REVIEW

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Safe Rehabilitation Practices For COVID-19 Patients on Mechanical Ventilators in the Intensive Care Units

Yoğun Bakım Ünitelerinde Mekanik Ventilatöre Bağlı Olan COVID-19 Hastaları İçin Güvenli Rehabilitasyon Uygulamaları

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ABSTRACT

A new type of coronavirus called Severe Acute Respiratory Syndrome (SARS-Cov-2) emerged in the city of Wuhan of China in December 2019. Due to its highly infectious nature, the new coronavirus (COVID-19) has spread over to more than 200 countries in the world and continues to infect more and more people worldwide. According to the World Health Organization, 5% of COVID-19 patients require the use of mechanical ventilators. Due to the fragile nature of the COVID-19 patients, it is of utmost importance that evidence-based safe exercises be applied to these patients. In this review, whole-body vibration, cycle ergometer, and electrical muscle stimulation were all investigated and evaluated in terms of their safety, feasibility, practicality, and the quality of evidence presented. According to the current evidence in the literature, they were all deemed safe and feasible alternatives to active exercises that could put the patients' health in jeopardy. Physiotherapists are recommended to work with the intensive care unit physicians regarding the implementation of these exercise programs and determine whether the patients with COVID-19 are suitable for the program. This review concluded that whole-body vibration, cycle ergometer, and electrical muscle stimulation modalities may serve as the safe rehabilitation practices for the physiotherapists worldwide to improve functional outcomes in patients with COVID-19, prevent muscle wasting, delirium, and decrease respiratory complications of COVID-19.

Key Words: COVID-19, Whole-body vibration, Cycle ergometer, Electrical muscle stimulation, Early mobilization

ÖZ

Aralık 2019'da Çin'in Wuhan şehrinde Şiddetli Akut Solunum Sendromu (SARS-Cov-2) adı verilen yeni bir koronavirüs türü ortaya çıktı. Oldukça bulaşıcı doğası nedeniyle, yeni koronavirüs (COVID-19) dünyada 200'den fazla ülkeye yayılmış ve dünya çapında giderek daha fazla insana bulaşmaya devam etmektedir. Dünya Sağlık Örgütüne göre, COVID-19 hastalarının %5'i mekanik ventilatör kullanımına ihtiyaç duymaktadır. COVID-19 hastalarının kırılganlığı nedeniyle, bu hastalara kanıtlarla desteklenen güvenli egzersizlerin uygulanması büyük önem taşımaktadır. Tüm vücut titreşimi, el-ayak ergometresi ve elektriksel kas stimülasyonu bu derlemede araştırılmış ve güvenlik, fizibilite, pratiklik ve ortaya konulan kanıt kalitesi açısından değerlendirilmiştir.

Literatürdeki mevcut kanıtlara göre hepsi, hastaların sağlığını tehlikeye atabilecek aktif egzersizlerin yerine,hasta sağlığı açısından güvenli ve uygulanabilir alternatifler olarak uygun görüldü. Fizyoterapistlerin, bu egzersiz programlarının uygulanması konusunda yoğun bakım ünitesi doktorlarıyla çalışması ve COVID-19 hastalarının, program için uygun olup olmadığını belirlemeleri önerilir. Bu derleme, tüm vücut titreşimi, el-ayak ergometresi ve elektriksel kas stimülasyonu yöntemlerinin, COVID-19'lu hastalarda fonksiyonel sonuçları geliştirmek, kas erimesini, deliryumu ve COVID-19'un solunumsal komplikasyonlarını azaltmak amacıyla, tüm dünyadaki fizyoterapistler için güvenli rehabilitasyon uygulamaları olabileceği sonucuna varmıştır.

Anahtar Sözcükler: COVID-19, Tüm vücut titreşimi, El-ayak ergometresi, Elektriksel kas stimülasyonu, Erken mobilizasyon

INTRODUCTION

A new type of coronavirus called Severe Acute Respiratory Syndrome (SARS-Cov-2) emerged in the city of Wuhan of China in December 2019(1). Due to its highly infectious nature, the new coronavirus (COVID-19) has spread over to more than 200 countries in the world and continues to infect more and more people worldwide. The most common way for it to spread is mainly through respiratory droplets or aerosols that are released after a sneeze or a cough (2). To date, there have been 11.591.595 confirmed cases of COVID-19 and 537.859 deaths reported to the World Health Organization (WHO) (3). The most common symptom of COVID-19 is fever (88.7%) which is followed by cough (67.8%), production of sputum (33.7%), nausea/vomiting (5.0%), and diarrhea (3.8%) (4). According to the WHO, 80% of the cases with COVID-19 infections show only mild symptoms or no symptoms at all, while 15% experience severe infections that require hospitalization and oxygen, and the remaining 5% suffer from critical infections that require the use of mechanical ventilators (5).

Considering the clinical presentation of COVID-19 and the need to rest in bed, most patients are unable to participate in mobilization exercises due to restrictions of movement imposed by the mechanical ventilators and hemodynamic instabilities. Intensive care unit acquired weaknesses (ICUAW) and psychological dysfunctions have emerged as the leading disadvantages of long-term stay at an intensive care unit (ICU), and their impact on the quality of life over the long-term is becoming increasingly apparent (6). Besides the pathophysiology of COVID-19, this pandemic requires extreme isolation from the outside world with limited space to move which then paves the way to delirious acts (7). Many hospitalized patients with severe symptoms will also develop delirium. Kotfis et al. reported that approximately 70-75% of patients on mechanical ventilators develop delirium which in turn tends to lengthen hospital stays, increase costs, and mortality rates (7).

To overcome the negative impact of prolonged ICU stays, recent studies have begun focusing on the potential benefits of early mobilization in the ICUs. Titsworth et al. found that early mobilization of patients with neurologic injuries was associated with shorter ICU and hospital length of stay (LOS), and fewer hospital/ICU acquired infections (8). In another study, Medical Research Council Manual Muscle Test Sum Score (MRC-SS) scores of patients on mechanical ventilators in ICU who were mobilized early were higher than the ones who were not mobilized in the early stages of their hospitalizations (9). This implies that the early mobilization group scored higher in strength testing when compared to the group who did not. Besides the strength gains, there are a few studies that reported that delirium could be reduced down to 50% on mechanically ventilated patients using the safety bundle called ABCDEFs developed by the Society of Critical Care Medicine (SCCM) (10, 11). The authors claimed that using lighter sedation and early mobilization was the key to reducing delirium in those respective studies.

It appears that the biggest obstacle to early mobilization seems to be the deep sedation levels and the presence of mechanical ventilators. One particular study reported very low participation in the early mobilization program due to sedation and patients being on ventilators (9). The authors reported that early mobilization was not achieved in 84% (1079/1288) of the total planned sessions despite having experienced physiotherapy staff on site. The other potential reason for such low participation in the early mobilization program was due to the fact that the authors aimed to implement only an active exercise program where the patients had to actively use their muscles and participate rather than a combination of both an active and a passive exercise program. Active exercises promote better functional outcomes such as improved bed mobility, ambulation distance, and timed up and go (TUG) test (12). Even though active exercises are the better choice in terms of functional outcomes, in cases where the patients are unable to actively participate in the program, passive exercises that are safe

for the patient could be implemented to improve patient participation.

Previous studies related to COVID-19 and the role of physiotherapy when it comes to this pandemic have mainly focused on the respiratory therapy part of the profession (13-16). Respiratory physiotherapy is undeniably one of the most crucial parts of managing respiratory-related issues in COVID-19 patients, however, it seems like it has been studied extensively enough, and the focus should now be shifted to finding safe rehabilitation practices to improve patients' functional status in the ICU.

Therefore, this article will discuss the safe rehabilitation practices for the COVID-19 patients on mechanical ventilators in the ICUs that could be implemented by the physiotherapists, doctors, and ICU staff in order to improve patient participation in mobilization exercises, prevent muscle wasting and delirium due to prolonged immobilization and extreme isolation.

Barriers to Mobilizing Patients on Mechanical Ventilators

Early mobilization, while arguably feasible and beneficial, is not still a norm in many ICUs worldwide. There are numerous concerns regarding the mobilization of patients that are on mechanical ventilators in the ICU. These concerns might be related to hemodynamic instability of the patient, lack of equipment, discipline, coordination, and protocols (17). One research study concluded that 63.5% of patients were unable to participate in the early mobilization program due to either intubation or deep sedation levels (18). If deemed medically safe, the patient's doctor could dose down the sedation levels and allow the patient to participate in the program. Some earlier studies have argued that it may be a contraindication for patients to rely on mechanical ventilators to breathe (19, 20). Several other studies, however, concluded that as long as the early mobilization program was performed by a qualified professional, mechanical ventilator and/or the intubation status of the patient was not considered a contraindication to early mobilization (21-23). Therefore, recent studies have shown that early mobilization is both safe and feasible even if the patients are on a mechanical ventilator or intubated. The hospitals and ICUs need to have early mobilization protocols in place and highly trained professionals such as physiotherapists to perform those tasks safely. Thus, the interaction between the physiotherapists and other healthcare professionals regarding the implementation of such programs is crucial for improving functional outcomes while maintaining patient safety.

Adverse Effects of Early Mobilizations

A Cochrane review study reviewing the potential adverse effects of early mobilization of critically ill patients in the ICU identified four Randomized Control Trials (RCTs) (24).

According to the information depicted in Table 1., three studies reported low occurrences of adverse events (25-27), and one study did not report any adverse events (28). Even though there should be more studies conducted in the future that investigates the safety and feasibility of mobilization of patients on mechanical ventilators, the current evidence suggests that it is both safe and feasible to mobilize mechanically ventilated patients in the ICU.

Safe Rehabilitation Practices

Safe rehabilitation practices described here were selected from the current literature for being both safe and having the ability to improve patient participation

Table 1. RCTs with adverse events as described in the Cochrane review.

Studies	Adverse Events	Types of adverse events	Related to physiotherapy?
Kayambu, 2015 (28)	No adverse events	No adverse event	No
Morris, 2016 (25)	8 events (total number of sessions not reported)	Endotracheal removal, vascular access device removal, fall,cardiac arrest	No
Schweickert, 2009 (26)	21 events out of 498 intervention sessions	Accidental dislodgement of the radial arterial catheter (1), oxygen desaturation <80% (1), patient instability (19)	Yes
Patman, 2001 (27)	15 adverse events (total number of sessions not reported)	Pulmonary complications	No

Table 2. Contraindications to whole-body vibration, cycle ergometer and electrical muscle stimulation.

Modality	Contraindications
Whole-body vibration	• Fractures or bone lesions • High risk of thromboembolism • Knee or hip prostheses • Angina pectoris • Low back pain • Cardiac disease • Recent trauma • Pacemaker • Epilepsy
Cycle ergometer	• Lower extremity instability issues (e.g. pelvic) • Lower extremity fractures • Presence of deep venous thrombosis
Electrical Muscle Stimulation	• Over areas of anterior neck region, carotid sinuses, heart, thoracic area, insensate skin, pregnancy • Presence of a cardiac pacemaker • Presence of a defibrillator, • During an electrocardiogram testing

even if the patient is intubated and mechanically ventilated. Moreover, another reason for selecting these modalities was that all had a passive exercise mode which would allow the patient to participate in the early mobilization program regardless of the patient's level of sedation.

Whole-Body Vibration

The whole-body vibration (WBV) method to improve outcomes in both healthy and unhealthy populations has become a focus of interest by the researchers in recent years. More and more studies are being conducted on this subject thanks to its multidimensional usability. It can be used both as an active and a passive exercise method which would mean that it could have a place in the ICU. WBV provides the users an opportunity to perform both static and dynamic exercises on a vibration platform in which the vibrations are transmitted up to the body through the feet (32). The vibration is suggested to cause muscle spindle activation, and α-motor neuron excitation and thus augment muscle activation (32). Also, during a WBV session, the sinusoidal vibration stimulation often exerts an additional load on the neuromuscular system, which is quite similar to that found in resistance training (32).

Currently, the researches have found evidence that WBV, when applied long enough, maintains muscular strength, increases bone density, and glucose metabolism (33, 34). Moreover, since the muscle contraction occurs at the spinal level, patients who are heavily sedated and unable to actively participate in the WBV sessions may benefit from the use of WBV in the ICU (35). In a study conducted on patients with spinal cord injuries, improvements in maximal isometric quadriceps strength were reported (36). Moreover, another study reported improvements in torque production in quadriceps and hamstring muscles following WBV sessions in patients with multiple sclerosis (37).

Wollersheim et al. have tested the safety and feasibility of WBV on mechanically ventilated patients in mixed and neuro intensive care units (35). Followed by a 6-minute warm-up performed by the physiotherapist, patients' knees and hips were flexed to about 20 degrees, vibration plates were placed under the patients' feet while making sure that adequate pressure was applied to the end of the bed. The WBV sessions lasted for 15 minutes. The authors reported that no adverse events were observed in any patients during the sessions. They also reported that the procedure was simple enough for the physiotherapist on staff to perform. The authors concluded that taking the absolute contraindications into account, implementation of WBV on mechanically ventilated patients were both safe and feasible (35). Additionally, the most recent study that reviewed the previous literature on the potential benefits of WBV on COVID-19 patients found that WBV did not induce dyspnea and alter oxygen saturation levels (6). Based on the evidence that the authors have found, WBV could be very well tolerated by COVID-19 patients and potentially provide the desired functional outcomes (6).

Cycle Ergometer

A cycle ergometer (CE) is an exercise device that could be easily used in a hospital bed by critically ill patients. This device could perform active, active-assisted, and passive exercises. A passive exercising option means that even people who are heavily sedated could utilize it. In recent years, there have been several studies conducted on the benefits of cycling in the ICUs specifically on mechanically ventilated patients (30, 38-40). Burtin et al., in an RCT study of 90 ICU patients with a diagnosed respiratory failure, studied the effects of 20 minutes of passive and active cycling (38). A total of 425 cycling sessions were completed with no adverse events. The authors found that cycling greatly improved quadriceps strength and 6-minute walking test distance in critically ill patients most of whom were on mechanical ventilators. Following these positive results, the authors concluded that the implementation of CE in critically ill patients regardless of whether they were mechanically ventilated and sedated or not was safe, feasible, and practical (38).

In another study conducted by Kho et al., a total of 541 cycling sessions were performed on critically ill patients (39). Of those 541 sessions, 432 (80%) sessions were performed while the patients were on a mechanical ventilator (whose 268 (62%) were done while they had an endotracheal tube). Only one adverse event was observed which was rare (0,2%). The authors' conclusions were that cycling was both safe and feasible to be implemented in ICU settings. Preiser et al. investigated the effects of passive cycling on heavily sedated, unconscious patients, and found that cycling decreased protein catabolism rates (30). Pires-Neto et al. also reported that the implementation of cycling in critically ill patients did not significantly change patient's hemodynamic, respiratory, and metabolic rates (40). The authors also concluded that cycling was a safe and feasible exercise type that could be associated with better functional outcomes in the ICU survivors.

Electrical Muscle Stimulation

Electrical muscle stimulation (EMS), in its simplest terms, is the stimulation and contraction of motor points on the muscles by the way of electrical impulses. This modality has been one of the go-to modalities in the physiotherapy and rehabilitation clinics for being easy to operate and studied effectiveness. Rodriguez et al. recruited 16 mechanically ventilated patients with septic shock into the study (41). He applied the EMS modality on the unilateral biceps and vastus medialis muscles for 2 separate 30-minute sessions on the same day for 13 days. The authors found that the muscle strength on the stimulated side increased drastically compared to the unstimulated side. They concluded that EMS may help prevent muscle weakness in the ICU (41). Additionally, Routsie et al. investigated whether or not the application of EMS on critically ill patients could help prevent the development of Critical Illness Polyneuropathy (CIPNM). The authors observed that the implementation of EMS on critically ill patients could assist in preventing CIPNM and reduce the period of weaning(42).

Poulsen et al. researched the effects of TENS on septic shock patients (43). He applied the EMS on the quadriceps muscle unilaterally for 60 continuous minutes for 7 days. Before and after images of the Computed Tomography (CT) showed that quadriceps muscle volume in the control group decreased by 16% compared to a 20% decrease in the EMS group. The authors here concluded that EMS application may not have any impact on the muscle volume increase in the critically ill population (43).

Contraindications to whole-body vibration, cycle ergometer, and electrical muscle stimulation modalities were listed in Table 2.

DISCUSSION

This review provided evidence-based, safe, feasible, and practical rehabilitation practices to the health professionals who are at the frontline in dealing with the drastic functional declines that the critically ill COVID-19 patients are currently experiencing in the ICUs worldwide. Even though no studies that are included here examined these methods directly on the COVID-19 patients, those studies were performed on critically ill patients whose symptoms resembled that of COVID-19. It is considered that the effects would be similar.

The general consensus of the scientific studies included in this review was that WBV, CE, and EMS methods were all deemed safe and feasible rehabilitation practices (35, 38, 39, 42, 44). The safety of these methods is of utmost importance to the healthcare professionals treating and providing care to the COVID-19 patients as these patients are extremely fragile and any unsafe exercises could have a detrimental effect on their health status. Therefore, the availability of such exercises that are evidence-based and safe is extremely important and helpful.

Prolonged stay at an ICU may cause a condition called intensive care unit acquired weakness (ICUAW).

ICUAW is characterized by generalized muscle weakness mainly affecting the limbs and respiratory muscles, leading to immobilization and prolonged hospitalization (45). ICUAW-related functional declines may persist for years after discharge (46). Dos Santos et al. conducted a prospective study of critically ill patients who were on mechanical ventilators for at least 7 days and investigated the long term effects of ICUAW up to 6 months after discharge (47). Through the use of electromyography (EMG), nerve conduction velocity (NCV) tests, and vastus lateralis biopsies for histologic, cellular, and molecular analyses, the authors assessed functional motor and voluntary contractile capacities, quadriceps volume, and strength (47). According to the findings of the study, strength, although significantly improved, failed to normalize by 6 months. Moreover, muscle atrophy was sustained in 73% of the patients 6 months after being discharged from the ICU. Although the quadriceps muscle mass normalized in 27% of the patients at the 6-month mark, the persistent weakness in the quadriceps muscles was still present due to reduced quadriceps voluntary contractile capacity (47).

In a case study conducted by Bagnato et al. on a 62-year-old COVID-19 patient, critical illness myopathy (CIM) was investigated following the discharge from the ICU (48). During her stay in the ICU, she was intubated and put on a mechanical ventilator for respiratory support. The patient spent a total of 38 days on the service floors and 30 days in the ICU. After 68 days of hospitalization, she was moved to a rehabilitation unit where she was diagnosed with a CIM. Therefore, with recent evidence showing that COVID-19 patients may develop serious neurological complications (49), ICUAW should be suspected in all coronavirus cases (48).

Thus, due to the increased number of patients with SARS-CoV-2 infection who require prolonged ICU stays, it can be deduced that many of them will develop ICUAW in the future (50). Since the course of the coronavirus disease requires sedation and the use of mechanical ventilators in severe cases, this leads the health care professionals to focus on safe and passive rehabilitation practices to be implemented such as WBV, CE, and EMS. However, despite all the evidence presented on the efficacy of WBV, CE, and EMS on the critically ill ICU patients, no studies were conducted specifically on the COVID-19 patients to date.

Additionally, physiotherapists and other health-care specialists are encouraged to review the recent literature regarding the contraindications to exercise for the modalities included in this review for patient safety (Table 2.).

CONCLUSION

This review concludes that WBV, CE, and EMS modalities could be safely implemented to the mechanically ventilated and sedated patients in the ICUs in accordance with the current evidence to improve functional outcomes, prevent muscle wasting, delirium, and decrease respiratory complications. Although these modalities were not implemented specifically on the COVID-19 patients, similar inferences could be also made regarding the COVID-19 patients who are treated in the ICUs worldwide on the prevention of long-term complications such as ICUAW. Physiotherapists are recommended to work with the ICU physicians regarding the implementation of these exercise programs and determine whether the patients with COVID-19 are suitable for the program. Future studies that work with the critically ill COVID-19 patients are needed to make further inferences regarding the efficacy of these practices.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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Ethical Approval

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All aspects of writing this manuscript: Dinçer CÜRE

REFERENCES

1. Del Rio C, Malani PN. 2019 novel coronavirus-important information for clinicians. Jama 2020; 323(11): 1039-1040.
2. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early transmission dynamics in wuhan, china, of novel coronavirus-infected pneumonia. N Engl J Med 2020; 382(13): 1199-1207.
3. WHO. Who coronavirus disease (covid-19) dashboard. 2020 08.07.2020 Available from: https://covid19.who.int/?gclid=Cj0KCQjw3ZX4BRDmARIsAFYh7ZIcTYjwrn9qGqGyJluVp6T6bQMHyh4Yj6yV4JO42ApKUdQVb4VxuogaAmVXEALw_wcB. (Accessed: 2020 08.07)
4. Guan W-J, Ni Z-Y, Hu Y, Liang W-H, Ou C-Q, He J-X, et al. Clinical characteristics of coronavirus disease 2019 in china. N Engl J Med 2020; 382(18): 1708-1720.

5. Who. Coronavirus disease 2019 (covid-19) situation report – 46. 2020 Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200306-sitrep-46-covid-19.pdf?sfvrsn=96b04adf_4. (Accessed: 08.07.2020)
6. Sañudo B, Seixas A, Gloeckl R, Rittweger J, Rawer R, Taiar R, et al. Potential application of whole body vibration exercise for improving the clinical conditions of covid-19 infected individuals: A narrative review from the world association of vibration exercise experts (wavex) panel. International Journal of Environmental Research Public Health 2020; 17(10): 3650-3673.
7. Kotfis K, Williams Roberson S, Wilson JE, Dabrowski W, Pun BT, Ely EW. Covid-19: Icu delirium management during sars-cov-2 pandemic. J Critical Care 2020; 24: 1-9.
8. Titsworth WL, Hester J, Correia T, Reed R, Guin P, Archibald L, et al. The effect of increased mobility on morbidity in the neurointensive care unit. J Neurosurg 2012; 116(6): 1379-1388.
9. TEAM Study Investigators. Early mobilization and recovery in mechanically ventilated patients in the icu: A bi-national, multi-centre, prospective cohort study. J Critical Care 2015; 19(1): 81-91.
10. Pun BT, Balas MC, Barnes-Daly MA, Thompson JL, Aldrich JM, Barr J, et al. Caring for critically ill patients with the abcdef bundle: Results of the icu liberation collaborative in over 15,000 adults. Crit Care Med 2019; 47(1): 3-14.
11. Ely EW. The abcdef bundle: Science and philosophy of how icu liberation serves patients and families. Crit Care Med 2017; 45(2): 321-330.
12. Eymir M, Erduran M, Ünver B. Active heel-slide exercise therapy facilitates the functional and proprioceptive enhancement following total knee arthroplasty compared to continuous passive motion. Knee Surg Sports Traumatol Arthrosc 2020; 28(8): 1-9.
13. Thomas P, Baldwin C, Bissett B, Boden I, Gosselink R, Granger CL, et al. Physiotherapy management for covid-19 in the acute hospital setting: Clinical practice recommendations. Journal of Physiotherapy 2020; 66(2): 73-82.
14. Deniz İ, Yağli NV, Sağlam M, Kütükcü EÇ. COVID-19 enfeksiyonunda akut ve post-akut fizyoterapi ve rehabilitasyon. Türk Fizyoterapi ve Rehabilitasyon Dergisi 2020: 31(1): 81-93.
15. Felten Barentsz KM, Van Oorsouw R, Klooster E, Koenders N, Driehuis F, Hulzebos EH, et al. Recommendations for hospital-based physical therapists managing patients with covid-19. Phys Ther 2020; 100(9): 1444-1457.
16. Lazzeri M, Lanza A, Bellini R, Bellofiore A, Cecchetto S, Colombo A, et al. Respiratory physiotherapy in patients with covid-19 infection in acute setting: A position paper of the italian association of respiratory physiotherapists (arir). Monaldi Arch Chest Dis 2020; 90(1): 163-168.
17. Dubb R, Nydahl P, Hermes C, Schwabbauer N, Toonstra A, Parker AM, et al. Barriers and strategies for early mobilization of patients in intensive care units. Annals of the American Thoracic Society 2016; 13(5): 724-730.
18. Olkowski BF and Shah SO. Early mobilization in the neuro-icu: How far can we go? Neurocrit Care 2017; 27(1): 141-150.
19. King J and Crowe J. Mobilization practices in canadian critical care units. Journal of Physiotherapy Canada 1998; 50(3): 206-211.
20. Morris PE. Moving our critically ill patients: Mobility barriers and benefits. Crit Care Clin 2007; 23(1): 1-20.
21. Fan E, Cheek F, Chlan L, Gosselink R, Hart N, Herridge MS, et al. An official american thoracic society clinical practice guideline: The diagnosis of intensive care unit-acquired weakness in adults. Am J Respir Crit Care Med 2014; 190(12): 1437-1446.
22. Bailey P, Thomsen GE, Spuhler VJ, Blair R, Jewkes J, Bezdjian L, et al. Early activity is feasible and safe in respiratory failure patients. Crit Care Med 2007; 35(1): 139-145.
23. Thomsen GE, Snow GL, Rodriguez L, and Hopkins RO. Patients with respiratory failure increase ambulation after transfer to an intensive care unit where early activity is a priority. Crit Care Med 2008; 36(4): 1119-1124.
24. Doiron KA, Hoffmann TC, and Beller EM. Early intervention (mobilization or active exercise) for critically ill adults in the intensive care unit. Cochrane Database Syst Rev 2018; 3(3): 1-52.
25. Morris PE, Berry MJ, Files DC, Thompson JC, Hauser J, Flores L, et al. Standardized rehabilitation and hospital length of stay among patients with acute respiratory failure: A randomized clinical trial. Jama 2016; 315(24): 2694-2702.
26. Schweickert WD, Pohlman MC, Pohlman AS, Nigos C, Pawlik AJ, Esbrook CL, et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: A randomised controlled trial. Lancet. 2009; 373(9678): 1874-1882.
27. Patman S, Sanderson D, and Blackmore M. Physiotherapy following cardiac surgery: Is it necessary during the intubation period? Australian Journal of Physiotherapy. 2001; 47(1): 7-16.
28. Kayambu G, Boots R, and Paratz J. Early physical rehabilitation in intensive care patients with sepsis syndromes: A pilot randomised controlled trial. Intensive Care Med 2015; 41(5): 865-874.
29. Monteleone G, De Lorenzo A, Sgroi M, De Angelis S, and Di Renzo L. Contraindications for whole body vibration training. J Sports Med Phys Fitness 2007; 47(4): 443-445.

30. Preiser J, De Prato C, Harvengt A, Peters L, Bastin M, and Fraipont V. Passive cycling limits myofibrillar protein catabolism in unconscious patients: A pilot study. J Nov Physiother 2014; 4(4): 1-6.
31. Poitras S and Brosseau L. Evidence-informed management of chronic low back pain with transcutaneous electrical nerve stimulation, interferential current, electrical muscle stimulation, ultrasound, and thermotherapy. The Spine Journal 2008; 8(1): 226-233.
32. Rittweger J. Vibration as an exercise modality: How it may work, and what its potential might be. Eur J Appl Physiol 2010; 108(5): 877-904.
33. Wang H-H, Chen W-H, Liu C, Yang W-W, Huang M-Y, and Shiang T-Y. Whole-body vibration combined with extra-load training for enhancing the strength and speed of track and field athletes. The Journal of Strength Conditioning Research 2014; 28(9): 2470-2477.
34. Cochrane D and Stannard S. Acute whole body vibration training increases vertical jump and flexibility performance in elite female field hockey players. Br J Sports Med 2005; 39(11): 860-865.
35. Wollersheim T, Haas K, Wolf S, Mai K, Spies C, Steinhagen-Thiessen E, et al. Whole-body vibration to prevent intensive care unit-acquired weakness: Safety, feasibility, and metabolic response. J of Critical Care 2017; 21(1): 1-10.
36. Bosveld R, Field Fote E. Single-dose effects of whole body vibration on quadriceps strength in individuals with motor-incomplete spinal cord injury. J Spinal Cord Med 2015; 38(6): 784-791.
37. Jackson KJ, Merriman HL, Vanderburgh PM, Brahler CJ. Acute effects of whole-body vibration on lower extremity muscle performance in persons with multiple sclerosis. Journal of Neurologic Physical Therapy 2008; 32(4): 171-176.
38. Burtin C, Clerckx B, Robbeets C, Ferdinande P, Langer D, Troosters T, et al. Early exercise in critically ill patients enhances short-term functional recovery. Crit Care Med 2009; 37(9): 2499-2505.
39. Kho ME, Martin RA, Toonstra AL, Zanni JM, Mantheiy EC, Nelliot A, et al. Feasibility and safety of in-bed cycling for physical rehabilitation in the intensive care unit. J Crit Care 2015; 30(6): 1419-1425.
40. Pires-Neto RC, Kawaguchi YMF, Hirota AS, Fu C, Tanaka C, Caruso P, et al. Very early passive cycling exercise in mechanically ventilated critically ill patients: Physiological and safety aspects-a case series. J PLoS One 2013; 8(9): 1-7.
41. Rodriguez PO, Setten M, Maskin LP, Bonelli I, Vidomlansky SR, Attie S, et al. Muscle weakness in septic patients requiring mechanical ventilation: Protective effect of transcutaneous neuromuscular electrical stimulation. J Crit Care 2012; 27(3): 319-326.
42. Routsi C, Gerovasili V, Vasileiadis I, Karatzanos E, Pitsolis T, Tripodaki E, et al. Electrical muscle stimulation prevents critical illness polyneuromyopathy: A randomized parallel intervention trial. J Crit Care 2010; 14(2): 1-11.
43. Poulsen JB, Møller K, Jensen CV, Weisdorf S, Kehlet H, and Perner A. Effect of transcutaneous electrical muscle stimulation on muscle volume in patients with septic shock. Crit Care Med 2011; 39(3): 456-461.
44. Wang H-H, Chen W-H, Liu C, Yang W-W, Huang M-Y, Shiang T-YJTJOS, et al. Whole-body vibration combined with extra-load training for enhancing the strength and speed of track and field athletes. Randomized Controlled Trial 2014; 28(9): 2470-2477.
45. Batt J, Santos CCD, Cameron JI, Herridge MS. Intensive care unit-acquired weakness. Am J Respir Crit Care Med 2013; 187(3): 238-246.
46. Herridge MS. Legacy of intensive care unit-acquired weakness. Crit Care Med 2009; 37(10): 457-461.
47. Santos CD, Hussain SNA, Mathur S, Picard M, Herridge M, Correa J, et al. Mechanisms of chronic muscle wasting and dysfunction after an intensive care unit stay. A pilot study. Am J Respir Crit Care Med 2016; 194(7): 821-830.
48. Bagnato S, Boccagni C, Marino G, Prestandrea C, D'agostino T, Rubino F. Critical illness myopathy after covid-19. International Journal of Infectious Diseases 2020; 99: 276-278.
49. Pinzon RT, Wijaya VO, Buana RB, Al Jody A, Nunsio PN. Neurologic characteristics in coronavirus disease 2019 (covid-19): A systematic review and meta-analysis. Frontiers in Neurology 2020; 11(1): 565-575.
50. Ayoğlu H . COVID-19 hastalarında yoğun bakım yaklaşımı. Türk Diyab Obez / Turk J Diab Obes 2020; 4(2): 183-193.