**BABEȘ-BOLYAI UNIVERSITY CLUJ-NAPOCA**
**FACULTY OF PHYSICAL EDUCATION AND SPORT**
**DOCTORAL SCHOOL**

**STAN (cas. BONCUȚ) DELIA-CLAUDIA**

# *Current technologies applied in movement therapy for the recovery of patients in the intensive care unit*

## ABSTRACT OF THE DOCTORAL THESIS

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# LIST OF PUBLISHED SCIENTIFIC PAPERS

Sandor, I., Isidori, E., Neag, S. A., Stan, D. C., (2021). Is E-Training a successful method for athletes during COVID-19? An answer based on a case study. *The International Scientific Conference eLearning and Software for Education;* Bucharest, Volume 1|Pages: 55-60.https://doi.org/10.12753/2066-026X-21-007

Stan, D. C., Sandor, I., (2022). The effectiveness of passive exercises on arterial blood gases in mechanically ventilated subjects from intensive care units. *Studia Universitatis Babeș-Bolyai, Educatio Artis Gymnasticae. 67*(4), 183–192. https://doi.org/10.24193/subbeag.67(4).46

Stan, D. C., Sandor, I., (2023). Early mobilization and the elastic band, an efficient solution for an intubated subject: a case study. *Studia Universitatis Babeș-Bolyai Educatio Artis Gymnasticae*,*68*(2), 57–67. https://doi.org/10.24193/subbeag.68(2).15

Stan, D. C., Boncuț, M., Miron, M. R., Sandor, I., Perme, C., (2024). Perme Intensive Care Unit Mobility Scale: Translation Into Romanian And Cross-Cultural Adaptation For Use In Romania. *Health, Sports & Rehabilitation Medicine Vol. 25, no. 1, January-March 2024, 4-8,*https://doi.org/10.26659/pm3.2024.25.1.4

# CONTAINED

Keywords: movement therapy, intensive care, mechanical ventilation, muscle weakness, passive exercises, elastic band, validation, functional mobility score, Blaze Pod, reaction speed, muscle strength

# INTRODUCTION

## Motivation

Starting from Blaise Pascal's statement "Our existence is movement, rest represents death", the current situation of the workplace where I have been working for more than 12 years as a senior physiotherapist, together with other specialized studies motivated me to deepen this topic. Prolonged immobilization with the impossibility of movement due to the serious suffering of patients in intensive care leaves its mark in the shortest time on functional mobility, sometimes with irreversible effects. The deep suffering felt by patients when they realize that they can no longer perform the usual movements they used to do "before", makes you, as an expert in medical recovery, think about ways you could improve or supplement the help offered. Their testimonies, which include phrases such as "I feel like a child, I am learning again to move and walk" urge you to find inspiration in the principle "Physical exercise, in itself, can replace any medicine, but no medicine in the world can replace physical exercise" (Binet, 1901).

## Novelty

The thesis makes an original contribution, exploring a topic that is insufficiently studied in the Romanian context, although physical therapy has been well received in intensive care units in our country for more than a decade.

In the international context, this thesis complements the specialized studies through the current technologies of Flash Reflex Training in the field of medical recovery for patients in intensive care.

Several categories of patients were approached and in each one the weakest side was highlighted and improved, less addressed by studies in the field.

Digital innovation in interventions to promote the recovery of ICU patients and their family members holds promise for improving accessibility and improving physical, psychological, and cognitive outcomes (Berger et al., 2024).

## News

The notion of critical care is current, but its foundations are deeper, the aspects of critical care can be seen in Florence Nightingale's contribution in the 1850s, during the conflict in Crimea, which included the idea of organizing patients who suffered more than others into different spaces (Murkute, 2024).

Over time, this sector has undergone many changes and improvements. These changes have been aided by innovations in diagnostic, therapeutic, and monitoring technologies, as well as the implementation of evidence-based guidelines and organizational structures within intensive care units. The current state of intensive care management is characterized by a multidisciplinary approach and the use of innovative technologies and research databases (Chander et al., 2023).

Critical care has evolved from a culture of deep sedation and bed rest to one of early awakening and mobilization; interventions within medical recovery have developed to meet the needs of patients. Physiotherapists play a more important role as leaders in clinical and research, and opportunities for interdisciplinary collaboration are growing (Kho & Connolly, 2023).

It is imperative that physiotherapy professionals constantly seek updating, adapting, and promoting new approaches in their practice. This involves promoting excellence in care through the development of guidelines and protocols for early mobilization, team training, implementation, monitoring, and investment by the state to provide adequate conditions for the development of this practice in the intensive care unit (Camilo, Barbosa, & Oliveira, 2024).

**Presentation of the results of previous research related to the chosen topic**

Recovery activities, including mobilization to prevent loss of muscle strength, have been identified as essential interventions. However, there is little data on the optimal frequency of mobilization, intensity, and time required, and it is unclear whether certain patient groups have different needs (Wozniak et al., 2024).

Early mobilization is associated with numerous benefits, including reduced muscle weakness, shorter duration of mechanical ventilation, reduced length of hospitalization and intensive care, and improved functional outcomes. However, safety concerns, staffing limitations, and patient-specific considerations are significant barriers to widespread adoption. Despite these challenges, early mobilisation is important for improving outcomes in ICU patients. By working collaboratively to overcome barriers and prioritize early mobilization, healthcare professionals can improve the quality of care and outcomes for critically ill patients in the intensive care unit (Singam, 2024).

Initiation of mobilization within 48-72 hours of admission may be optimal for considerably better clinical outcomes. Early mobilization, defined as any intervention by the patient initiating passive or active exercise, within the first 72 hours of admission to the intensive care unit, compared to standard care, has effects on loss of muscle strength and other patient outcomes (Daum et al., 2023).

The main barriers to mobilization were the lack of devices. The observations show that initiating physical rehabilitation with an intensity higher than that required to stay on the edge of the bed during the first five days after admission to intensive care seems to be the preferred strategy for improving the independence of daily activities upon discharge from the hospital. Overcoming the mobilization barrier may also be necessary for a better rate of independence of daily activities upon discharge from hospital (Watanabe et al., 2023).

Some countries with limited resources do not have the necessary physiotherapists and equipment and then recovery services are provided by nurses or resident doctors. Measuring blood gases is another limitation (Nwose et al., 2024).

In the intensive care unit we meet several categories of patients depending on the state of consciousness (RASS sedation level). Depending on this level, we have also organized this research. Patients with sedation score between -5 and -1 were intubated, mechanically ventilated, and sedated patients who did not respond to verbal or physical stimuli, responded to physical stimuli but did not respond to verbal stimuli, moved and opened their eyes on demand but did not look at the examiner, open their eyes on demand (less than 10 seconds), and look at the examiner, They could open their eyes on demand (over 10 seconds) and look at the examiner, these patients had from deep sedation to mild sedation. The first study in this research was designed for this category of patients.

Study 2 was designed for the RASS score 0 category, i.e. the patient is awake and calm, but intubated and mechanically ventilated. And for the category of conscious, cooperative, non-intubated patients, study 4 was designed. In order to be able to use the assessment tools for study 4, study 3 was required.

In this thesis we addressed several categories of patients admitted to the intensive care unit, from those in comas without response to stimuli, to the conscious and cooperative and we chose the right type of physical exercise for each category, including the current modern technology based on Flash Reflex Training. In each study, I tried to preserve or recover as much of the functional capacity of patients admitted to the intensive care unit as possible.

**The objectives were:**

Evaluation of the efficacy of passive exercises on arterial blood gas parameters in intensive care subjects.

Early mobilization and elastic band exercises in an intubated and mechanically ventilated subject in the intensive care unit.

Validation and application of the Perme Score and IMS Scale.

Investigation of the effects of Blaze Pod-integrated exercises on muscle strength, reaction speed, and functional mobility in ICU patients.

**Research hypotheses**

It is assumed that performing passive exercises in intubated and mechanically ventilated subjects will lead to an improvement in blood arterial gas parameters.

Improving the parameters of arterial blood gases will reduce the period of mechanical ventilation, and finally, speed up extubation.

The hypothesis of the second study is based on the premise that performing exercises with elastic band and early mobilization will be effective, safe, representing the ideal solution for the successful detachment of the subject from the ventilator.

In order to achieve the translation into Romanian of the Perme Score and the IMS, a strong agreement and reliability between the evaluators and a positive correlation between the two scales will be needed.

Subjects who will benefit from exercises integrated with Blaze Pod will have better results in the final assessment of muscle strength, reaction speed and functional mobility compared to the control group.

It is assumed that demographic data will influence muscle strength, reaction speed and the degree of functional mobility in intensive care subjects.

**Presentation of the research methodology and justification of the chosen methods**

In the intensive care unit, we do not meet only one category of patients and that is why each case is individualized in treatment and approach. In order to cover as widely as possible, the needs and requirements of patients in the intensive care unit, we have conducted several studies.

In the first study, we investigated the extent to which passive exercise has an effect on arterial blood gas parameters. Based on the findings of this study, passive exercise was an effective method for improving arterial blood gas parameters in mechanically ventilated subjects in the intensive care unit. The result: passive exercises revealed a slight tendency of beneficial changes at the cellular level in mechanically ventilated subjects from the first day after application of the protocol (Vollenweider et al., 2022); which may indicate a reduction in the inspiratory fraction of oxygen and

ultimately minimize the time spent in intensive care, ease the transition from the ventilator to other oxygen delivery devices, improve overall health and quality of life (Omar et al., 2024).

In the second study, we followed the efficacy of early mobilization and elastic band exercise program in an intubated and mechanically ventilated subject. These proved to be effective, safe and feasible for an intensive care unit and were the right solution for the success of the subject's detachment from the ventilator even if they required a substantial effort on his part and the entire medical team.

In order to be able to assess the degree of mobility functionality in patients in the intensive care unit, we conducted the third study, in this regard there are also in our country two cross-culturally validated functional mobility assessment scales.

In the fourth study we tested and verified the new technology based on Flash Reflex Training from Blaze Pod. Flash Reflex Training devices can be used as assessment tools in recovery; Therapists can create personalized tests and specific training programs. With these devices, visual stimuli can be created that require rapid and precise motor responses from subjects, allowing their ability to adapt and respond to visual information effectively to be assessed. These tools can provide objective and measurable data on subjects' outcomes, allowing their progress to be assessed and monitored over time. In addition, they can be used to identify areas for improvement and adapt recovery programs to the specific needs of each topic.

In summary, Flash Reflex Training devices can serve as effective tools for evaluating outcomes in subjects' recovery, providing valuable insights for therapists and researchers.

**Limits of the studies carried out, peculiarities of research conditions**

One of the major limitations was the COVID-19 pandemic, during this period the access of caregivers to the hospital was prohibited, this made it difficult to obtain informed consent from patients' caregivers for the participation in the study of intubated and mechanically ventilated subjects.

Other limitations for the small number of participants in the study were the fact that they were unaware and that they depended on the ward resident caring for the patient to collect samples for the Astrup analysis.

Another limitation was represented by the conditions in the intensive care unit, where a wide range of manoeuvres are carried out and several categories of medical personnel collaborate in patient care. Each member of the medical team has their own protocol to follow, which has made it

difficult to research and identify the optimal time for the patient for the purpose of physical recovery, with priority given to essential life-saving work. In order to succeed in putting the recovery protocol into practice, a certain time was established, so as not to delay the program with the performance of other labors.

For this reason, we have chosen techniques that require little time and effort and that bring the most benefits to the patient.

**Future research directions**

The results of these studies should be implemented as routine protocols in intensive care units, which should then be adjusted by the multidisciplinary team according to the needs of patients. Future studies should aim to understand the pathophysiological mechanisms that contribute to muscle weakness acquired in intensive care units in patients in our country.

**Clinical and social perspectives**

Suffering from a serious condition that requires treatment in an intensive care unit can be a traumatic experience that can affect both the patient and their relatives for a long time even after discharge from the hospital. Physical symptoms such as fatigue, reduced muscle mass, muscle weakness as well as a reduced degree of functional mobility, are also common after discharge and are important aspects, as they lead to increased dependence on others. The need to follow a recovery treatment after discharge has a significant impact on the patient, his family and society.

In this regard, the need to implement protocols for the early mobilization of patients in intensive care units is absolutely vital, as they must be discharged with a degree of functional mobility as high as possible and with as few deficiencies as possible. So that they can reintegrate as quickly as possible into their professional activity and resume their life prior to hospitalization.

# PART I. THEORETICAL FOUNDATION AND TOPICALITY OF THE TOPIC IN THE LITERATURE

## SUMMARY CHAPTER I. THEORETICAL NOTIONS ABOUT THE INTENSIVE CARE UNIT

Intensive Care (ICU) is the highest level of care in a health unit with beds (Systems, n.d.). Marshall et al., 2017, gave a global definition to intensive care – the ability to care for the sickest patients in the healthcare system. An intensive care unit is an organized system that provides specialized care and assistance to patients with critical conditions. It offers an increased monitoring capacity and multiple ways of physiological support and maintenance of organs in acute failure for a certain period of time.

The critical patient is that patient with unstable vital functions or with conditions that may have irreversible complications and that require emergency medical intervention or care in an intensive care unit. The critical patient requires long recovery periods, thus there is the possibility of complications with functional risk, generating disability and requiring specialized care in the field of medical recovery (Berteanu et al., 2009).

Critical patient care in the intensive care unit requires a multidisciplinary and integrated approach, which is essential from admission to rehabilitation after discharge (Jackson & Cairns, 2021).

Mechanical ventilation is one of the most common interventions implemented in the intensive care unit. More than half of patients in the intensive care unit are ventilated within the first 24 hours after admission, these are people who have acute respiratory failure, compromised lung function, shortness of breath or inability to protect their airways (Mechanical Ventilation in the Intensive Care Unit, 2011).

A ventilator is a machine that helps the patient breathe, the ventilator partially or completely supports lung functions. A ventilator: - provides oxygen to the lungs, helps remove carbon dioxide from the lungs, provides pressure to prevent the small air pockets in the lungs (alveoli) from collapsing. Providers can adjust the settings on the device to meet the patient's specific needs (ICU Ventilators, 2024).

Intubation and mechanical ventilation often occur together, but they are not the same. Invasive mechanical ventilation involves placing an endotracheal tube through the patient's mouth or nose into the trachea (the upper part of the airway that leads to the lungs). The endotracheal tube is connected to a machine that delivers a predetermined amount of oxygen and air volume, along with a set number of breaths per minute. These are adjusted according to the patient's oxygen and carbon dioxide levels (Walter, Corbridge, & Singer, 2018).

Despite the life-saving nature of mechanical ventilation, it is not without complications and side effects. In fact, prolonged mechanical ventilation affects almost every organ system in the body, including the cardiorespiratory, gastrointestinal, renal, brain, hematological, and immune systems. Success depends on the ability to prevent possible complications, and achieving this goal requires proper knowledge and planning (Mahboobi & Sohail, 2023).

Analgesia and sedation have been routinely used in intensive care patients for many years, especially in mechanically ventilated patients. The primary objective of analgo-sedation is patient comfort, reduction of anxiety and stress, assessed by ensuring adequate sleep. In the mechanically ventilated patient, the choice of sedatives and analgesics will be made individualized according to the patient's needs, often requiring a combination of medications. Thus, it is very important to ensure the patient's comfort and tolerability and to avoid the appearance of stress and discomfort (Systems, n.d.)

Blood gas analysis is a commonly used diagnostic tool to assess partial blood gas pressures and acid-base content. Understanding and using blood gas analysis allows professionals to interpret respiratory, circulatory, and metabolic disorders (Castro, 2024).

The sample can be obtained either from a catheter placed in an artery or by using a needle and syringe to harvest from the artery. These syringes are pre-heparinized and manipulated to minimize exposure to air that will alter blood gas values (World Health Organization, 2010).

# SUMMARY CHAPTER II

# COMPLICATIONS, RISKS FOR INTENSIVE CARE PATIENTS

Movement is life. From birth to death and every moment in between, even when we sleep, people move and change their position. This makes the condition of a long-term medically induced coma, as is standard practice for certain critically ill patients, stress on normal human physiology (Engel & Brummel, 2024). Even in healthy individuals, bed rest damages the systems, affecting several organs - it depletes bone density, improperly adapts the vestibular system, baroreceptors in the vascular system. Metabolic disorders and insulin resistance affect skeletal muscles' ability to function and support homeostasis, as immobility and disease accelerate muscle catabolism without the necessary anabolic reconstruction (Parry & Puthucheary, 2015).

Immobilization is a major risk factor for many complications related to the patient's condition in an intensive care unit. About 40% or more of muscle strength can be lost in the first week after immobilization. Immobilization and functional decline are associated with an increased risk of delirium, pneumonia, prolonged mechanical ventilation, pressure injury, deep vein thrombosis, increased cardiac load, reduced cardiac output, decreased orthostatic tolerance, and increased production of pro-inflammatory cytokines (Tirona, 2023).

Muscle weakness acquired in the intensive care unit is a common problem encountered in critically ill patients and is associated with a number of negative outcomes. These results include the need for long-term mechanical ventilation and prolonged hospitalization. Muscle weakness acquired in the intensive care unit is associated with multiple risk factors, including age, existing conditions, disease severity, organ failure, sepsis, immobilization, mechanical ventilation, and other factors related to critical care (Chen & Huang, 2023).

Despite the historical precedent of mobilizing critically ill patients, bed rest remains a standard practice globally, especially for mechanically ventilated patients. In patients receiving mechanical ventilation, skeletal muscle decreased by 12.5% in the first week after admission (Hashem, Nelliot & Needham, 2016).

Although muscle weakness acquired in intensive care is a common finding in intensive care, understanding of this disease is limited and many associated problems require solutions. The connection between nerves and muscles has not been sufficiently studied, and research in this area is limited (Vanhorebeek et al., 2020). Future research should focus on the pathophysiological

mechanisms of muscle weakness acquired in intensive care, as the development of an effective treatment requires a clear understanding of the causes to help patients reintegrate into society and increase their quality of life (Wang et al., 2020).

There are many terms used to describe exercise or rehabilitation interventions in the intensive care unit. The World Health Organization defines rehabilitation as a set of actions aimed at optimizing the functioning and reduction of disability in people with health conditions in relation to their environment. This process focuses specifically on physical activity (Liu et al., 2024).

Therapeutic exercise involves performing a prescribed movement in order to correct a deficit or to recover muscle and bone function. Therapeutic exercise is a specific physical activity performed in order to achieve and maintain an optimal physical state, minimizing side effects and respecting individualized contraindications according to the particularities of the subject (Bielecki & Tadi, 2023).

Early application of exercise is vital to prevent the occurrence of postoperative complications and those associated with bed immobilization. The patient should return to their normal functions as soon as possible (Pinkaew et al., 2020).

Recent trends in research have therefore moved towards exploring the optimal dosage and the right time to apply exercise (e.g.: - intensity, duration, frequency) (Liu et al., 2024).

When initiated shortly after the start of mechanical ventilation, early mobilization plays an important role in reducing the duration of mechanical ventilation and hospitalization (Hashem et al., 2016). Early mobilization is essential to limit the occurrence of post-operative complications and those related to bed rest. The patient must regain his functional capacities as soon as possible (Antonello et al., 2016).

The early mobilization of surgical patients starting with the second postoperative day was also mentioned by Drăgan et al., 1981. No effective pharmacological treatments are available, but early mobilization in intensive care, tailored to the specific needs of the patient, can effectively improve muscle strength (Latronico et al., 2023).

Therefore, an intensive care rehabilitation program can be the cornerstone of treatment for muscle weakness. Elastic band exercises have also been described in the therapeutic treatment of patients with impaired motor skills. Band exercises are an inexpensive and simple technique that is quite appealing to implement in a protected environment such as intensive care (Chen et al., 2016).

# SUMMARY CHAPTER III

# SPECIFIC MEANS OF ACHIEVING THE PROPOSED OBJECTIVES

Physical activity is the repetition of actions with a specific purpose. Depending on the methods of achievement, therapeutic exercises can be divided into two broad categories - active exercises and passive exercises. In active exercise, movement is generated by the contraction of muscles, while passive exercise uses an external force to initiate movement (Introduction and Classification of Therapeutic Exercise, 2021).

Exercise or passive movement, which refers to the manipulation of the body or a part of it without conscious effort or involving the muscles, has a long and rich tradition in medicine and physiology (Trinity & Richardson, 2019).

Passive exercise contributes to the proper functioning of all body systems. In the case of prolonged bed rest, early mobilization can be beneficial for improving outcomes in critically ill patients. In them, the instability of the parameters can last for days or weeks, delaying active mobilization, resulting in the possible onset of disability (Omar et al., 2014). Passive exercise is a widespread treatment for patients who are unable to move their arms or legs voluntarily, due to coma or sedation (Tanvir, Batool, & Saeed, 2023).

Passive mobilization is a method used by physiotherapists to avoid functional deterioration in critically ill patients. Although it has been widely used by professionals, its effects in terms of patients' clinical recovery have yet to be established (Machado et al., 2017). Passive exercise can be considered a strategy that helps mobilize patients who are mechanically ventilated and are in critical condition, until they are ready to engage in active exercise (Amidei, 2012). There is a lack of evidence evaluating the effectiveness of passive movements (Stiller et al., 2023). Passive exercise was well tolerated by ventilated and sedated ICU subjects, this type of exercise being the most appropriate form of activity in the early phase (Amidei & Sole, 2013).

The flexibility and availability of elastic bands make them a desirable choice for various groups of people and conditions. They facilitate the development of muscle strength comparable to that achieved through traditional training, especially in the context of rehabilitation. This adaptability is essential for individuals who do not have standard equipment, given that elastic bands are easy to transport and quite affordable (Aidar et al., 2021).

The elastic band exercise program improved the parameters of strength, contraction speed and speed of movements (Gaamouri et al., 2023). Elastic band exercises have a favorable impact on daily activities, hand muscle strength, balance, and lower limb muscle strength in older people. In addition, the low cost and benefits of these exercises help promote health. Including elastic band exercises in routine activities and at different ages is important (Su et al., 2022). Elastic band exercises are an attractive method, as they are useful for several patients in order to increase muscle strength (Decha et al., 2020).

Strength exercises performed with elastic bands have been increasingly researched in recent times as a possible option to weight training. The low price and high accessibility make the use of elastic bands a tempting solution for people who cannot invest in expensive fitness equipment (Langer, 2021).

Therapists can control the intensity of the exercise using different color codes or sizes of elastic bands. In addition, elastic bands are portable and can be used almost anywhere, and they are inexpensive and easy to maintain (Kim, Kuruma, & Thawisuk, 2021).

A recent technology called Blaze Pod, which evaluates reaction time, is now available on the market and has been used by experts (De-Oliveira et al., 2021).

Blaze Pod is a system that emits a visual signal designed to enhance training by adding color codes, lights, for different exercises. Blaze Pod's Flash Reflex Training system combines cognitive training that teaches the brain to think better and faster with physical training that pushes the athlete's motor skills to the maximum.

Blaze Pod bridges can be placed in different positions bringing major improvements in reaction time, agility, strength and decision-making (Grădinaru et al., 2023).

It is important to note that while Blaze Pod can be a valuable tool in recovery, they should be used under the guidance of physical therapists who can design safe and effective recovery programs. The specific benefits and results of using Blaze Pod in medical recovery may vary depending on the patient's condition and the physical therapist's expertise in using this technology (Blazepod, n.d.).

# SUMMARY CHAPTER IV

# ASPECTS FOLLOWED IN PATIENTS IN THE INTENSIVE CARE UNIT

Muscle strength is one of the most important motor qualities, there is no movement that can be achieved without strength. Current literature shows that muscle strength is associated with objective outcomes of functional capacity, as well as disease severity/level of disability (Gamborg et al., 2023).

Muscle weakness and/or muscle loss are recognized as a key medical problem in critically ill patients in intensive care units around the world (Schefold, 2020). Muscle weakness acquired in intensive care is defined as clinically identifiable weakness, acquired in critically ill patients, which is directly attributed to hospitalization in intensive care, where other causes of weakness have been excluded (Taylor, 2023).

The female gender was considered a risk factor, an independent predictor of acquired paresis, due to physiological differences in body composition, muscle strength and energy metabolism (Engelhardt et al., 2022).

Acute skeletal muscle loss and muscle weakness is an important medical problem of critically ill patients. Muscle mass decreases rapidly in the early phase of a critical illness. Muscle loss is the result of reduced physical activity and decreased protein synthesis, and loss of muscle mass in the first week of hospitalization is associated with increased mortality at 60 days (Hardy et al., 2023).

The occurrence of lesions caused by the negative effects of immobilization in the intensive care unit is associated with a reduced level of functional autonomy, a decrease in quality of life and the persistence of these problems even after discharge. A longer hospitalization period is correlated with muscle weakness and poor physical condition, affecting patients admitted to intensive care due to immobilization. For this reason, it is essential to implement a patient recovery program that includes early mobilization in its strategies (Cavalcante et al., 2023).

In the long term, muscle weakness acquired in intensive care has been associated with physical disorders, including unsteady gait, sensory loss, dropped leg, and, in more severe cases, persistent tetraparesis and ventilator dependence. Muscle weakness acquired in intensive care seems to strongly influence patients' failure to return to their initial state of health after discharge. There is a lack of evidence-based therapeutic methods to reduce the incidence of muscle weakness acquired

in intensive care; however, early initiation of recovery could be an effective intervention to enhance functionality (Latronico et al., 2014).

The implementation of physical exercise as a therapeutic and preventive intervention for patients during and after hospitalization in intensive care is a proposed solution to address this situation. An appreciation of the positive impact of physical exercise will be of real help to practitioners in their efforts to recover patients who have survived intensive care, improving their quality of life and facilitating a return to the usual routine prior to hospital discharge (Liu et al., 2024).

The motor quality "speed" expresses the body's ability to perform motor acts quickly. This quality cannot develop against a background of fatigue, so after a few repetitions it is necessary to take breaks for a complete recovery (Scarlat & Scarlat, 2002).

Simple reaction time, the minimum time required to respond to a stimulus, is a basic measure of processing speed (Woods et al., 2015). Reaction time is a simple means of determining an individual's sensory-motor performance (Grrishma, 2013).

Reaction time is very important for our daily lives and needs an intact sensory system, cognitive processing and motor performance. Reaction time is a good indicator of an individual's sensorimotor coordination and performance (Balakrishnan et al., 2014).

Recognizing its essential role in daily activities, extensive research has explored the various factors that influence reaction times, including age, gender, physical condition, health, psychological state, alertness, fatigue, distraction, body temperature, experience, anticipation, alcohol consumption, and personality. Also, the limb used for the test, the biological rhythm and health, and whether the stimulus is auditory or visual. Gender differences suggest that the interval between stimulus activation and muscle reaction is the main source of the observed differences, men tend to be faster, while women show higher accuracy (Sangolkar, 2024). Prolonged reaction time denotes poor performance (Balakrishnan et al., 2014). Beyond a certain duration and/or intensity of exercise, muscle fatigue induces an increase in reaction time that may be due to decreased cognitive performance (Le Mansec, 2019). Reaction speed is the ability to react to a particular stimulus as quickly as possible. The development of speed is closely related to the development of strength; in order to be able to perform a certain motor task, the athlete must apply force as quickly as possible. Force is understood as a product of mass and acceleration. The force required to perform the movement is produced by the skeletal muscles (Training Speed Abilities, n.d.).

# PART II. EXPERIMENTAL RESEARCH

# CHAPTER V. STUDY 1

# EFFICACY OF PASSIVE EXERCISES ON ARTERIAL BLOOD GAS PARAMETERS IN MECHANICALLY VENTILATED PATIENTS

## *5.1. Introduce*[1]

Patients who are mechanically ventilated and are seriously ill are most often bedridden and sometimes completely immobilized due to severe illness and sedative administration (Younis & Ahmed, 2015). Immobilization affects the functional status of the subject through muscle weakness, coordination disorders, delayed ventilator detachment, prolonged hospitalization (Berry et al., 2014). Early exercise is essential to limit the occurrence of complications related to bed rest. Active exercises are not possible in patients with deep sedation and unable to follow commands, and in this sense, passive exercises are an interesting alternative (Pinheiro et al., 2017). Yelvar et al. in 2016 showed that a single session of manual therapy improves lung function, inspiratory muscle strength, and oxygen saturation, reduces dyspnea, fatigue, heart rate, and respiratory rate in subjects with chronic obstructive pulmonary disease. Meawad et al., 2018, argue for the importance of adding the early thoracic physiotherapy program to mechanically ventilated subjects because it increases oxygen saturation, arterial oxygen pressure, and decreases complications, length of stay in intensive care, and reduced healthcare costs. Passive exercises have been considered as an effective method of stabilizing physiological parameters in mechanically ventilated subjects; therefore, it can be implemented as a routine procedure (Fahmy et al., 2021). Passive exercise was well tolerated by ventilated and sedated ICU patients, this type of exercise being the most suitable form of activity in the early phase (Amidei & Sole, 2013).

[1] The content of this chapter is entirely the manuscript published in the journal Studia Universitatis Babeș-Bolyai, Educatio Artis Gymnasticae: Stan, D. C., Sandor, I., (2022). The effectiveness of passive exercises on arterial blood gases in mechanically ventilated subjects from intensive care units. *Studia Universitatis Babeș-Bolyai, Educatio Artis Gymnasticae. 67*(4), 183–192. https://doi.org/10.24193/subbeag.67(4).46

### *5.2. Objective*

The objective of the study was to evaluate the effectiveness of passive exercise on arterial blood gas parameters in mechanically ventilated subjects in the intensive care unit.

### *5.3. Assumptions*

The first hypothesis starts from the presumption that the application of passive exercises to intubated and mechanically ventilated subjects will lead to an improvement in arterial blood gas parameters.

The second hypothesis assumes that improving arterial blood gas parameters will result in a reduction in the duration of use of mechanical ventilation and ultimately faster extubation of subjects.

### *5.4. Subjects and location of the study*

The study was carried out at the Regional Institute of Gastroenterology and Hepatology Prof. Dr. Octavian Fodor, Cluj-Napoca, intensive care unit, between September 2021 and February 2022.

A total of five subjects (three male and two female) were included in the study, whose recruitment was made in the intensive care unit based on inclusion/exclusion criteria. The small number of subjects was due to the fact that COVID-19 restrictions were in force during that period, when the access of caregivers to hospital institutions was prohibited. In this sense, obtaining consent for participation in the study from the subjects' relatives (the participating subjects being intubated and mechanically ventilated) was very difficult. The study was quasi-experimental.

Inclusion criteria:

- the age of the subjects must be over 18 years old
- be mechanically ventilated
- RASS score between -5 and -1

Exclusion criteria:

- Subjects with hemodynamic instability
- who have active bleeding

- with neuromuscular diseases
- who have recently suffered a heart attack
- increased intracranial pressure
- Recent fractures

Subjects were included in a single batch that included both genders.

### *5.5. Tools*

The evaluation of the subjects was aimed at: arterial blood gases (pH: hydrogen potential, FIO2 - inspiratory oxygen fraction, O2 - total amount of oxygen, CO2 - carbon dioxide, pO2/FIO2 - ratio between total amount of oxygen / partial pressure of oxygen in arterial blood), state of consciousness (RASS).

### *5.6. Recovery protocol*

The subjects participating in the study had a score on the RASS scale between -4 (does not respond to verbal stimuli, only physical stimuli) and -3 (moves and opens his eyes on demand, but does not look at the examiner). The subjects before 30 minutes of the application of the passive exercises did not undergo any medical maneuver and remained in supine position, with their heads raised at an angle of 30°. A total of 10 repetitions were performed at each joint in three sets, in all axes of movement of the joint, clockwise (Pinheiro et al., 2017). The arterial blood gas sample was collected by the ward resident five minutes before the start of the work protocol and 15 minutes after performing passive exercises (Saad, 2020).

The work protocol was performed by a single physiotherapist, for five days, one session per day in three sets of ten repetitions each. The physical therapist initiated, led and ended the movement rhythmically, tensing the soft parts at the end of each movement and maintaining the tempo at each repetition. The sequence of movement was from distal to proximal, also favoring veno-lymphatic return. The application of the socket and the counter socket was also considered. The change of socket was gentle, avoiding any discomfort for the subjects.

## *5.7. Presentation, analysis and interpretation of results*

### 5.7.1. Presentation of subjects

The study included five subjects, three male, two female aged 45-79 years, with a mean of 61.6 years and a standard deviation of ± 8.30. The subjects came from Cluj County, with a percentage of 60% from rural areas and 40% from urban areas. As for the state of consciousness, 40% fell into RASS -4 (no response to voice, only movement or opening of the eyes to physical stimulation) and 60% to RASS -3 (movements or opening of the eyes to verbal stimulation). All five subjects, i.e. 100%, had the diagnosis of liver cirrhosis, were under sedation and were in CPAP (continuous positive airway pressure) ventilation mode.

### 5.7.2. Data analysis and interpretation

The statistical analysis of the data has been processed in EXCEL WINDOWS 10.

For the mean and standard deviation, descriptive statistics of arterial blood gas parameter scores before and after the application of passive exercises to mechanically ventilated subjects were used.

The t-test was used to compare the values of the averages obtained before and after the application of passive exercises. In order to be able to track whether there are statistically significant differences, confidence intervals of 95% and $p \leq 0.05$ were established.

### 5.7.3. Presentation of the results of the variables

1. PH: the mean pH value before and after the application of the protocol was 7.4 ± 0.075 and 7.4 ± 0.032. There was no significant difference (p = 0.98), the percentage decrease was 0.0002 (Table No. 2).

2. FIO2: the mean FIO2 before and after the application of the protocol was 43.75 ± 8.34, respectively 35.62 ± 3.20. This registers a difference of 8.13 percent and a p-value of 0.006 (Table No. 2).

3. O2: the mean O2 value was 107.5 ± 24.90 and 118.78 ± 23.13, respectively, registering an increase of 11.28 percent and a p-value of 0.13 (Table No. 2).

4. CO2: the average CO2 value before and after the application of the protocol was 28.97 ± 7.67 and 26.87 ± 3.72, with a decreasing percentage of 2.1 (Table No. 2).

5. O2/FIO2: the average ratio was 278.12 ± 80.61 and 315.28 ± 87.23, respectively, with a significant increase of 37.16 percent (Table No. 2).

### *5.8. Discussions*

Mechanical ventilation improves the ability to retain carbon dioxide and acid-base stability. Subjects on mechanical ventilation suffer from muscle weakness acquired in the intensive care unit as a result of immobilization and sedative administration (Yue et al., 2018). Over the past decade, interest in the early mobilization and recovery of critically ill subjects has increased, in response to the growing awareness of the long-term effects felt by many survivors (Denehey, Lanphere, & Needham, 2017). The improvement in arterial gases can be attributed to the fact that passive exercise had a positive effect on physiological parameters, such as respiratory rate and blood oxygen levels (Fahmy et al., 2021). Early mobilization has been found to contribute to increasing forced vital capacity, maximizing voluntary ventilation, and improving arterial oxygenation (Zafiropoulos, Alison, & McCarren, 2004). The thoracic physiotherapy protocol that includes vibration, percussion, suction, and exercises for the lower and upper limbs, has been shown to be an effective approach for relieving arterial blood gases in mechanically ventilated subjects (Saad et al., 2020).

### *5.9. Conclusions*

The two hypotheses were confirmed, the application of passive exercises to intubated and mechanically ventilated subjects generated advances in the values of arterial blood gas parameters, and as a result of this, the duration of mechanical ventilation was reduced and the subjects extubated faster.

According to the findings of this study, passive exercise proved to be an effective method for optimizing arterial blood gases in mechanically ventilated subjects in the intensive care unit. These exercises demonstrated a slight trend of favorable changes at the cellular level in mechanically ventilated subjects from the first day after the implementation of the protocol (Vollenweider et al., 2022), which could suggest a decrease in the inspiratory fraction of oxygen and ultimately reduce the duration of hospitalization in intensive care, facilitating the transition from the ventilator to other oxygen delivery devices, contributing to the improvement of general well-being and quality of life (Omar et al., 2024).

# CHAPTER VI

# STUDY 2

# EARLY MOBILIZATION AND ELASTIC BANDING AN EFFECTIVE SOLUTION FOR AN INTUBATED PATIENT: A CASE STUDY

## *6.1. Introduce*[2]

Every year, between 13 and 20 million people worldwide need treatment in intensive care units (Wang, 2020). Subjects who have been mechanically ventilated for more than 48 hours develop rapid skeletal muscle atrophy (Hodgson, 2022). Muscle strength decreases by about 20-27% after two weeks of immobility, making it more difficult to give up ventilator support and causing functional losses (Skals, 2018). Muscle weakness acquired in intensive care is a common complication that affects the prognosis of critical subjects. The dynamometer for measuring hand muscle strength has been shown to be sensitive in detecting reduced muscle strength in this type of subject (Samosawala, Vaishali & Kalyana, 2016).

Initiating the recovery process within two or three days of admission to the intensive care unit is recommended rather than postponing it (Hodgson, 2021). The benefits of early mobilization in the intensive care unit include: a shorter duration of hospitalization, reduced intervals of use of mechanical ventilation, fewer days of immobilization, a lower number of complications, and a longer ability to walk a longer distance (Perme et al., 2014).

## *6.2. Case description*

### 6.2.1. History of the subject

The subject described in the case study was a 65-year-old man who is taken to the intensive care unit known with the diagnosis of axial hiatal hernia, for whom the hiatal hernia cure was practiced. Associated with trivascular coronary artery disease, triple coronary artery bypass in 2010,

[2]The content of this chapter represents entirely the manuscript published in the journal Studia Universitatis Babes-Bolyai, Educatio Artis Gymnasticae: Stan, D. C., Sandor, I., (2023). Early mobilization and the elastic band, an efficient solution for an intubated subject: a case study. *Studia Universitatis Babeș-Bolyai Educatio Artis Gymnasticae*, *68*(2), 57–67. https://doi.org/10.24193/subbeag.68(2).15

previous old myocardial infarction, degenerative mitral regurgitation, mild tricuspid insufficiency, atrial fibrillation converted to sinus rhythm in 2010, heart failure, ankylosing spondylitis.

### *6.3. Objective*

The objective of the case study was to present the fact that early mobilization and elastic band exercises were effective solutions for an intubated and ventilated subject in the intensive care unit.

### *6.4. Hypothesis*

The hypothesis of the study is based on the premise that performing exercises with elastic band and early mobilization will be effective, safe, representing the ideal solution for the success of the subject's detachment from the ventilator.

### *6.5. Material and method*

The case study was carried out in the intensive care unit in Cluj-Napoca within the Regional Institute of Gastroenterology and Hepatology Prof. Dr. Octavian Fodor, between September and October 2022.

The study showed that early mobilization and elastic band exercises were effective solutions for an intubated subject in the intensive care unit.

The work protocol was explained to the subject and the informed consent signed. The baseline dates were noted before the recovery protocol began.

#### 6.5.1. Tools

The subject's state of consciousness was assessed with the Richmond Agitation Sedation Scale (RASS) to describe their level of alertness. This scale ranges from -5 to +4 (Sessler et al., 2002). In our case the subject had a score of 0, which meant that he was awake, alert and calm.

The muscle strength of the upper limb was tested with an EH 101 electronic handheld dynamometer, which is one of the latest products launched. High-precision power measurement, providing momentary digital reading of gripping power. Automatic capture of maximum gripping power and displayed value. Evaluation of results according to age and gender - weak/normal/strong.

### 6.5.2. Intervention

*Table No. 3 Description of the physical therapy program per day*

| Kinetotherapy/ Day | Assessment | Exercises/ Exercises with elastic band | Transfer/Mers |
|---|---|---|---|
| 1 | Clinical: Intubated, conscious, cooperative subject<br>Signed informed consent<br>Richmond Agitation Scale 0<br>The muscle strength in the upper limbs was 27.6 kg – weak<br>At the level of the cervical spine, welding of the vertebrae with the impossibility of flexion, extension, rotation or tilting of the head | Global analytical exercises, 10 repetitions in bed<br>Diaphragmatic breathing exercises, 10 repetitions | Transfer to the edge of the bed, sitting, steps by the bed |
| 8 | Premiere | Global analytical exercises, 10 repetitions in bed<br>Diaphragmatic breathing exercises, at the edge of the bed, 10 repetitions<br>For the upper part specific exercises with the elastic band at the edge of the bed, 10 reps / 2 sets<br><br>Global analytical exercises in bed, 10 reps | Transfer to the edge of the bed, sitting, steps by the bed<br>Walk, intubated, more than 25 minutes |
| 28 - 30 | Detachment from the fan!<br>Muscle strength 31.7 kg - normal | The therapeutic program was continued, adjusting the dosage of the exercises according to the clinical condition of the subject | Walk, independent, including oxygen |

## *6.6. Results*

The purpose of the case study was to present that early mobilization and elastic band exercises were effective solutions for an intubated subject in the intensive care unit. The subject was able to maintain functional independence before being hospitalized, and this capacity was maintained during hospitalization. On the RASS scale, the subject obtained a score of 0, indicating that he was conscious and calm throughout the recovery process. He showed a lot of cooperation and strictly followed the recovery program. Communication was greatly simplified due to the subject's use of a smartphone. The values of hemodynamic and respiratory parameters allowed the start of the recovery program from the first day of intensive care.

At the initial evaluation of muscle strength in the upper limb with the EH 101 dynamometer, the result was 27.6 kg, which means weak muscle strength. After ten days of physical therapy, a normal muscle strength of 32.8 kg was obtained, which increased by 5.2 kg compared to the initial evaluation. At the end of the 30 days of physical therapy, the muscle strength of the upper limb decreased, i.e. 31.7 kg, this was due to the fact that the subject had several difficult periods with many complications during his stay in intensive care.

The subject was very cooperative, compliant and responsive, having excellent communication skills. He managed to cover over a hundred meters with the mechanical ventilation device while he was intubated. This achievement was extremely significant for our intensive care unit, as it was the first time that an intubated and mechanically ventilated subject moved in these conditions. This was also another key factor that facilitated the success of the eventual fan detachment. The physical therapy program, compliance with the subject and teamwork were essential in this effort to eliminate mechanical ventilation.

### *6.7. Conclusions*

In this case study, the hypothesis was confirmed and the early mobilization and the elastic band exercise program proved to be effective, safe, affordable and suitable for an intensive care unit, representing the ideal solution for successful detachment from the ventilator. In addition, active exercises (including walking with the intubated subject) have been shown to be safe, viable and achievable, even if they required considerable effort on the part of the subject and the entire medical team. An important observation regarding previous research in this area is that without early intervention for mobilization, the likelihood of ceasing ventilator use would have been very low. Participants who have been mechanically ventilated for more than 48 hours experience rapid loss of muscle mass (Hodgson et al., 2022). About 63% of patients who benefit from mechanical ventilation experience muscle weakness acquired in the intensive care unit (Cottereau et al., 2021). Although the subject went through numerous complex medical maneuvers with high risk, he managed to retain the muscle strength necessary to breathe spontaneously. The use of elastic band training can increase the disconnection rate from mechanical ventilation by up to 78%, being an easy technique to learn and without special space requirements (Chang, 2020).

# CHAPTER VII

# STUDY 3

# PERME INTENSIVE CARE UNIT MOBILITY SCORE AND ICU MOBILITY SCALE: ROMANIAN TRANSLATION AND INTERCULTURAL ADAPTATION FOR USE IN ROMANIA

## *7.1. Introduce*[3]

Subjects admitted to the intensive care unit are usually mostly bedridden, this limits their mobility and could affect several physiological systems (Alapharthi et al., 2020). Long recovery time increases the chance of functional decline for ICU subjects (Hodgson et al., 2023). Assessment of functional mobility in intensive care is necessary to support the subject's recovery, identify those who could benefit from recovery, and track the effectiveness of therapeutic interventions. Safety during mobilization requires a thorough assessment of the subject's physical health prior to mobilization. However, there is a limitation of specific recommendations in this regard (Yang et al., 2021). There are benefits for clinical and research practice, related to the results obtained in the monitoring of early mobilization. There are already several tools available that can be used to assess the mobility status of subjects (Parry et al., 2017).

Parry and collaborators in 2015 reported that only 6 of the 26 instruments for measuring functional mobility were specifically developed for use in the intensive care unit. None of these tools, although considered golden, could determine the level of mobility of the subject to help the multidisciplinary team objectively assess mobility (Nawa et al., 2014).

## *7.2. Objective*

The objective of the study was to validate a functional mobility assessment score, adapted to

[3]Conținutul acestui capitol reprezintă în întregime manuscrisul publicat în revista Health, Sports & Rehabilitation Medicine: Stan, D. C., Boncuț, M., Miron, M. R., Sandor, I., Perme, C., (2024). Perme Intensive Care Unit Mobility Scale: Translation Into Romanian And Cross-Cultural Adaptation For Use In Romania. *Health, Sports & Rehabilitation Medicine Vol. 25, no. 1, January-March 2024, 4-8,*https://doi.org/10.26659/pm3.2024.25.1.4

the needs of patients in the intensive care unit for our country.

### *7.3. Hypothesis*

The translation into Romanian of the Perme Score and the IMS Score, we hope to have a strong agreement and reliability between the evaluators, as well as a positive correlation between the two scores; They will be successfully adapted for implementation in the intensive care unit.

### *7.4. Material and method*

#### 7.3.1. Research protocol

**a). Period and place of research**

The study was carried out at the Regional Institute of Gastroenterology and Hepatology Prof. Dr. Octavian Fodor in Cluj-Napoca between March and October 2023, a hospital unit with 14 surgical beds and 6 medical beds. The study was of a prospective observational type.

**b). Subjects**

The study participants were over 18 years old and were admitted to the intensive care unit. The procedures were performed by two experienced physiotherapists, as well as sworn translators**.**

**c). Tools**

Current standards for translation and intercultural adaptation of tools, with strict methodology, have been used to translate, interculturally adapt and validate the Perme and IMS Score (Beaton et al., 2000; Wild et al., 2005).

The stages of the process included:

1) Preparation: The principal investigator contacted the authors of the original tool to obtain permission to use, translate, and validate the Perme Score and IMS Scale interculturally.

2) Translation: the two instruments were independently translated from English into Romanian by two translators who were native Romanian speakers and spoke fluent English, one with experience in the medical field, the other not.

3) Reconciliation and synthesis: two physiotherapists who were familiar with both tools reviewed the first Romanian version of the tools, item by item and compared it with the original English version.

4) Backward translation: for the backward translation, the second Romanian version of the two instruments was sent to two native English speakers who were also proficient in Romanian. None of the translators had access to the English version.

5) Revision and harmonization of reverse translation: in order to identify any discrepancies and make necessary adjustments, the retro-translated versions, each element of both tools were compared with their original English versions by the researchers in the evaluation committee.

6) Approval by the original author of the tool: the final version of the back-translation has been sent to the original author of both tools for review and comment.

7) Pre-test: two senior physiotherapists with more than five years of experience were trained in administering and grading the final Romanian version of the Perme and IMS score.

**d) Statistical processing**

The clinical characteristics of the population were determined by collecting information on age, gender, reason for admission to intensive care, use of mechanical ventilation, use of vasoactive drugs and additional factors. Version 27.0.1 IBM SPSS Statistical, was used to perform the statistical study. The mean and standard deviation were used to describe the clinical characteristics of the subjects, weighted kappa statistics and 95% confidence intervals were used to assess the degree of agreement between raters in the score of each instrument.

## *7.5. Results*

The demographics of the subjects evaluated in this study are shown in table number 4. The group consisted of a total of 110 subjects, 56% (n=62) men and 44% (n=48) women. Of the subjects, 27% (n = 29) were hospitalized for clinical reasons, including 5% (n = 5) with respiratory problems, 6% (n = 6) with gastroenterological problems, and 16% (n = 18) with liver disease accounting for the majority of cases. Surgical subjects had a considerable proportion of 73% (n=80) including 61% (n=67) gastroenterological problems, 5% (n=5) hepatic and 7% (n=8) respiratory cases. Mechanical ventilation was used in 19% (n = 21) of the subjects and 36% (n = 40) of the cases involved used vasoactive drugs. Subjects had an average of 1.41 days of mechanical ventilation. The duration of hospitalization in intensive care at the time of evaluation was 5.04 days.

Table number 5 shows the reliability (Cronbach's alpha coefficient and internal consistency) and inter-rater agreement (kappa statistics and 95% CI) for IMS and each item of the Perme Score.

The agreement between the assessors and the reliability of the IMS was very good (Ranganathan et al., 2022).

*Table No. 5 Reliability and agreement between raters for the IMS Scale and the Perme Score*

| Instrument | Evaluator 1 Median [min-max] | Evaluator 2 Median [min-max] | Coefficient Reliability Cronbach Alpha | Agreement between the assessors *k* (95% CI) |
|---|---|---|---|---|
| IMS | 4[0-8] | 4[0-8] | 0.99 | 0.99 (0.98-1.00) |
| Perme ICU Mobility Score | | | | |
| 1) Mental state: item 1 | 2 [0-2] | 2 [0-2] | 0.98 | 0.95 (0.90-0.99) |
| 2) Mental state: item 2 | 1 [0-1] | 1 [0-1] | 0.98 | 0.97 (0.91-1.00) |
| 3) Potential barriers: item 3 | 1 [0-1] | 1 [0-1] | 0.99 | 0.98 (0.94-1.00) |
| 4) Potential barriers: item 4 | 0 [0-1] | 1 [0-1] | 0.92 | 0.86 (0.77-0.96) |
| 5) Potential barriers: item 5 | 0 [0-1] | 0 [0-1] | 1.00 | 1.00 |
| 6) Potential barriers: item 6 | 0 [0-0] | 0 [0-0] | 1.00 | 1.00 |
| 7) Functional force: item 7 (left leg) | 1 [0-1] | 1 [0-1] | 1.00 | 1.00 |
| 8) Functional force: item 7 (right leg) | 1 [0-1] | 1 [0-1] | 1.00 | 1.00 |
| 9) Functional strength: item 8 (right arm) | 1 [0-1] | 1 [0-1] | 1.00 | 1.00 |
| 10)Functional force: item 8 (left arm) | 1 [0-1] | 1 [0-1] | 1.00 | 1.00 |
| 11) Mobility in bed: item 9 | 3[0-3] | 3[0-3] | 1.00 | 1.00 |
| 12) Mobility in bed: item 10 | 3[0-3] | 3[0-3] | 0.99 | 0.98(0.96-1.00) |
| 13) Transfers: item 11 | 1 [0-3] | 1[0-3] | 1.00 | 1.00 |
| 14) Transfers: item 12 | 0.5[0-3] | 0 [0-3] | 0.99 | 0.98 (0.97-1.00) |
| 15) Transfers: item 13 | 0 [0-3] | 0 [0-3] | 1.00 | 1.00 |
| 16) Mersul: item 14 | 0 [0-3] | 0 [0-3] | 0.99 | 0.99 (0.99-1.00) |
| 17) Endurance: item 15 | 0 [0-3] | 0 [0-3] | 1.00 | 1.00 |
| 18) Perme ICU Mobility Score (Total) | 15 [0-30] | 15 [0-30] | 1.00 | 1.00 |

### *7.6. Discussions*

The tools, the Perme Score and the IMS have been carefully translated into Romanian and adapted according to the local culture for use in Romania. Both the Romanian versions and the original versions of the instruments proved to be semantically and technically equivalent. Our results indicated that both tools had high reliability and good agreement between the evaluators in their translated versions for Romania, after only a short period of familiarization and training. There was also a significantly positive correlation between the Perme Score and the IMS. Prior to this study, there were no interculturally adapted tools to assess the mobility of patients in intensive care that could be used in Romania. Now, healthcare providers in Romania have two tools at their disposal that could help improve the quality of care provided to critically ill patients.

### *7.7. Conclusions*

The hypothesis of the study was confirmed, both the Perme Score and the IMS were validated interculturally and successfully adapted for use in intensive care units in our country.

Also, a strong agreement and reliability between the evaluators was achieved as well as a positive correlation between the two instruments, which means that both the Perme Score and the IMS can be put into practice with confidence by medical professionals in intensive care units.

In this context, patients will benefit from an accurate, reliable assessment and personalized recovery programs according to their requirements. Physical therapists and not only have the opportunity to perform a correct and individualized evaluation of the patient.

# CHAPTER VIII

# STUDY 4

# EFFECTS OF EXERCISES INTEGRATED WITH BLAZE POD ON MUSCLE STRENGTH, REACTION SPEED AND FUNCTIONAL MOBILITY IN INTENSIVE CARE PATIENTS

## *8.1. Introduce*

The increasing use of "vision sports training" is based on the fact that practicing with demanding visual, perceptual, cognitive or oculomotor tasks can improve the ability to process and respond to what is seen, thus improving sports performance. This practice is not necessarily new, but it has been very advanced in recent years through new digital technology that can be implemented during training activity (Appelbaum & Erickson, 2016).

Initiating an early mobilization program requires changing the culture in intensive care units, and technology can help increase staff compliance (Lipshutz & Gropper, 2013). Training with interactive lights, is the perfect cognitive and motor training system that can be adjusted and modified to meet the needs of each user, type of sport and training practices (Örs et al., 2019).

The speed at which an individual responds to a stimulus is called reaction time. Reaction time is an excellent test to observe the cognitive functions of individuals because it involves the sensory and motor systems. It is a measure of speed processing. Therefore, the evaluation is for both sensory and motor systems (Shankaregowda et al., 2022).

## *8.2. Material and method*

### 8.2.1. Location and subjects included in the study

The study was carried out at the Regional Institute of Gastroenterology and Hepatology Prof. Dr. Octavian Fodor, Cluj-Napoca, intensive care unit, between January and June 2024, and was an experiment type, with a control group and an experimental group.

The study included 56 subjects, 27 in the experimental group and 28 in the control group, recruited in the intensive care unit after admission by simple randomization.

### *8.3. Objective*

The objective of the study was to investigate the effects of exercises integrated with Blaze Pod on muscle strength, reaction speed and functional mobility in intensive care patients.

### *8.4. Assumptions*

**8.4.1. Null hypothesis -** there are no statistically significant differences in the results obtained between the two groups of subjects.

**8.4.2. Specific assumptions**

1. Subjects who have benefited from exercises integrated with Blaze Pod will have better results in the final assessment of muscle strength, reaction speed and functional mobility compared to the control group.

2. It is assumed that demographic data will influence muscle strength, reaction speed and the degree of functional mobility in intensive care subjects.

### *8.5. Tools*

**8.5.1. Blaze Pod - Flash Reflex Training**

**8.5.2. Electronic handheld dynamometer EH 101**

**8.5.3. Perme ICU Mobility Score**

**8.5.4. ICU Mobility Scale (IMS)**

### *8.6. Work protocol*

The study included 2 groups:

- 1 control group comprising 28 subjects
- 1 experiment batch comprising 27 subjects

**For the control group**, the recovery program was the standard one that was applied in the intensive care unit, according to the department's work protocol, with early mobilization of the

subjects, within the first 24 hours after admission, if the subject is hemodynamically and respiratory stable (Ho et al., 2022).

**The subjects in the experimental group** benefited in addition to the standard program of the intensive care unit, from the exercises integrated with Blaze Pod, which consisted of exercises for both the upper and lower limbs.

## *8.7. Presentation, analysis and interpretation of results*

### 8.7.1. Presentation of the subjects

*Table No. 6 Representation of subjects in batches according to mean age, gender and area*

| Lot | M ± SD | Gen % | Județ (Area) |
|---|---|---|---|
| Control | 63.75 ± 10.017 | 57.1 % masculin | 78.6 % - zona NV |
| | | 42.9 % feminin | 17.9 % - CENTRAL area |
| | | | 3.6 % - zona SV |
| Experiment | 65.85 ± 10.030 | 63 % masculin | 74.1 % - zona NV |
| | | 37% female | 18.5 % - CENTRAL area |
| | | | 7.4 % - SW |

Data are expressed as average, standard deviation ± and %

*Table No. 7 Representation of subjects by groups according to studies, diagnosis and day of intensive care*

| Lot | Education % | Diagnostic % | TI Day |
|---|---|---|---|
| Control | 67.9 % - Medium | 89.3 % - chirurgical | < 5 – 75% |
| | 32.1 % - superior | 10.7 % - nechirurgical | ≥ 5 – 25% |
| Experiment | 96.3 % - Medium | 96.3 % - chirurgical | < 5 – 62.9 % |
| | 3.7 % - higher | 3.7 % - nechirurgical | ≥ 5 – 37.1 % |

Data are expressed in percentages %

### 8.7.2. Experimental design and statistical analysis

The data were characterized by median and 25-75th percentiles, as the data did not have a normal distribution. Comparisons between tests were performed with the ANOVA test for repeated two-factor measurements. The value of $p < 0.05$ was considered statistically significant.

## *8.8. Results*

The distribution was non-normal, so the mean and standard deviation are not reported, but the median and percentiles. Following the statistical analysis, the following descriptive data were

presented. Exercises with BlazePod Flash Reflex Training have led to significant improvements in: - muscle strength, IMS (functional mobility) score, reaction speed.

### *8.10. Conclusions*

**The null hypothesis was refuted**, statistically significant results were obtained in terms of muscle strength, IMS score and reaction speed.

**The specific hypotheses were confirmed**, following the application of the exercises integrated with Blaze Pod, statistically significant results were obtained in the variable muscle strength, IMS score, reaction speed.

Muscle strength was affected by age, gender, number of days of intensive care and diagnosis, registering lower values.

The variable Perme Score and IMS had results independent of muscle strength, the results not being influenced by it.

Reaction speed was affected by age, gender and number of days in intensive care rather than muscle strength.

In conclusion, the exercises integrated with Blaze Pod had favorable effects on the variables, which were independent of each other, but were influenced by age, gender, number of days in intensive care and diagnosis. The specific hypotheses were confirmed. These results could be of great interest to the scientific community and could have practical implications in the future.

# GENERAL CONCLUSIONS OF THE DOCTORAL THESIS

The main objective of the thesis was to evaluate and implement innovative methods of recovery of patients admitted to intensive care units, with a focus on early mobilization, the use of adapted physical exercise and the integration of modern technologies. Following the analysis and interpretation of the data obtained, **the research results confirm the initial hypotheses** and demonstrate the positive impact of the proposed interventions on the functionality of critically ill patients.

***The main conclusions based on the studies carried out***

**1. Efficacy of passive exercises on arterial blood gases in mechanically ventilated subjects**

- Passive exercises have proven to optimize blood arterial gas parameters, thus facilitating patients' transition from mechanical ventilation to spontaneous breathing.
- The improvements observed at the cellular level from the first day of application of the protocol confirm that early mobilization is a valuable therapeutic tool for intubated patients.
- These results support the integration of passive exercise into standard protocols for the care of mechanically ventilated critical patients.

**2. Early mobilization and elastic banding, an effective solution for an intubated subject: a case study**

- Early mobilization, in combination with elastic band exercises, has been shown to be safe, feasible, and effective for critically ill intubated patients.
- The study demonstrates that this method can reduce the mechanical ventilation period and improve functional recovery time.
- The considerable effort of the patient and the medical team involved in recovery is justified by the obvious benefits in terms of muscle strength and functional independence.
- These results suggest that this protocol can be widely implemented in intensive care units in Romania, offering a viable alternative to traditional recovery methods.

**3. Perme Intensive Care Unit Mobility Score and ICU Mobility Scale: Romanian translation and intercultural adaptation for use in Romania**

- The study demonstrated that the translation and cultural adaptation of these scales was successful, the results confirming the high reliability and inter-rater agreement.
- These mobility assessment tools are now available for use in Romania, providing an objective standard for monitoring the progress of patients in the intensive care unit.
- Their validation fills an existing methodological gap in the recovery of critically ill patients, ensuring an accurate measurement of functional progress.

**4. Effects of Blaze Pod Integrated Exercises on Muscle Strength, Reaction Speed and Functional Mobility in Intensive Care Patients**

- Exercises with BlazePod Flash Reflex Training have led to significant improvements in:

- Muscle strength
- IMS (functional mobility) score
- Reaction speed

- This groundbreaking study demonstrates that integrating visual cognitive-motor training into the rehabilitation of critically ill patients can accelerate recovery and increase patient motivation.
- Flash Reflex Training devices can become a standardized assessment and rehabilitation tool for critically ill patients, providing an interactive and attractive method of stimulating motor and cognitive abilities.

## *Final conclusion*

The thesis adds a significant contribution to the literature, demonstrating the effectiveness of early mobilization, adapted exercise and innovative technologies in the recovery of critically ill patients.

By validating an integrated rehabilitation method, the research provides a solid basis for changing clinical practices in intensive care in Romania.

The results obtained underline the importance of early intervention and personalization of the recovery process, opening up new opportunities to improve the quality of care for critical patients and reduce the negative impact of prolonged immobilization.

# GENERAL LIMITATIONS OF RESEARCH

Although this research has made significant contributions to the field of patient recovery in intensive care units through the integration of adapted movement therapy and the use of modern technologies, it is important to highlight a number of **methodological, logistical and contextual limitations** that can influence the interpretation and applicability of the results in practice.

**1. Methodological limitations**

Sample size – The relatively small number of patients included in the study may affect the extrapolation of the results to a wider population. Although the data were rigorously analyzed, a larger sample, including patients from several intensive care units in Romania, would have allowed a more robust validation of the conclusions and a better generalization of the results.

**2. Logistical and operational limitations**

The context of the COVID-19 pandemic – One of the biggest challenges was conducting research during the pandemic crisis.

**3. Technological and infrastructure limitations**

Availability of resources in Romanian hospitals - Although this research has demonstrated the effectiveness of modern technologies (e.g. Blaze Pod Flash Reflex Training), many public hospitals in Romania do not have adequate funds for the necessary equipment.

**4. Limitations related to the variability of the human factor**

The degree of involvement of the medical staff – The application of the early mobilization and functional recovery interventions was influenced by the level of training and the availability of the staff in the intensive care units.

**5. Limitations on measuring long-term impact**

Post-discharge monitoring – A big challenge was the follow-up of patients after discharge from intensive care. In Romania, there is no integrated national system for monitoring critical patients after discharge from the hospital.

# ELEMENTS OF ORIGINALITY OF THE THESIS

The thesis makes significant contributions in the field of recovery of patients in intensive care units, integrating **innovative methods** and **modern technologies** into rehabilitation programs. The originality of the study derives from **the multidimensional approach of early mobilization**, the use of **validated tools for Romania** and the integration of **interactive digital technologies in the recovery of critical patients**.

**1. The original contribution of each individual study**

**Study 1: Efficacy of Passive Exercise on Blood Arterial Gas Parameters in Mechanically Ventilated Subjects**

It is the first study conducted in Romania that demonstrates that passive exercises applied to mechanically ventilated patients in intensive care can improve arterial gas parameters from the first day of application of the protocol.

The study highlights the beneficial changes at the cellular level, an aspect insufficiently explored in the literature in our country.

By applying these exercises, a new perspective is opened on the role of passive mobilization in reducing pulmonary complications and the duration of mechanical ventilation.

**Study 2: Early mobilization and elastic banding, an effective solution for an intubated subject: case study**

It is the first Romanian case study to demonstrate the effectiveness of a structured early mobilization program combined with elastic band exercises in facilitating detachment from the ventilator.

It presents a simple, safe, affordable and easy to implement method in intensive care units in Romania, without requiring expensive equipment.

The results can substantiate practical recommendations for optimizing recovery strategies for critical patients, with immediate applicability in the Romanian medical system.

**Study 3: Perme Intensive Care Unit Mobility Score and ICU Mobility Scale: Romanian translation and cross-cultural adaptation for use in Romania**

The study contributes to the standardization of the assessment of ICU patient mobility, by translating, adapting and validating two tools used internationally:

- Perme Intensive Care Unit Mobility Score

- ICU Mobility Scale (IMS)

These scales are available for the first time in Romanian, providing an objective and validated method for assessing the progress of critically ill patients in recovery.

This contribution will allow the standardization of recovery strategies and increase the quality of the medical act in the ICU wards in Romania.

**Study 4: Effects of Blaze Pod-Integrated Exercises on Muscle Strength, Reaction Speed, and Functional Mobility in Intensive Care Patients**

It is the first research in Romania to demonstrate the benefits of Flash Reflex Training in the recovery of critical patients in the intensive care unit.

Blaze Pod is used for the first time in this context, offering an innovative method of stimulating cognitive and motor reaction through interactive visual cues.

The study demonstrates statistically significant improvements in the following essential variables for recovery:

- Muscle strength
- IMS (functional mobility) score
- Reaction speed

This training system can be a modern and affordable solution for accelerating the recovery of critical patients, making the rehabilitation process more interactive and efficient.

Our thesis brings significant elements of originality, demonstrating the applicability of innovative methods of recovery of critical patients. Each of the studies carried out contributes to the development of new directions of medical practice, having a real impact on improving the care of patients in intensive care.

By integrating early mobilization, modern technologies and validated tools in the medical practice in Romania, this research lays the foundations for important changes in the recovery of critical patients and provides a reference model for future studies in the field.

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