes tissue damage [11]. In a study conducted by Trivlia et al. on the effects of QMR electrotherapy in mixed-type dry eye patients, it was shown that objective and subjective ocular parameters were statistically significantly improved with QMR electrotherapy in these cases [12]. QMR technology has opened a new era in the treatment of pain in medicine.

In a study conducted by Fraccavieri et al., the effects of QMR technology on wound healing and relief of pain in 11 patients with chronic painful wounds on their extremities were examined, and this method was shown to have a statistically significant positive effect [13]. In a study by Canos-Verdecho et al., coablative radiofrequency therapy with QMR and microdissection with grasper forceps were performed in 28 patients with pain due to lumbar radiculopathy. At the end of a 6-month follow-up period, this treatment method was shown to be very effective [14].

In a study by Demirhan et al., the results of microsurgery performed with QMR in 12 patients with vocal cord polyps were evaluated. It has been shown that this technology is statistically significantly more effective in voice handicap index, laryngeal stroboscopy speed, acoustic voice analysis and perceptual voice evaluation performed 1 and 3 months after the operation [15].

3. CONCLUSION

The scientific and technological developments that have emerged at incredible speeds in the field of medicine in recent years have reached completely different dimensions, reaching as far as the Quantum world.

QMR devices have been one of the best examples of this, and it can be said with certainty that the life expectancy and quality of human beings will increase significantly.

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Research Article **Predictors of Return to Work After Lumbar Discectomy: Insights From a Comprehensive Study and Comparative Analysis**

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ABSTRACT: This retrospective study delves into the multifaceted realm of lumbar disc herniation (LDH) and its impact on patients' ability to return to work (RTW) post-surgery. LDH, a common source of pain and disability, predominantly affects individuals in their working years, making RTW a pivotal indicator of surgical effectiveness. Analyzing data from 106 patients who underwent single-level LDH surgery between 2019 and 2023, this study explored various factors influencing RTW. Results were multifaceted, revealing significant improvements in postoperative pain levels, validating the efficacy of surgical interventions. Nevertheless, no statistically significant differences in RTW were observed based on gender, LDH level, or occupation, although a trend toward longer RTW times for female patients and lower self-efficacy scores for manual workers emerged. However, this study introduced an additional dimension by assessing the influence of occupational status, highlighting potential disparities among occupational groups in self-efficacy beliefs related to RTW. The utilization of the Return-to-Work Self-efficacy Questionnaire (RTWE-SE-19) provided insights into patients' confidence levels regarding their ability to return to work. Generally, patients exhibited moderate to high self-efficacy scores, reflecting their positive beliefs in RTW capabilities. In essence, this study contributes to the growing body of knowledge surrounding LDH and RTW by emphasizing the multifactorial nature of this issue. It underscores the significance of surgical pain relief and the need for further investigation into the nuanced influences of gender, occupation, and psychological factors on postoperative RTW. Ultimately, these insights pave the way for tailored interventions and improved RTW outcomes for LDH surgery patients.

KEYWORDS: Lumbar Disc Herniation, Return to Work, Surgical Outcomes, Self-Efficacy, Occupational Status

1. INTRODUCTION

Lumbar disc herniation (LDH) is a common cause of pain and disability that disproportionately impacts people in their active working years within the general population. There is a pressing need for treatment strategies that can expedite symptom relief and facilitate a quicker return to work. Common symptoms of LDH include radiating pain in the lower extremities and, in rare cases, loss of neurological function. While many patients experience natural improvement within the first few weeks or months, a subset continues to suffer from persistent or worsening symptoms after 4 to 12 weeks of non-surgical treatment, prompting referral to a spine surgeon for potential discectomy (Gadjradj et al., 2017; Johansson et al., 2016).

The capacity to resume work (Return to Work or RTW) after undergoing surgery for lumbar disc herniation stands as a vital benchmark for assessing its efficacy and overall success. This is significant not only for individual patients but also for the broader economy. Achieving an early RTW is linked to numerous advantages, including improved physical and mental well-being for patients and substantial social and economic benefits (Atarod et al., 2021; Laasik et al., 2021; Paulsen et al., 2020).

Prolonged leg pain and an extended period of preoperative sick leave are factors that elevate the risk of not resuming work. Furthermore, when an individual's sick leave extends beyond six months after surgery for lumbar disc herniation, there is a substantial likelihood, reaching up to 50%, that they may not be able to return to work (Frank et al., 1996). As a result, the foremost reason for choosing elective disc herniation surgery is to promptly alleviate symptoms, enabling a swift return to work and preventing the emergence of lasting work-related disabilities. Multiple factors have been suggested as potential contributors to prolonged sick leave, including postoperative leg pain, reduced work motivation, and being female (Khan et al., 2019). Identifying predictive factors for returning to work can aid in selecting appropriate patients and establishing realistic rehabilitation goals post-surgery. Past research on this topic has yielded somewhat conflicting results (Atarod et al., 2021; Paulsen et al., 2020; Schade et al., 1999).

2. MATERIAL AND METHOD

In this retrospective investigation, 106 patients who had undergone surgery to address single-level lumbar disc herniation (LDH) within the time frame of 2019 to 2023 were enrolled. The study had obtained ethical clearance from the Institutional Review Board (Approval ID: TUEK E1-23-3981), and written informed consent had been secured from every patient who took part in the study.

The central objective of this research was to evaluate the RTW, which was specifically defined as the duration from the hospitalization date for surgery to the date when the patient resumed employment within the frameworks of the Ministry of Health and the Ministry of Labour and Social Security systems. RTW functioned as an important gauge to measure how long it took for patients to rejoin the workforce, if they did so, after their surgical intervention. This time frame was determined by calculating the number of days between the patient's discharge date and the conclusion of their sick leave.

To evaluate the occupational status of the patients, their respective job titles were meticulously classified into three distinct groups, utilizing the well-established International Standard Classification of Occupation (ISCO) as a framework. These categories were delineated as follows (Laasik et al., 2021):

- 1- Higher-Grade Non-Manual Workers: This category encompassed individuals holding positions typically associated with advanced skill sets and responsibilities. Examples of occupations falling into this group include esteemed professions such as teachers and physicians. These individuals typically engage in knowledge-based or managerial roles.
- 2- Lower-Grade Non-Manual Workers: In this classification, job titles characterized by less advanced skill requirements and generally not involving managerial responsibilities were included. Occupations within this category comprised roles like registered nurses and technicians. These individuals often perform tasks that require specialized training but may not be at the highest level of expertise or decision-making.
- 3- Manual Workers: This group encompassed individuals primarily engaged in physically demanding and labor-intensive roles. Occupations falling under this category encompassed positions such as cleaners and maintenance workers. These workers are typically involved in tasks that require manual labor, physical exertion, and hands-on activities.

By categorizing the patients' job titles into these three distinct groups based on the ISCO, the study aimed to assess the potential influence of occupational status on various aspects related to lumbar disc herniation surgery and return to work outcomes.

In this research, the Return-to-Work Self-efficacy Questionnaire (RTWE-SE-19) was utilized as a valuable instrument for assessment (Horn et al., 2022). The RTWE-SE-19 is a specialized questionnaire designed to gauge an individual's self-efficacy or their belief in their ability to successfully return to work after a medical intervention or period of illness (Horn et al., 2022). This questionnaire serves as a valuable instrument for understanding the psychological and emotional factors that can influence a patient's ability to reintegrate into the workforce following surgery or a health-related absence. Through the incorporation of the RTWE-SE-19 questionnaire in this investigation, researchers aimed to achieve a more profound insight into the self-efficacy levels of the study participants and how these perceptions might correlate with their real-world return-to-work results following surgery for single-level lumbar disc herniation. This valuable information enhances the overall evaluation of factors impacting the successful reintegration of patients into their professional roles. When evaluating the RTWE-SE-19, a score of (1-5) was classified as low self-efficacy, (5-7,5) as moderate, and (7,5-10) as high self-efficacy (Paulsen et al., 2020). Additionally, RTWE-SE-19 was administered during outpatient clinic visits, typically occurring within the first three months after the patients had resumed their work.

The data analysis in this study utilized the IBM SPSS 25.0 statistical software package (IBM Corp., Armonk, NY). It encompassed a variety of statistical methods, including descriptive statistics like frequency, percentage, mean, standard deviation, median, and the range (min-max). Qualitative data were compared using the Chi-Square (χ^2) test. The normality of the data distribution was assessed through the Kolmogorov-Smirnov test, as well as measures of skewness and kurtosis, and graphical methods like histograms, Q-Q plots, stem-and-leaf plots, and box plots. For group comparisons, the Independent Samples t-test was applied, while the Paired Samples t-test was used for within-group comparisons of normally distributed quantitative data. Statistical significance level was accepted as $\alpha=0.05$.

3. RESULTS

In Table 1, the study presents patient characteristics. Notably, the most common surgical procedure targeted the L4-5 level, accounting for 46.2% of cases, while right-sided lumbar disc herniation (LDH) was observed in 60.3% of patients. Among the

study participants, 62.3% were male, and the mean age was 44.2 years with a standard deviation of 8.9 years. Importantly, a significant decrease in the Visual Analogue Scale (VAS) score was observed postoperatively, with a mean preoperative VAS score of 7.9 ± 1.4 decreasing to 1.7 ± 1.1 , a change that reached statistical significance ($p < 0.05$).

When assessing RTW times, no statistically significant differences were found when stratified by gender, LDH level, or occupation ($p > 0.05$). However, it's worth noting that although not statistically significant, female patients tended to have longer RTW times compared to their male counterparts. Similarly, when examining the results of the RTWE-SE-19 in relation to occupation, no statistically significant disparities were detected ($p > 0.05$). Nevertheless, it's noteworthy that the manual worker group exhibited slightly lower RTWE-SE-19 questionnaire scores compared to the other two occupational groups, despite this difference not reaching statistical significance. These findings collectively provide valuable insights into the patient demographics, surgical outcomes, and factors related to return to work following lumbar disc herniation surgery.

4. DISCUSSION

The findings of this retrospective study shed light on several important aspects related to LDH surgery and the RTW process. LDH is a prevalent source of pain and disability, primarily affecting individuals in their working years. Given the significant societal and economic implications of LDH-related work disability, understanding the factors influencing RTW is of utmost importance.

Numerous previous studies have explored the factors influencing the RTW after lumbar discectomy, with some findings showing inconsistencies. In a study by Than et al., the authors investigated predictors of RTW at the three-month mark in a cohort of 105 patients using data from a US neurosurgical registry (Schade et al., 1999; Than et al., 2016). Interestingly, they found that younger age was the sole statistically significant predictor of postoperative RTW. Variables such as sex, body mass index (BMI), smoking status, and comorbidity did not exhibit a significant association with RTW. It is noteworthy that their study reported a high RTW rate, with 94% of patients having returned to work by the 12-month follow-up, averaging around 67 days post-surgery (Than et al., 2016).

Similarly, Paulsen et al. conducted a Danish study involving 146 patients and arrived at findings that aligned with the results of Than et al. Specifically, they found no significant associations between sex, BMI, smoking status, and RTW (Paulsen et al., 2020; Than et al., 2016). These results from Than et al. and Paulsen et al. are consistent with the findings presented in our study, suggesting a lack of substantial impact of these demographic and lifestyle factors on RTW outcomes (Paulsen et al., 2020; Than et al., 2016).

It is worth noting that while these previous studies, including Than et al., did not find significant associations between certain factors (e.g., sex, BMI, smoking status) and RTW, the present study, as described earlier, introduced the element of occupational status as an additional variable of interest (Than et al., 2016). Despite this distinction, our findings align with the previous research, indicating that factors beyond these demographic and lifestyle attributes may play a more prominent role in determining RTW outcomes following lumbar discectomy.

In summary, the results of our study corroborate the findings of Than et al. and Paulsen et al. by indicating that factors such as sex, BMI, and smoking status do not appear to be significant predictors of RTW after lumbar discectomy (Paulsen et al., 2020; Than et al., 2016). While our study introduced the consideration of occupational status, the consistency in results across these studies underscores the notion that other factors, possibly related to patients' specific medical conditions, psychological factors, or the nature of their occupations, may have a more substantial impact on RTW outcomes. Further research is warranted to delve deeper into these determinants of RTW and to develop tailored interventions to optimize postoperative recovery and RTW for lumbar discectomy patients.

One of the key findings of this study is the significant improvement in patients' pain levels, as evidenced by the substantial reduction in the VAS score postoperatively. This decrease in pain is consistent with the expected outcome of LDH surgery, where the primary goal is to alleviate symptoms and improve patients' quality of life. The observed reduction in VAS scores highlights the effectiveness of the surgical intervention in providing pain relief, which is a crucial aspect of facilitating RTW.

Interestingly, this study did not find statistically significant differences in RTW times when stratified by gender, LDH level, or occupation. While it is notable that female patients tended to have slightly longer RTW times than their male counterparts, this difference did not reach statistical significance. This observation underscores the need for further investigation into the potential

factors contributing to this trend. Factors such as societal expectations, differences in physical demands of occupations, and postoperative recovery experiences could play a role in this variation.

The classification of patients' occupations into three distinct groups, namely higher-grade non-manual workers, lower-grade non-manual workers, and manual workers, provided valuable insights into the potential influence of occupational status on RTW outcomes. Although not statistically significant, the manual worker group exhibited slightly lower scores on the RTWE-SE-19 compared to the other two occupational groups. This finding suggests that individuals engaged in physically demanding and labor-intensive roles may perceive greater challenges in returning to work after LDH surgery. These patients may benefit from targeted interventions and support to enhance their self-efficacy and facilitate a smoother RTW process.

The use of the RTWE-SE-19 questionnaire itself is a notable aspect of this study. This specialized instrument allowed for the assessment of patients' self-efficacy beliefs related to returning to work after surgery. The classification of self-efficacy into low, moderate, and high categories provides a nuanced understanding of patients' confidence in their RTW abilities. The findings indicate that, on average, patients had moderate to high self-efficacy scores, which is a positive sign regarding their belief in their ability to return to work.

5. CONCLUSION

In conclusion, this study contributes valuable insights into the factors influencing RTW after LDH surgery. The significant reduction in pain levels postoperatively underscores the effectiveness of surgical interventions in improving patients' well-being. While no statistically significant differences in RTW times were observed based on gender, LDH level, or occupation, the trends identified, such as longer RTW times for female patients and lower RTWE-SE-19 scores for manual workers, warrant further investigation. Future research can build upon these findings to develop tailored interventions aimed at optimizing the RTW process for all LDH surgery patients, regardless of their demographic or occupational characteristics.

Disclosure Statement

All authors declare that they have no conflict of interest to disclose.

Ethics Statement

This study was approved by the Institutional Review Board (TUEK E1-23-3981), and written informed consent was obtained from each patient.

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