AASHEESH KUMAR

Publications
● Roy A, **Kumar A**, Kakkadi V, Nag TC, Katyal J, Gupta YK, Jain S. rTMS treatment improved cognitive dysfunction through adult neurogenesis in ICV-STZ rat model of sporadic Alzheimer's disease. Age and Ageing, Volume 52, Issue Suppl_1, Jan 2023, afac322.037. https://doi.org/10.1093/ageing/afac322.037.
● Akhtar N, **Kumar A,** Mattoo B, Deepak KK, Bhatia R. Introducing virtual classrooms for undergraduate physiology teaching during the COVID-19 pandemic: acceptance by students and subjective impact on learning. Adv Physiol Educ. 2023 Sep 1;47(3):376-382. doi: 10.1152/advan.00252.2022. Epub 2023 May 18. PMID: 37199736.
● **Kumar A**, Kumar U, Bhatia R. Advancement in non pharmacological treatment strategies for the management of fibromyalgia syndrome. Int J of Sci Res. Volume 12, Issue 6, Jun 202 Page 5-8. https://rb.gy/zampd
● Akhtar N, **Kumar A,** Bhatia R.. Exploring the Advantages and Challenges of Blended Learning in Medical Education: A Focus on Physiology Adv Physiol Educ. 2023 August. (Accepted and In Press)
● Dwivedi A, **Kumar A,** Bhatia R. Decoding role of inhibitory neurotransmitters in pain of labor. Indian Obstetrics and Gynaecology. Volume 13 Issue 3. September 2023. (Accepted and In Press)
● **Kumar A**, Singh A, Yadav R, Venkataraman S, Kumar U, Deepak KK, Bhatia R. Exploring pain status and flexibility in fibromyalgia: Effect of 20 sessions of yoga therapy. Indian J. Physiol. Pharm. (Accepted and In Press)

Abstracts
● **Kumar A.,** Venkataramn S., Kumar U., Yadav R., Singh A., Dada R., Khan MA., Deepak KK., Bhatia R. Effect of 4-week medical yoga therapy on pain sensitivity, flexibility and range of motion in fibromyalgia patients. International Day of Yoga 2022, New Delhi, India. **(Poster Presentation)**
● **Kumar A.,** Yadav R., Singh A., Venkataramn S., Kumar U., Deepak KK., Bhatia R. Effect Of 28-Day Yoga Program On Pain Sensitivity And Flexibility In Fibromyalgia Syndrome. APPICON 2022, Chandigarh, India (**Oral Presentation)**

Publications (Submitted/Under Review/Under Process)
● Tiwari VK, **Kumar A**, Nanda S, Chaudhary S, Sharma R, Kumar U, Kumaran SS, Bhatia R. Effect of neuronavigated repetitive Transcranial Magnetic Stimulation on pain, cognition and cortical excitability in fibromyalgia syndrome. Indian Journal of Medical Research. (Submitted & Under Review)
● **Kumar A**, Sharma G, Venkataraman S, Kumar U, Bhatia R. Demographic and clinical characteristics of fibromyalgia patients in the Indian population. Indian Journal of Rheumatology. (Submitted & Under Review)
● **Kumar A,** Roy A. Comprehensive review on culprits of neurodegeneration in Alzheimer's disease: Bench to bedside impression. Current Journal of Neurology. (Submitted & Under Review)
● **Kumar A,** Sharma G, Kumar U, Venkataraman S, Singh A. Bhatia R. Do Pressure Pain Threshold Serve as a Diagnostic Tool or act as Remedy for Fibromyalgia Patients ? Pain Practice. (Submitted & Under Review)
● **Kumar A,** Roy A, Karaddi V, Katyal J, Nag TC, Jain S. Repetitive magnetic field stimulation (17.96μT, 50 Hz) partially ameliorates behavioral deficit by facilitating neurogenesis and attenuating oxidative stress in the hippocampus and entorhinal cortex of streptozotocin rat model of Alzheimer's disease. (Under Process of Submission)

Abstracts (Accepted but not presented yet)
● **Kumar A.,** Venkataramn S., Kumar U., Yadav R., Bhatia R. Effect of 28-day medical yoga therapy program on pain sensitivity, flexibility and range of motion in fibromyalgia syndrome. 13th International Conference of the European Pain Federation EFIC 2023, Budapest, Hungary. **(Accepted for Poster Viewing)**
● **Kumar A.,** Venkataramn S., Kumar U., Yadav R., Bhatia R. Effect of 28-day medical yoga therapy program on pain sensitivity, flexibility and range of motion in fibromyalgia syndrome. Controversies on Rheumatology and Autoimmune Diseases 2023, Turin, Italy. **(Accepted for Poster Viewing)**

JOURNAL ARTICLE

1145 RTMS TREATMENT IMPROVED COGNITIVE DYSFUNCTION THROUGH ADULT NEUROGENESIS IN ICV-STZ RAT MODEL OF SPORADIC ALZHEIMER'S DISEASE

A Roy, A Kumar, V Kakkadi, T C Nag, J Katyal, Y K Gupta, S Jain

Age and Ageing, Volume 52, Issue Supplement_1, January 2023, afac322.037, https://doi.org/10.1093/ageing/afac322.037

Published: 16 January 2023

Abstract

Background

Intracerebroventricular streptozotocin injection at 3mg/kg of b/w causes phenotypes similar to that of sporadic Alzheimer's disease (sAD) from 14th day post-injection. On the other hand, the body of evidence indicated that impairment in the sAD is the major contributor for cognitive decline. Taken together, we tested the adult neurogenesis hypothesis in streptozotocin model of sAD in female Wistar rats after extremely low magnetic stimulation (MF: 17.96, 50Hz, 2hr/day, 21days).

Method

33 rats were randomly divided into three groups viz. Sham+MF, AD and AD+MF. Consequently, animals were first induced AD with stereotaxic manipulation and then they were exposed to low frequency magnetic field stimulation, followed by terminal cognitive behavioural tasks brain tissue being isolated for both biochemical and subcellular expression experiments *(ethical no. 12/IAEC-1/2017)*.

Results

Showed reduction in latency to the goal quadrant (p= 0.002) and transfer latency (p= 0.045) in AD+MF group versus AD. Even, Dirichlet distribution of time spent in 4 quadrants indicated uniform in all the groups except AD group (p= 0.067, LRS= 7.35). Further, cell count in CA3 and DG exhibited increase in cell density in AD+MF group (p<0.05). However, we found significant reduction in SOD1 activity after MF treatment (p= 0.035) but no change in GSH level in hippocampus and frontal cortex. Interestingly, these changes in AD+MF animals are associated with increase in density of BrdU+/Nestin+ cells in granular layer (p= 0.002) and hilus region (p= 0.0005) of DG along with increase in expression of L-type Ca2+ channels as compared to AD group.

Conclusion

This experimental evidence suggests that non-invasive brain stimulation can promote adult neurogenesis by activating L-type ca2+ channels in the hilus, which intern helps in retention of long-term memory even after sAD.

8/29/23, 10:29 PM 1145 RTMS TREATMENT IMPROVED COGNITIVE DYSFUNCTION THROUGH ADULT NEUROGENESIS IN ICV-STZ RAT MO…

https://academic.oup.com/ageing/article-abstract/52/Supplement_1/afac322.037/6987738?redirectedFrom=fulltext&login=false

REVIEW ARTICLE
Volume - 12 | Issue - 06 | June - 2023 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ADVANCEMENT IN NON PHARMACOLOGICAL TREATMENT STRATEGIES FOR THE MANAGEMENT OF FIBROMYALGIA SYNDROME

Health Science

Aasheesh Kumar MSc All India Institute of Medical Sciences (AIIMS), New Delhi- 110029.
Uma Kumar MD All India Institute of Medical Sciences (AIIMS), New Delhi- 110029.
Renu Bhatia* MD All India Institute of Medical Sciences (AIIMS), New Delhi- 110029. *Corresponding Author

ABSTRACT

Fibromyalgia is a chronic idiopathic progressive musculoskeletal pain syndrome, which affects a large proportion of the population; around 2-4 % worldwide. The prevalence of fibromyalgia across the globe is much higher in women than in men and the ratio is approximately 9:1. Besides musculoskeletal pain, which is the major symptom of the disease, patients manifest cognitive impairment, sleep disturbances, memory loss, anxiety and depression. There is no permanent cure for the disease. Devastating pain and related syndromes of the fibromyalgia and the lack of proper treatment strategy make the patient hopeless and reduce their quality of life Therefore, they have to completely rely on the medications which can temporarily attenuate the pain and other related symptoms such as psychological disorders, fatigue, morning stiffness, sleep problems and various other health issues, but fail to improve the quality of life and lead to drug dependence and tolerance in most clinical cases. Nowadays, various lifestyle interventions such as e yoga, exercise regimens , tai-chi, hydropathy, physiotherapy and others have emerged to improve the quality of life of fibromyalgia patients. Most of them are non invasive and cost-effective however, these methods are under trials and available to patients, subject to their participation in different trial-based studies. In addition to these, some advanced non-invasive therapeutic interventions such as rTMS, Biofeedback techniques and TENS are also replicated by the researchers in their investigations. Most of the interventions are certainly low-cost practices, which can be easily adopted in day-to-day life at home; but their effectiveness and reliability are not so good. The two most common hurdles which increase the treatment burden for a clinician are the large variability in FM symptoms from severe pain to psychological distress and sleep disturbances and the long-term sustainability of the benefits of interventions to avoid recapitulation of symptoms after leaving the treatment regime. And furthermore, this reduces the quality of life and overall well-being of the patients. Considering the huge impact of fibromyalgia on quality of life of the patient , It is pertinent at this stage to focus more on the non-invasive management strategies for this disorder.

KEYWORDS

Fibromyalgia Syndrome, Pain Management, Lifestyle Intervention, Therapeutic Intervention

INTRODUCTION:

Fibromyalgia is a common neurologic chronic health problem that causes widespread pain and tenderness (sensitivity to touch); the pain and tenderness tend to come and go, and move about the body. Most often, people with this chronic illness are fatigued and have sleep problems (ACR Definition). It is diagnosed by a history of chronic widespread pain for at least 3 months and demonstration of significant pain in at least 11 out of the 19 tender points [1]. Musculoskeletal pain is the most common symptom of the disease; it is distributed to specific tender points, most of which are paired and present on the dorsal surfaces of the neck, shoulder, and back of the patients, it shows mild to severe pain for at least 3 months; which worsen with age [1]. Fibromyalgia can be diagnosed and treated on the basis of widespread pain Index (WPI) and Symptom Severity Score (SSS) of the patient (ACR, 2010). Besides persistent musculoskeletal pain, other high rated symptoms of fibromyalgia includes morning stiffness, fatigue, poor quality of sleep, anxiety, depression, cognitive impairment and memory loss [2] (see Figure 1). However, the musculoskeletal and neurological examinations are normal in most of the fibromyalgia patients [3]. There are various pathophysiology of the disease like oxidative burden, inflammation, sensitization due to chronic pain and tenderness. Amongst them, most are contraindicatory and thus the disease is still idiopathic in nature. Few genes are also found to be involved in the pathophysiology of the disease, like SLC64A4, TRPV2, etc; most of which are transporters and ion channels [4]. Incidence of FM has been reported over 2% in the general population [5]. This disorder predominantly affects women between 30-60 years aged in a ratio of 9:1 compared to men [6]. It is interesting to note that men have less fatigue, morning stiffness, and irritable bowel syndrome when compared to women [7]. Interestingly symptoms of FM have also been reported in juveniles and clinical presentation is quite similar to adult patients [8].

Musculoskeletal Symptoms	Non-musculoskeletal Symptoms	Other Complications
• Pain in muscle and joints • Fatigue • Morning stiffness • Jaw and neck pain • Restless leg syndrome • Movement and posture problems	• Headache • Memory loss • Anxiety • Depression • Cognitive impairment • Sleep disturbances	• Problem with vision • Skin problems • Dizziness • Nausea • Gastrointestinal problems • Dysmenorrhea

Figure 1: Fibromyalgia as a syndrome

There is no permanent cure of the disease; treatment strategies for FM are general in nature and include the use of both pharmacological and non-pharmacological symptoms management strategies; former comprises of common medications like: acetaminophen, ibuprofen, naproxen, cyclobenzaprine, amitriptyline, and aspirin [2]. Some of the FDA approved antidepressants and analgesics drugs are pregabalin, duloxetine and milnacipran which help to control symptoms of fibromyalgia syndrome. Amitriptyline are also used to control symptoms; but pure opioids should be avoided [9]. Following lifestyle and therapeutic interventions are extensively being studied by the researchers across the globe:

- Physical Activity and Exercise: Stretching, aerobic and resistance exercises (EULAR Recommendation, 2019)
- Massage Therapy
- Hydrotherapy
- Yoga and Meditation
- Repetitive Transcranial Magnetic Stimulation (rTMS)
- Transcutaneous Electric Nerve Stimulation (TENS)
- Vibrator therapy

In the present article, we are going to review all the newer advancements in the treatment strategies for the management of pain and related symptoms of fibromyalgia syndrome in the past 3 decades. Fibromyalgia is among one of the newest diseases which was discovered in the late 20th century. Lack of proper treatment strategy and the pin-point cure of the disease, make patients more worried and hopeless which ultimately degrades the quality of life of the fibromyalgia patients. Management of fibromyalgia becomes more cumbersome as it comprises of diverse symptoms from sleeplessness and fatigue to psychological distress. Timeline of some of the relevant interventions according to its implementation in the clinical trials and optimistic approach are given in Figure 2.

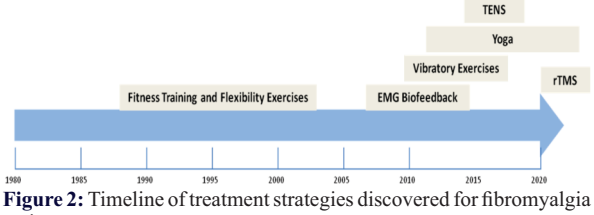


Figure 2: Timeline of treatment strategies discovered for fibromyalgia patients:

Classical Treatment Strategies For Fibromyalgia Patients:
Fibromyalgia as a syndrome was recognized in the late 20th century; earlier it was thought to be a musculoskeletal problem linked with either chronic low back pain or chronic fatigue syndrome [6].

Physical Activity And Exercises
Since, musculoskeletal pain is the primary symptom of fibromyalgia; so, researchers started working toward rehabilitation techniques like physical, aerobic, resistance and cardiovascular exercises for management of the disease. Within few years of discovery of the disease; scientists across globe started to prove physical exercises as a novel intervention for the management of fibromyalgia and related symptoms. In 1988, McCain and colleagues recruited 38 fibromyalgia patients in a study to validate the effect of 20 weeks of cardiovascular fitness training and simple flexibility exercises (3 sessions/week) and found significant improvement in musculoskeletal pain and psychological distress [10]. Aerobic fitness training and stretching exercise are also beneficial for fibromyalgia patients [11]. Moreover, Physical Activity, comprising at least twice a week can reduce fatigue, depression and other FM related symptoms [12]. Exercise is widely used as a treatment option to minimise micro-muscle trauma and central sensitization and emphasise low-intensity exercise, individualise exercise, and maximise self-efficacy [13-14]. Benefits of exercise therapy, jogging, cycling and swimming are well documented from various RCTs in the fibromyalgia patients [15-16]. Vibration therapy program is also useful and feasible for improving dynamic balance in women with FM [17]. EULAR recommended physical activity as one of the treatment strategies of fibromyalgia.

Massage Therapy
Massage therapy could be considered as one of the alternative and complementary treatments for the management of fibromyalgia syndrome [18]. Massage therapy with duration ≥5 weeks had beneficial immediate effects on improving pain, anxiety, and depression in patients with fibromyalgia [19]. While, another pilot study suggest modest benefits to FM patients at four weeks which is not significant at later time-points [20]. So, there are fewer and contraindicatory findings about the beneficial effect of massage therapy in fibromyalgia.

Water Therapy
Aquatic Physical Training (APT) contributes to increase variable oxygen uptake and improve clinical symptoms of fibromyalgia, but no association has been established yet [21]. A 16 week hydrotherapy program (45 minutes, twice a week) was found effective to improve quality of life, pain intensity and fibromyalgia impact in women with fibromyalgia syndrome despite of any changes in scapular kinematics due to adaptive movement pattern due to chronic painful condition [22-23]. In-pool exercise education programme (n=134) showed a small but significant improvement in health status of fibromyalgia patients as compared with that of education only and patients with milder symptoms improved most with this treatment strategy [24]. Water therapy including deep water running and in-pool aquatic training, may be recommended as a non-pharmacological complementary approach for the management of FMS in improving pain, postural control, fatigue, and quality of life - these therapeutic effects are achieved by the physiological changes caused by in-water exercising [23, 25-26]. Nowadays, warm-water exercising and water-based Ai Chi program are also recommended to improve mental and physical health and the quality of life in women with fibromyalgia [27-29].

Yoga And Meditation
Yoga is culturally believed as a strategy to direct attention and attitude toward wellness of mind and body. To restore sensorimotor dysfunction and alleviation of pain, yoga therapy is formally being investigated in fibromyalgia patients. Robust evidence already exists that documents the role of yogic lifestyle intervention and relaxation techniques in the management of fibromyalgia [30]. Yoga improves quality of life and act as analgesia through physiological mechanisms - hypothalamic-pituitary-adrenal (HPA) axis and parasympathetic nervous system tuning [31]. Yoga negotiates the increased morning cortisol levels in chronic pain patients [32-33]. An eight week yoga awareness program, comprising 2 hours of yoga once a week, was found to significantly reduce pain and other fibromyalgia related symptoms subjectively (n=53) than the patients on standard care [34]. On contrary, Curtis and colleagues subjectively studied the effect of an eight-week Mindfulness Based Stress Reduction (MBSR) in 173 fibromyalgia patients; authors claim no improvement in pain and psychological symptoms like sleep problems, quality of life and cognition after intervening patients with 2.5 hours MBSR session (once a week) and 45 minutes home practice (5 sessions/week) [35]. Reductions in pain catastrophizing behaviour and pain inventory along with sleeplessness were noticed after six weeks of weekly 210 minutes yoga session (5 days home video practice) by another group too [36]. Twice a week gentle *Hatha* yoga was also found to reduce FM related symptoms [37]. Since, yoga can improve pain experience, it would be logical to assume that yoga might be acting, at least in part, to favourably modulate the perceptual control over pain.

Modern Treatment Strategies For Fibromyalgia Patients:
Transcutaneous Electrical Nerve Stimulation
Transcutaneous Electrical Nerve Stimulation (TENS) is an emerging technique to treat patients with various musculoskeletal problems. Four weeks of active TENS use showed a significant improvement in movement-evoked pain and other clinical outcomes of fibromyalgia syndrome as compared to sham analog [38]. Most vital advantage of TENS is its simultaneous application at different tender points for fatigue and pain relief with no side effects [18, 39]. Pain relief and inhibitory activity was also reported on quantitative electroencephalography after TENS for 20 minutes [40]. Another study demonstrated modest treatment effects of reduced disease impact, pain and functional impairment from wearable TENS in individuals with fibromyalgia. Patients with higher pain sensitivity exhibited larger treatment effects. Wearable TENS may be a safe treatment option for fibromyalgia patients [41]. TENS restores central inhibition in primary fibromyalgia and consequently reduces pain, fatigue, and hyperalgesia in the patients [42]. High-frequency TENS could be a potential adjuvant therapy for fibromyalgia patients for relieving pain, anxiety, fatigue, stiffness and in improving ability to work [43].

Biofeedback Techniques
Electromyography is a diagnostic tool to assess muscle activity but its application as restorative therapeutic intervention in fibromyalgia is recently reported by few authors [44]. EMG Biofeedback (BFB) is an established intervention in the rehabilitation of headache and other pain disorders but it showed no health status improvement fibromyalgia patients [45]. While other literature suggests that EMG biofeedback therapy could be a useful treatment modality to reduce pain of FM patients, along with improvements in quality of life, movement and number of tender points [46]. Although, there are paucity of literatures for EMG biofeedback but it is an emerging therapy to manage fibromyalgia syndrome; more clinical trials are required to recommend it for therapeutic use. Heart rate variability biofeedback may also be a useful treatment strategy for fibromyalgia, perhaps mediated by autonomic changes [47]. Hence, newer techniques such as heart rate variability biofeedback techniques also seem to be promising.

Vibration Therapy
Whole body vibration therapy is an emerging intervention for fibromyalgia; it has been shown to improve functional disability and pain sensitivity of fibromyalgia patients immediately after the therapy program; which was not maintained in the follow-ups [48]. Greater benefits were suggested with the use of rotational rather than vertical whole body vibration. The use of the rotational modality is recommended in the standard therapy program for patients with fibromyalgia [49]. Sonic wave vibration therapy can also lead to acute and chronic pain reduction and improves quality of life in patients with fibromyalgia [50]. Other non-nociceptive somatosensory stimulation like vibrotactile stimulation also has potential role in the symptomatic treatment of fibromyalgia patients [51].

Repetitive Transcranial Magnetic Stimulation
Fibromyalgia is a psychosomatic problem rather than a peripheral syndrome. So, non invasive brain stimulation could be a potential tool to restore sensory and motor aberrations using direct stimulation of the brain areas responsible for cortical plasticity in fibromyalgia. There is an increased cortical excitability of the fibromyalgia patients due to chronic pain condition [52-53]. Low frequency brain stimulation is a non invasive tool to treat patients with chronic pain conditions with minimal adverse effect. rTMS is also recommended by FDA for its use in treating patients with depression. Repetitive Transcranial Magnetic Stimulation (rTMS) for four weeks at dorsolateral prefrontal cortex was proved to improve pain and related symptoms of fibromyalgia when targeted [54-55]. Transcranial Direct Current Stimulation

(tDCS) can also result in significant pain relief in FM patients and may be an effective complementary treatment strategy [56]. High frequency rTMS can also have the similar effect like physical exercise in ameliorating pain, emotional status and related impact of women with fibromyalgia [57]. Hence, neuromodulation techniques are quiet safe and can be suggested for immediate relief in pain and related impact of fibromyalgia patients.

All the major treatment strategies along with details are systematically summarized in the Table 1.

Table 1: Evolution of treatment strategies for patients with fibromyalgia syndrome

Authors	Sample Size	Intervention	Duration	Inferences
McCain et al. 1988	FM = 38	Cardiovascular fitness training or Simple Flexibility exercises	20 Week (3 sessions/week)	Improvement in FM associated symptoms and psychological distress
Valim et al. 2003	FM = 76	Aerobic fitness training or Stretching exercises	20 Weeks	Exercises are beneficial to patients with FM
Babu et al. 2007	FM = 30	EMG Biofeedback	6 Days, 45 minutes	Biofeedback reduces pain in along with improvements in quality of life, movement and number of tender points in FM patients.
Etnier et al. 2009	FM = 16	Physical Activity program	18 Weeks (2 sessions/week)	Significant reduction in fatigue, depression and FM symptoms
Gusi et al. 2009	FM = 21	Tilt vibratory exercise	12 Weeks, 30 minutes daily (3 sessions/week)	Useful and feasible for improving dynamic balance in FM patients
Carson et al. 2011	FM = 53	Yoga program & Waitlist	8 Weeks (2 hours/week)	Significant reduction in FM symptoms
Rudrud et al. 2011	FM = 10	Gentle Hatha Yoga	8 Weeks (Twice/week)	Hatha yoga reduced FM related symptoms
Dailey et al. 2013	FM = 103	Transcutaneous Electrical Nerve Stimulation	4 Weeks (2 hours daily)	Active TENS use can significantly improve movement-evoked pain and other clinical outcomes of FM.
Avila et al. 2017	FM = 20	Hydrotherapy program	16 Weeks, 45 minutes (Twice/week)	Hydrotherapy was effective to improve quality of life, pain intensity and fibromyalgia impact
Lazaridou et al. 2019	FM = 36	Yoga Program	6 Weeks (weekly) Daily home video practice (5 days/week)	Improved pain and impact, Sleep Quality Improved
Pujol et al. 2019	FM = 77	Gentle vibrotactile stimulation	3Weeks (3hours at night)	Support a potential role for vibrotactile stimulation in the symptomatic treatment of fibromyalgia
Tanwar et al. 2020	FM = 90	Repetitive Transcranial Magnetic Stimulation at DLPFC	4 Weeks	Right DLPFC rTMS can significantly reduce pain and associated symptoms of FM
Mingorance et al. 2021	FM = 20	Rotational whole body vibration	12 weeks	Improvements in functional disability, static equilibrium and vibration sensitivity and a reduction of pain sensitivity.

FM – Fibromyalgia, EMG – Electromyography, DLPFC – Dorsolateral prefrontal cortex

Conclusion and Future Directions:

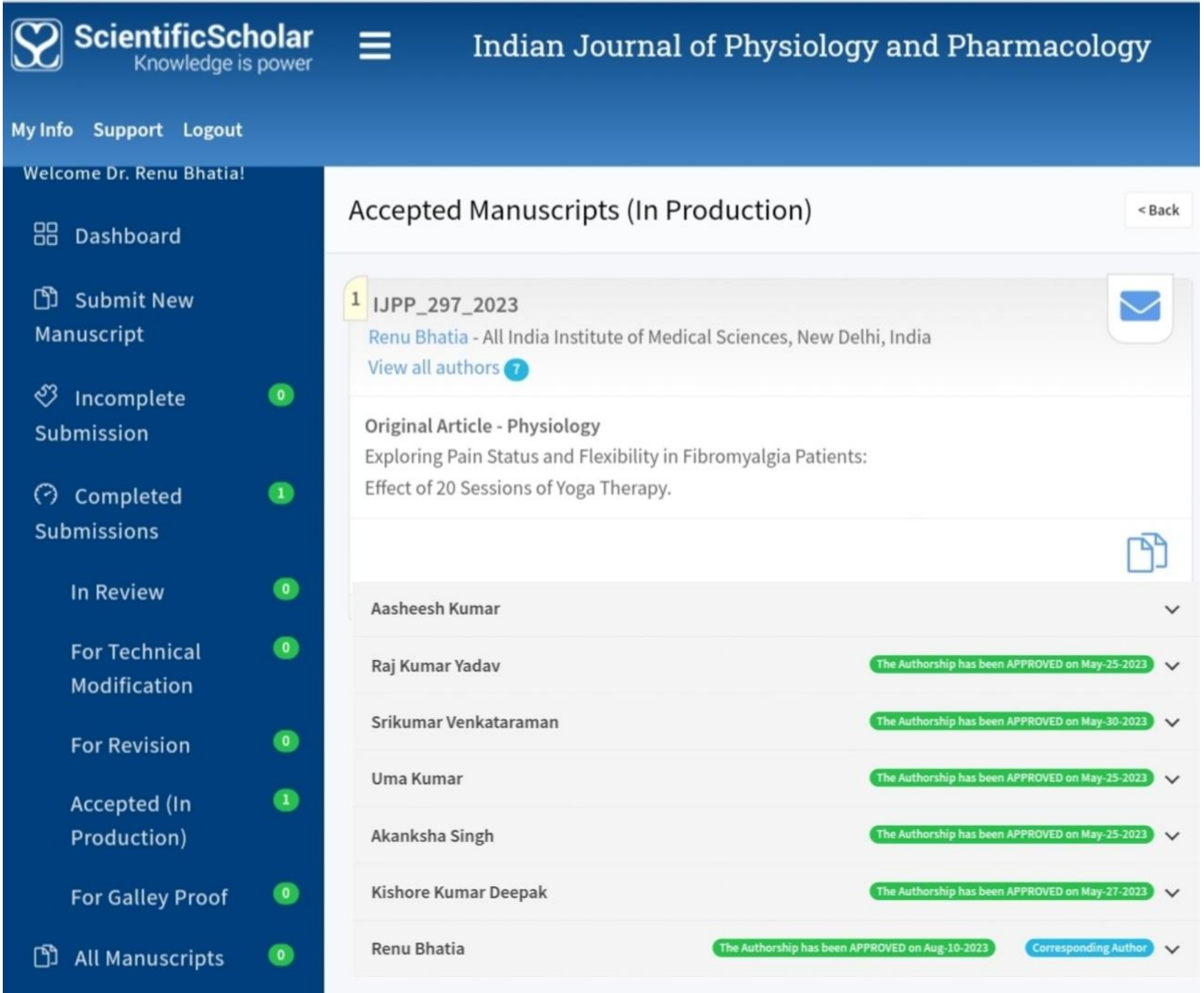
Although few FDA approved drugs are available to get symptomatic relief from fibromyalgia symptoms but there is no permanent cure of the disease. In past two decades some of the non invasive treatment strategies like lifestyle interventions such as medical yoga therapy, vibration therapy, and repetitive Transcranial Magnetic Stimulations are emerging and could have potential role in management of fibromyalgia syndrome to a certain extent. Clinical trials on non pharmacological treatment modalities are mainly focussed on assessing symptoms using subjective outcomes; there is also a need to incorporate objective assessment tools for better visualization of the effect of these interventions.

Conflict of Interest: There is no conflict of interest till date.

REFERENCES:

1. Wolfe F, Clauw DJ, Fitzcharles M.A. The American College of Rheumatology preliminary diagnostic criteria for fibromyalgia and measurement of symptom severity. Arthritis Care and Research. 2010; 62:600–610.
2. Bennett RM, Jones J, Turk DC, Russell IJ, Matallana L. An internet survey of 2,596 people with fibromyalgia. BMC Musculoskelet Disord. 2007 Mar 9;8:27.
3. Bellato E, Marini E, Castoldi F, Barbasetti N, Mattei L, Bonasia DE, Blonna D. Fibromyalgia syndrome: etiology, pathogenesis, diagnosis, and treatment. Pain Res Treat. 2012;2012:426130. doi: 10.1155/2012/426130. Epub 2012 Nov 4. Erratum in: Pain Res Treat. 2013;2013:960270.
4. D'Agnelli S, Arendt-Nielsen L, Gerra MC, Zatorri K, Boggiani L, Baciarello M, Bignami E. Fibromyalgia: Genetics and epigenetics insights may provide the basis for the development of diagnostic biomarkers. Mol Pain. 2019; 15:1744806918819944.
5. Wolfe, F., Russel, I. J., Viparo, G., Ross, K., Anderson, J. Serotonin level, pain threshold, and fibromyalgia syndrome in general population. J Rheumatol. 1997;24:555-559.
6. Staud R. Evidence for shared pain mechanisms in osteoarthritis, low back pain, and fibromyalgia. Curr Rheumatol Rep. 2011.
7. Yunus MB, Inanici F, Aldag JC, Mangold RF. Fibromyalgia in men: comparison of clinical features with women. J Rheumatol. 2000.
8. Yunus MB, Masi AT. Juvenile primary fibromyalgia syndrome. A clinical study of thirty-three patients and matched normal controls. Arthritis Rheum. 1985 Feb;28(2):138-45.
9. Kwiatek R. Treatment of fibromyalgia. Aust Prescr. 2017 Oct;40(5):179-183.
10. McCain GA, Bell DA, Mai FM, Halliday PD. A controlled study of the effects of a supervised cardiovascular fitness training program on the manifestations of primary fibromyalgia. Arthritis Rheum. 1988 Sep;31(9):1135-41.
11. Valim V, Oliveira L, Suda A, Silva L, de Assis M, Barros Neto T, Feldman D, Natour J. Aerobic fitness effects in fibromyalgia. J Rheumatol. 2003 May;30(5):1060-9.
12. Etnier JL, Karper WB, Gapin JI, Barella LA, Chang YK, Murphy KJ. Exercise, fibromyalgia, and fibrofog: a pilot study. J Phys Act Health. 2009 Mar;6(2):239-46.
13. Jones KD, Burckhardt CS, Clark SR, Bennett RM, Potempa KM. A randomized controlled trial of muscle strengthening versus flexibility training in fibromyalgia. J Rheumatol. 2002 May;29(5):1041-8.
14. Bidonde J, Busch AJ, Schachter CL, Overend TJ, Kim SY, Góes SM, Boden C, Foulds HJ. Aerobic exercise training for adults with fibromyalgia. Cochrane Database Syst Rev. 2017 Jun 21;6(6):CD012700.
15. Meiworm L, Jakob E, Walker UA, Peter HH, Keul J. Patients with fibromyalgia benefit from aerobic endurance exercise. Clin Rheumatol. 2000;19(4):253-7.
16. Busch AJ, Webber SC, Brachaniec M, Bidonde J, Bello-Haas VD, Danyliw AD, Overend TJ, Richards RS, Sawant A, Schachter CL. Exercise therapy for fibromyalgia. Curr Pain Headache Rep. 2011 Oct;15(5):358-67.
17. Gusi N, Parraca JA, Olivares PR, Leal A, Adsuar JC. Tilt vibratory exercise and the dynamic balance in fibromyalgia: A randomized controlled trial. Arthritis Care Res (Hoboken). 2010 Aug;62(8):1072-8.
18. Sunshine W, Field TM, Quintino O, Fierro K, Kuhn C, Burman I, Schanberg S. Fibromyalgia benefits from massage therapy and transcutaneous electrical stimulation. J Clin Rheumatol. 1996 Feb;2(1):18-22.
19. Li YH, Wang FY, Feng CQ, Yang XF, Sun YH. Massage therapy for fibromyalgia: a systematic review and meta-analysis of randomized controlled trials. PLoS One. 2014 Feb 20;9(2):e89304. doi: 10.1371/journal.pone.0089304.
20. Alnigenis M NY, Bradley J D, Wallick J, Emsley C L. Massage therapy in the management of fibromyalgia: A pilot study. J Musculoskel Pain 2001; 9(2)55–67.
21. Andrade CP, Zamunér AR, Forti M, Tamburús NY, Silva E. Effects of aquatic training and detraining on women with fibromyalgia: controlled randomized clinical trial. Eur J Phys Rehabil Med. 2019 Feb;55(1):79-88. doi: 10.23736/S1973-9087.18.05041-4. Epub 2018 Jul 6.
22. Avila MA, Camargo PR, Ribeiro IL, Alburquerque-Sendin F, Zamuner AR, Salvini TF. Effects of a 16-week hydrotherapy program on three-dimensional scapular motion and pain of women with fibromyalgia: a single-arm study. Clin Biomech. 2017;49:145–154.
23. Zamunér AR, Andrade CP, Forti M, Marchi A, Milan J, Avila MA, Catai AM, Porta A, Silva E. Effects of a hydrotherapy programme on symbolic and complexity dynamics of heart rate variability and aerobic capacity in fibromyalgia patients. Clin Exp Rheumatol. 2015 Jan-Feb;33(1 Suppl 88):S73-81. Epub 2015 Mar 18.
24. Mannerkorpi K, Nordeman L, Ericsson A, Arndorw M; GAU Study Group. Pool exercise for patients with fibromyalgia or chronic widespread pain: a randomized controlled trial and subgroup analyses. J Rehabil Med. 2009 Sep;41(9):751-60.
25. Assis MR, Silva LE, Alves AM, Pessanha AP, Valim V, Feldman D, Neto TL, Natour J. A randomized controlled trial of deep water running: clinical effectiveness of aquatic exercise to treat fibromyalgia. Arthritis Rheum. 2006 Feb 15;55(1):57-65.
26. Latorre PÁ, Santos MA, Heredia-Jiménez JM, Delgado-Fernández M, Soto VM, Mañas A, Carbonell-Baeza A. Effect of a 24-week physical training programme (in water and on land) on pain, functional capacity, body composition and quality of life in women with fibromyalgia. Clin Exp Rheumatol. 2013 Nov-Dec;31(6 Suppl 79):S72-80. Epub 2013 Dec 18. PMID: 24373364.
27. Munguía-Izquierdo D, Legaz-Arrese A. Exercise in warm water decreases pain and improves cognitive function in middle-aged women with fibromyalgia. Clin Exp Rheumatol. 2007 Nov-Dec;25(6):823-30.
28. Segura-Jimenez V, Carbonell-Baeza A, Aparicio VA, et al. A warm water pool-based exercise program decreases immediate pain in female fibromyalgia patients: uncontrolled clinical trial. Int J Sports Med. 2013;34(7):600–605.
29. Pérez de la Cruz S, Lambeck J. A new approach towards improved quality of life in

fibromyalgia: a pilot study on the effects of an aquatic Ai Chi program. Int J Rheum Dis. 2018 Aug;21(8):1525-1532.
30. Langhorst J, Klose P, Dobos GJ, Bernardy K, Häuser W. Efficacy and safety of meditative movement therapies in fibromyalgia syndrome: a systematic review and meta-analysis of randomized controlled trials. Rheumatol Int. 2013 Jan;33(1):193-207.
31. Arya S, Yadav RK, Venkataraman S, Deepak KK and Bhatia R (2022) Objective evidence for chronic back pain relief by Medical Yoga therapy. Front. Pain Res. 3:1060685.
32. Woolery A, Myers H, Sternlieb B, Zeltzer L. A yoga intervention for young adults with elevated symptoms of depression. Altern Ther Health Med. 2004 Mar-Apr;10(2):60-3.
33. Park CL, Braun T, Siegel T. Who practices yoga? A systematic review of demographic, health-related, and psychosocial factors associated with yoga practice. J Behav Med. 2015 Jun;38(3):460-71.
34. Carson JW, Carson KM, Jones KD, Bennett RM, Wright CL, Mist SD. A pilot randomized controlled trial of the Yoga of Awareness program in the management of fibromyalgia. Pain. 2010;151(2):530-539.
35. Curtis K, Osadchuk A, Katz J. An eight-week yoga intervention is associated with improvements in pain, psychological functioning and mindfulness, and changes in cortisol levels in women with fibromyalgia. J Pain Res. 2011;4:189-201. doi: 10.2147/JPR.S22761. Epub 2011 Jul 26.
36. Lazaridou A, Koulouris A, Devine JK, Haack M, Jamison RN, Edwards RR, Schreiber KL. Impact of daily yoga-based exercise on pain, catastrophizing, and sleep amongst individuals with fibromyalgia. J Pain Res. 2019 Oct 17;12:2915-2923.
37. Rudrud L. Gentle hatha yoga and reduction of fibromyalgia-related symptoms: A preliminary report. International Journal of Yoga Therapy. 2012;22:53–58.
38. Dailey DL, Vance CGT, Rakel BA, Zimmerman MB, Embree J, Merriwether EN, Geasland KM, Chimenti R, Williams JM, Golchha M, Crofford LJ, Sluka KA. Transcutaneous Electrical Nerve Stimulation Reduces Movement-Evoked Pain and Fatigue: A Randomized, Controlled Trial. Arthritis Rheumatol. 2020 May;72(5):824-836.
39. Lauretti, G.R., Chubaci, E.F. & Mattos, A.L. Efficacy of the use of two simultaneously TENS devices for fibromyalgia pain. Rheumatol Int 33, 2117–2122 (2013).
40. Yüksel M, Ayaş Ş, Cabıoğlu MT, Yılmaz D, Cabıoğlu C.Quantitative data for transcutaneous electrical nerve stimulation and acupuncture effectiveness in treatment of fibromyalgia syndrome. Evidence-based Complement Altern Med 2019;2019:9684649.
41. Jamison RN, Edwards RR, Curran S, Wan L, Ross EL, Gilligan CJ, Gozani SN. Effects of Wearable Transcutaneous Electrical Nerve Stimulation on Fibromyalgia: A Randomized Controlled Trial. J Pain Res. 2021 Jul 24;14:2265-2282.
42. Dailey DL, Rakel BA, Vance CGT, et al. Transcutaneous Electrical Nerve Stimulation (TENS) reduces pain, fatigue, and hyperalgesia while restoring central inhibition in primary fibromyalgia. Pain 2013;154(11):2554–62.
43. Carbonario F, Matsutani LA, Yuan SL, Marques AP. Effectiveness of high-frequency transcutaneous electrical nerve stimulation at tender points as adjuvant therapy for patients with fibromyalgia. Eur J Phys Rehabil Med. 2013;49(2):197-204. 29.
44. Glombiewski JA, Bernardy K, Häuser W. Efficacy of EMG- and EEG-Biofeedback in Fibromyalgia Syndrome: A Meta-Analysis and a Systematic Review of Randomized Controlled Trials. Evid Based Complement Alternat Med. 2013;2013:962741.
45. Baumueller E, Winkelmann A, Irnich D, Weigl M. Electromyogram Biofeedback in Patients with Fibromyalgia: A Randomized Controlled Trial. Complement Med Res. 2017;24(1):33-39. doi: 10.1159/000454692. Epub 2017 Jan 31.
46. Babu, A. S., Mathew, E., Danda, D., & Prakash, H. (2007). Management of patients with fibromyalgia using biofeedback: A randomized control trial. Indian Journal of Medical Sciences, 61(8), 455-461.
47. Hassett, A.L., Radvanski, D.C., Vaschillo, E.G. et al. A Pilot Study of the Efficacy of Heart Rate Variability (HRV) Biofeedback in Patients with Fibromyalgia. Appl Psychophysiol Biofeedback 32, 1–10 (2007).
48. Mingorance JA, Montoya P, Miranda JGV, Riquelme I. The Therapeutic Effects of Whole-Body Vibration in Patients With Fibromyalgia. A Randomized Controlled Trial. Front. Neurol. 2021. 12:658383.
49. Mingorance JA, Montoya P, Vivas Miranda JG, Riquelme I. A Comparison of the Effect of Two Types of Whole Body Vibration Platforms on Fibromyalgia. A Randomized Controlled Trial. International Journal of Environmental Research and Public Health. 2021; 18(6):3007.
50. Barnes MJ, McLean S.Fibromyalgia symptoms are reduced by sonic wave vibration therapy: a case study. Clinical Kinesiology. 2012;66(1): 19+.
51. Pujol, J., Ramos-López, D., Blanco-Hinojo, L. et al. Testing the effects of gentle vibrotactile stimulation on symptom relief in fibromyalgia. Arthritis Res Ther 21, 148 (2019).
52. Mhalla A, Baudic S, de Andrade DC, Gautron M, Perrot S, Teixeira MJ, Attal N, Bouhassira D. Long-term maintenance of the analgesic effects of transcranial magnetic stimulation in fibromyalgia. PAIN®. 2011 Jul 31; 152(7):1478-85.
53. Tiwari VK, Nanda S, Arya S, Kumar U, Sharma R, Kumaran SS, Bhatia R. Correlating cognition and cortical excitability with pain in fibromyalgia: a case control study. Adv Rheumatol. 2021 Feb 18;61(1):10.
54. Tanwar S, Mattoo B, Kumar U, Bhatia R. Repetitive transcranial magnetic stimulation of the prefrontal cortex for fibromyalgia syndrome: a randomised controlled trial with 6-months follow up. Adv Rheumatol. 2020 Jun 29;60(1):34.
55. Guinot M, Maindet C, Hodaj H, Hodaj E, Bachasson D, Baillieul S, Cracowski JL, Launois S. Effects of Repetitive Transcranial Magnetic Stimulation and Multicomponent Therapy in Patients With Fibromyalgia: A Randomized Controlled Trial. Arthritis Care Res (Hoboken). 2021 Mar;73(3):449-458.
56. Kang, JH., Choi, SE., Park, DJ. et al. Effects of add-on transcranial direct current stimulation on pain in Korean patients with fibromyalgia. Sci Rep 10, 12114 (2020).
57. Izquierdo-Alventosa R, Inglés M, Cortés-Amador S, Gimeno-Mallench L, Sempere-Rubio N, Serra-Añó P. Effectiveness of High-Frequency Transcranial Magnetic Stimulation and Physical Exercise in Women With Fibromyalgia: A Randomized Controlled Trial. Phys Ther. 2021 Oct 1;101(10):pzab159.


ScientificScholar
Knowledge is power
Indian Journal of Physiology and Pharmacology
My Info
Support
Logout
Welcome Dr. Renu Bhatia!
Dashboard
Submit New Manuscript
Incomplete Submission 0
Completed Submissions 1
In Review 0
For Technical Modification 0
For Revision 0
Accepted (In Production) 1
For Galley Proof 0
All Manuscripts 0
Accepted Manuscripts (In Production)
< Back
1 IJPP_297_2023
Renu Bhatia - All India Institute of Medical Sciences, New Delhi, India
View all authors 7
Original Article - Physiology
Exploring Pain Status and Flexibility in Fibromyalgia Patients:
Effect of 20 Sessions of Yoga Therapy.
Aasheesh Kumar
Raj Kumar Yadav
The Authorship has been APPROVED on May-25-2023
Srikumar Venkataraman
The Authorship has been APPROVED on May-30-2023
Uma Kumar
The Authorship has been APPROVED on May-25-2023
Akanksha Singh
The Authorship has been APPROVED on May-25-2023
Kishore Kumar Deepak
The Authorship has been APPROVED on May-27-2023
Renu Bhatia
The Authorship has been APPROVED on Aug-10-2023
Corresponding Author

Adv Physiol Educ 47: 376–382, 2023.
First published May 18, 2023; doi:10.1152/advan.00252.2022

american physiological society

ADVANCES IN PHYSIOLOGY EDUCATION

EDUCATION RESEARCH

Introducing virtual classrooms for undergraduate physiology teaching during the COVID-19 pandemic: acceptance by students and subjective impact on learning

Nasreen Akhtar, Aasheesh Kumar, Bhawna Mattoo, Kishore Kumar Deepak, and Renu Bhatia
Department of Physiology, All India Institute of Medical Sciences (AIIMS), New Delhi, India

Abstract

The COVID-19 pandemic and worldwide lockdowns brought major changes in education systems. There was a sudden obligatory shift toward utilization of digital resources for teaching and learning purposes. Medical education, specifically physiology teaching, comprises hands-on training in the laboratory. It is challenging to offer a course like physiology in a virtual format. The objective of this study was to assess the effectiveness and influence of virtual classroom technology on online physiology education in a sample size of 83 first-year MBBS undergraduates. A questionnaire comprising questions related to technology accessibility and utilization, comprehensibility and effectiveness of instructions, faculty proficiency, and learning outcomes was administered to the group. The responses were collected and analyzed. Validation through principal components and factor analysis showed that online teaching is not very effective and has a limited application in the physiology education of undergraduate MBBS students. Our study also revealed that virtual physiology teaching of undergraduate medical students during the COVID-19 pandemic had a moderate level of effectiveness.

NEW & NOTEWORTHY In the present qualitative study, we have conducted and validated an online physiology teaching platform at a medical college to continue medical education during the peak times of the COVID-19 pandemic and prolonged lockdowns. Furthermore, we have evaluated the effectiveness of online physiology teaching through multidimensional feedback from undergraduate MBBS students. It is experimental evidence of inadequate sustainability, moderate efficacy, limited application, and poor first-hand experience gained by the students in virtual physiology teaching in a preclinical and clinical setting.

factor analysis; online physiology teaching; principal component analysis

INTRODUCTION

The suspension of classroom teaching in all educational institutions was enforced as a measure of social distancing to control the spread of the COVID-19 pandemic. India was among the first nations to enforce a complete and all-encompassing lockdown. Institutions were forced to teach a traditional in-person physiology course in a virtual format. We found ourselves in a situation that required us to promptly transition our meticulously designed curriculum to an unfamiliar mode of delivery. Because of the uncertainty and new challenges arising from the limit reached by internet infrastructure, it was necessary to adapt to the "new normal" (1). The use of digital resources for teaching and learning became obligatory in most fields of education (2, 3). Physiology courses require significant laboratory work and practical training, which is challenging to replicate in a virtual setting. When the nationwide lockdown was imposed because of the COVID-19 pandemic, the traditional modes of teaching were disrupted, and online modes of teaching emerged as alternative options to ensure the continuity of education.

The study was designed to validate the effectiveness of online physiology teaching through the virtual classroom format. The purpose of this study was threefold: first, to determine whether online physiology teaching could be a substitute for traditional classroom instruction; second, to ascertain students' views on the virtual teaching; and third, to examine the impact of online physiology instruction on the overall academic performance of first-year MBBS undergraduates.

METHODS

A cross-sectional, questionnaire-based observational study was designed. After approval from the Institutional Ethics Committee, All India Institute of Medical Sciences, New Delhi (IEC-578/06.08.2021), the study was initiated after obtaining informed consent from the participants.

An online questionnaire was shared as a Google form along with participants' information among the first-year undergraduates of a medical college. The questionnaire was administered between June 2020 and August 2020, after

Correspondence: R. Bhatia (renuaiims28@gmail.com).
Submitted 8 December 2022 / Revised 15 May 2023 / Accepted 17 May 2023

their second assessment but before the final professional examination. Participation was completely voluntary and not linked to their curriculum and assessments. The responses did not include any information that revealed the identity of the students. Eighty-three medical undergraduates (~78% of the total strength of the class) gave informed consent for the study. The study was aimed at the validation of the effectiveness of online physiology teaching for undergraduate medical students in different aspects of medical education such as overall interaction, attitude, learning outcomes, and use of technology with structured feedback-based questions. The duplicity of the feedback was taken care of by having their college roll number (mandatory) and phone number (optional) as primary and secondary identification of the participants, respectively.

The questionnaire included 43 questions (Table 1); of these, 27 questions were Likert type. Using questionnaires, we assessed the students on various aspects of learning outcomes such as "students' use of technology" (4 items), "online classroom experience" (11 items)," interaction with faculty" (6 items), "students' interactions among themselves" (2 items), and "learning outcomes" (4 items). In the Likert items, 23 were positive and 4 were negative worded (Table 2). Each question was unambiguous, self-descriptive, and complete in itself. The Likert 5-point scale questions were agreement type (15 questions), frequency type (7 questions), performance type (4 questions), and intensity type (1 question).

To assess the magnitude and direction of attitude toward online learning, 10 questions (*questions 34–43*) based on the Osgood differential semantic scale were also used, as given in Table 1 (4). The direction of the attitude was measured by agreement or disagreement with the statement, and the strength of the attitude was assessed by the degree of agreement or disagreement of the participants. Each response to bipolar adjectives of opposite nature was scored from 1 to 7 on a different rating scale, making the maximum possible score 56. An attitude score was obtained by summing the responses of the questions. The Osgood differential semantic scale was used to correlate the responses to their midterm scores already undertaken.

Kaiser–Meyer–Olkin (KMO) test was used for sampling adequacy and to measure the suitability of the data for factor

Table 1. *List of questions*

Question
1. Which gadget do you use to access online classes?
2. Do you have internet connectivity for access to online classes?
3. Do you have an exclusive gadget available to access online classes?
4. The technologies used in this course worked the way it was intended.
5. I had some problems logging into the class with my assigned link.
6. I find the online classes conducive to the way I like to learn.
7. The online classes are helpful in learning the topic.
8. I would like the duration of online classes to be longer.
9. How much of your time during online class was spent actively listening to the faculty?
10. How much of your time during online class was spent in other activities like email, Facebook, Instagram, etc.?
11. Would you prefer availability of a discussion forum on WhatsApp or Facebook with faculty and other students?
12. Which medium would you like to be added for enhanced learning (multiple items can be selected)?
13. Motivation to learn online is as high as in face-to-face classroom.
14. The incentive to participate and interact in class is
15. It is easier to be absent in online classrooms.
16. It is easy to get distracted in online classrooms.
17. I was able to understand the concepts in online teaching mode.
18. The online mode supported my learning.
19. Online mode should be the only mode of learning.
20. I prefer face-to-face traditional classrooms to online learning.
21. There is not much difference in online and face-to-face classrooms.
22. How much of your interaction occurred with the faculty as compared to face-to-face classroom?
23. Facial expressions and gestures of teacher in face-to-face classroom enhance learning experience.
24. The faculty in the online classroom was able to identify me during interactions.
25. The faculty was active and engaged with the students.
26. There was adequate opportunity to interact online with the faculty.
27. The faculty replied to the queries/comments raised in class.
28. There was adequate opportunity to interact online with other students.
29. Feasible online study groups
30. Scope of self-learning
31. Discussions and interactions with other students
32. Summarizing acquired knowledge to help learning of other students
33. Consolidating and managing my own learning
34. Online learning is: Monotonous/Varied
35. Online learning is: Passive/Active
36. Online learning is: Dull/Exciting
37. Online learning is: Boring/Interesting
38. Online learning is: Bad/Good
39. Online learning is: Taxing/Nontaxing
40. Online learning is: Knowledge Based/Skill Based
41. Online classes are: Ineffective/Effective
42. Online classes are more of: Facts/Ideas
43. Online classes are: Unstructured/Structured

Table 2. *Average score on 5-point Likert scale of the factors and variables of the study*

Question	Factors	Variable Characteristics	Mean	SD	Communalities
1	The technologies used in this course worked the way it was intended.	Technology	3.39	0.778	0.515
2	I had some problems logging into the class with my assigned link.	Logging	3.05	1.070	0.247
3	I find the online classes conducive to the way I like to learn.	Conducive to learn	2.93	1.156	0.733
4	The online classes are helpful in learning the topic.	Helpful in learning	3.16	1.099	0.738
5	Duration reverse scored	Duration	1.93	1.080	0.344
6	How much of your time during online class was spent actively listening to the faculty?	Active listening	3.39	0.824	0.554
7	Motivation to learn online is as high as in face to face classroom.	Motivation	2.41	1.288	0.612
8	The incentive to participate and interact in class is	Incentive	2.73	1.013	0.518
9	It is easier to be absent in online classrooms.	Absence	2.36	1.077	0.590
10	It is easy to get distracted in online classrooms.	Distraction	1.86	1.061	0.632
11	I was able to understand the concepts in online teaching mode.	Understanding	3.31	0.999	0.742
12	The online mode supported my learning.	Support in learning	3.16	1.053	0.801
13	Online mode should be the only mode of learning.	Sole mode	1.83	1.248	0.635
14	I prefer face-to-face traditional classrooms to online learning.	Conventional classroom	2.08	1.118	0.708
15	There is not much difference in online and face-to-face classrooms.	Difference	1.93	0.960	0.190
16	How much of your interaction occurred with the faculty as compared to face-to-face classroom?	Interaction with faculty	2.23	0.941	0.603
17	Facial expressions and gestures of teacher in face-to-face classroom enhance learning experience.	Facial expressions	2.12	1.130	0.464
18	The faculty in the online classroom was able to identify me during interactions.	Identify me	2.51	0.992	0.590
19	The faculty was active and engaged with the students.	Faculty engagement	3.18	0.857	0.612
20	There was adequate opportunity to interact online with the faculty.	Interaction with faculty	2.81	1.006	0.748
21	The faculty replied to the queries/comments raised in class	Queries	3.40	0.910	0.504
22	There was adequate opportunity to interact online with other students.	Interaction with students	2.70	1.079	0.569
23	Online study group	Study groups	3.25	1.069	0.573
24	Self learning	Self learning	2.78	1.083	0.345
25	Discussions and interactions with other students	Group discussion	2.46	1.151	0.532
26	Summarizing acquired knowledge to help learning of other students	Help others learning	2.18	1.112	0.736
27	Consolidating and managing my own learning	Managing own learning	2.89	0.959	0.788

Questions 9, 10, 14, and *17* are negatively worded on Likert scale. *Questions 1–4*: student use of technology; *questions 5–15*: online classroom experience; *questions 16–21*: interaction with faculty; *questions 22* and *23*: student interactions among themselves; *questions 24–27*: learning outcomes.

analysis in terms of the proportion of variance in the variables that probably are due to underlying factors. KMO value (normal value 0 to 1) was assessed; KMO value for our study variables was between 0.8 and 1.0 (KMO = 0.82), which indicates adequate sampling and meritorious enough for further analysis (N = 83). Communalities or h^2 is the sum of squared factor loadings for the variables and measures internal variability in the factors. Bartlett's test of sphericity was used to test the null hypothesis. Correlation matrix indicated whether the variables of the student feedback in our study were unrelated to each other and whether there is an adequate redundancy in the variables and therefore unsuitable for structure detection of the study. A value < 0.05 indicated that factor analysis could be worthwhile for our datasets. Our sample size was <300, so the average communality of the retained items has to be tested for internal consistency in the variables. An average value > 0.6 is acceptable for a sample size < 100. Communalities of all the factors are given in Table 1. Communalities of ~70% of the variables of our study were in the acceptable range, i.e., ≥0.5, which suggests adequate internal consistency among the variables used in the study. Checking internal consistency was required to proceed with factor loadings and factor analysis and performance of principal component analysis.

With factor analysis we clustered similar variables into the same factor to identify underlying variables using a data correlation matrix. Principal component analysis of the Likert-type questions was performed with factor extraction methods. The reliability of the questions was examined with Cronbach's α, which provided the simplest way to measure whether or not a scoring scale is reliable. Cronbach's α has a range between 0 and 1, according to which a moderate score of Cronbach's α was found in our study (Cronbach's α = 0.46). The rotation sums of squared loadings for the total variance explained of the components were the correlation between each variable.

In the present study, an extraction method-based principal component analysis was performed. Using factor extraction, we encompass determining the least number of factors that can be used as core variables of the interrelationships among the set of variables in the feedback questions of learning outcomes. The Kaiser criterion (eigenvalue criterion) and the scree test were used to determine the number of initial unrotated factors to be extracted from the data set (Table 1). Eigenvalues were the ratio of common variance in the feedback responses and their specific variance explained by a specific factor extracted for the set of questions framed for various domains of learning objectives. The correlation between online learning effectiveness score based on the

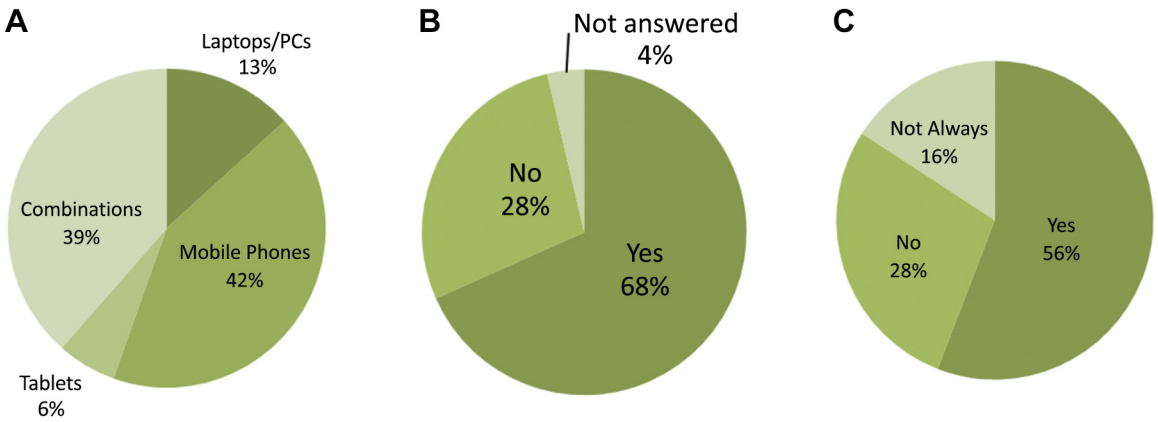


Figure 1. Non-Likert questions assessing student use of technology. *A*: gadgets used for attending online classes. *B*: regular internet connectivity for access to online classes. *C*: had an exclusive gadget to access online classes. Pie chart distribution is the proportion of students in a class size of 83. Besides nominal responses, a blank response option was given in the questionnaire (*B* and *C*).

Osgood differential semantic scale and the midterm marks obtained by the candidate was calculated by Spearman correlation.

Statistical Analysis

The data analyses was performed with SPSS v.25 (SPSS Inc. Statistical Software, Chicago, IL) and Graph Pad Prism 8.01 for Windows (GraphPad Software, San Diego, CA). Factor analysis and principal component analysis were performed with SPSS v.25. Shapiro–Wilk test was used to check for the normality of the data, and Spearman correlation was used to test the strength of association between variables.

RESULTS

Distribution of gadgets and connectivity of the students' use of technology for attending online classes were among the non-Likert questions (Fig. 1). Approximately 68% (56 students, ~2/3) of students had regular internet access, and most of the students (42%) were attending the online lectures on their mobile phones. Furthermore, 56% of the students always had an exclusive gadget available to access online classes (Fig. 1). Mean response scores, standard deviations, and communalities of the responses of all the variable characteristics of the Likert scale are given in Table 2.

Maximum and minimum feedback response scores on the 5-point Likert scale were 4.89 and 1.83, respectively. The range of the items' feedback response score was 3.06. Ratio of maximum and minimum was 2.67, and mean feedback response score on the Likert scale for all the variables was 4.69. For Bartlett's test of sphericity of the dataset approximate chi square was 1,242.857 (degree of freedom = 51), and significance was 0.000.

Out of the initial loading of 1.00, extractions of the principal component variables are given in Table 3. Eigenvalues along with the extraction sums of squared loadings (both cumulative and percentage variance in them) are given in Table 3. Eigenvalues > 1.72 were selectively treated as principal components, and correlation of the crude components was done with a transformational matrix based on the rotational sum method: Varimax with Kaiser normalization (Table 3).

There was no correlation (r = 0.019) between the Osgood differential semantic scale and the midterm marks obtained by the candidate; furthermore, it was found to be nonsignificant (P = 0.86) (Fig. 2). The relationship between components and eigenvalues of principal component analysis is shown in Fig. 3 in the form of a scree plot. Principal components were extracted based on their eigenvalues and the squared sum of their loadings (Table 3). Then components were correlated; sums of squared loadings cannot be added to obtain a total variance. Four components were designated as principal components based on the principal components and intercomponent matrices. The component transformation matrix for the same is given in Table 4. The principal components were

Component 1: The online mode supported my learning (r = 0.827; factor: Supported Learning).
Component 2: There was adequate opportunity to interact online with the faculty (r = 0.789; factor: Interaction).
Component 3: Online mode should be the only mode of learning (r = 0.696; factor: The Only).
Component 4: How much of your interaction occurred with the faculty as compared to face-to-face classroom (r = 0.638; factor: Other Activities)?

Table 3. *Factor analysis and principal component analysis*

Components	Eigenvalues	% Variance	Extraction Sums of Squared Loadings, cumulative %	Rotation Sums of Squared Loadings
Supported Learning	9.098	33.695	33.695	5.941
Interaction	2.270	8.409	42.104	3.778
The Only	1.946	7.208	49.312	2.836
Active Listening	1.755	6.500	55.811	2.514

Eigen threshold for the principal components was set at 1.72.

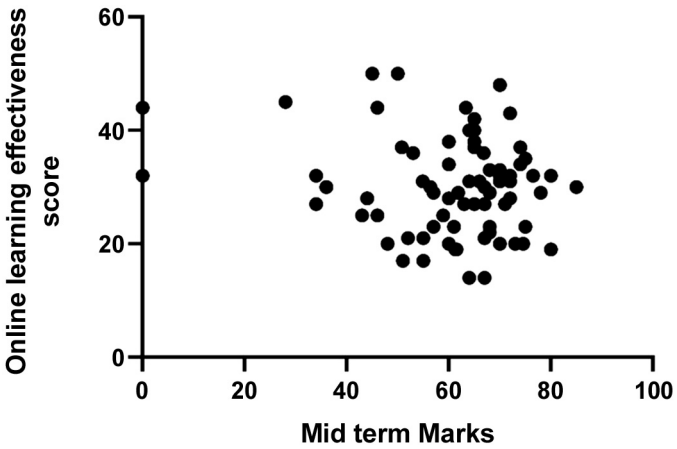


Figure 2. Correlation between online learning effectiveness score based on Osgood differential semantic scale and midterm marks obtained by the candidate. Correlation coefficient was calculated by Spearman *r* and was found to be statistically nonsignificant ($r = 0.019$, $P = 0.86$).

DISCUSSION

The present study was aimed at understanding the role of virtual teaching (online mode of classes) in overall learning by undergraduate medical students during the COVID-19 pandemic amid nationwide prolonged lockdown. Eighty-three undergraduate medical students of a medical college answered a questionnaire consisting of 43 items about their experience of online classes, and the responses were recorded and analyzed online. The online mode of teaching was introduced for the very first time for medical students by Izet Masic in 2008 (5). It initiated a series of studies designed to assess the feasibility and effectiveness of online classes for medical students. Among the various components analyzed by Likert scale, four components emerged as principal components, which are also the primary outcome measures of the overall assessment by the students (6). There are many differences between virtual and physical classroom teaching. In a physical classroom, a teacher/instructor uses "immediacy cues," eye contact, smiles, tone of voice to welcome students and support their contributions, in the absence of which online learners experience isolation as no one is there to convey all the nonverbal messages of support; nor can the students have the physical presence of other learners for the social support that is very crucial for active learning (7).

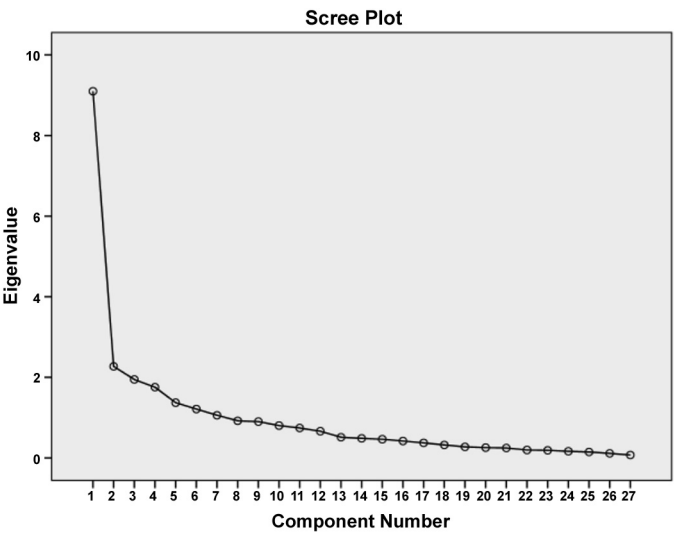


Figure 3. Scree plot: component-wise eigenvalue distribution. Relationship between components and eigenvalues of principal component analysis based on the candidates' collective response.

Table 4. *Component transformation matrix: rotation method: Varimax with Kaiser normalization*

Components	Supported Learning	Interaction	The Only	Active Listening
Supported Learning	0.742	0.524	0.345	0.237
Interaction	−0.517	0.137	0.388	0.750
The Only	0.182	0.037	−0.819	0.542
Active Listening	−0.386	0.840	−0.242	−0.294

"Online mode supported my learning" is the first principal component. Averaged feedback response of the participants is between neutral and agreement that online mode/virtual classrooms supported their learning. Other studies from previous literature have also endorsed this viewpoint (8). "There was adequate opportunity to interact online with the faculty" is another principal component regarding the ability of students to interact with the faculty during the class. Only a limited (25–50%) opportunity was there, where students could interact with the faculty during the class. However, some students also declared that some interaction was possible with the faculty in an online class (9–14). The third principal component was "Online mode should be the only mode of learning"; only ~6% of the students showed preference for online mode as the sole mode of learning physiology, and most of the students disagreed and preferred other modes such as physical mode as a more productive mode of learning, which seems to be a more acceptable mode for everyone in the medical field. "How much of your time during online class was spent actively listening to the faculty?" is the last principal component extracted. Students' feedback to it suggests that only some of the times (25–50%) did students actively listen to the lecture during online classes, indicating a counterproductive way of learning and a very difficult situation to be assessed, detected, or controlled by teachers. A previous study, based on these principal components, also showed that online classes are a favorable mode of learning but required discipline on the part of the students, as they were prone to use other means of entertainment during the unsupervised online classrooms (15). The recent introduction of several virtual modes of communication to day-to-day life such as mobile phones, laptops, digital notebooks, and other gadgets has already eased our ability to communicate and dispose of information on a large scale. Moreover, the younger generation is more accepting and comfortable in using these virtual modes of attending lectures and taking physical notes in the classroom. However, there are certain drawbacks, such as

1) Assessment of attentiveness
2) One-to-one interaction with faculty
3) Lack of feedback to the teacher, which could improve the interaction
4) Enjoyment achieved by group learning/activities

Although it may be tempting to simply rely on some of the available technology to impart education in a large group of students, the direct conversion of a 50- to 75-min in-person teaching experience to an online-only format has been shown to be detrimental to student attention and knowledge retention (16).

In our study Cronbach's α of standardized items was 0.91, which showed that the items used in the study were moderately dependable on the outcomes related to the feedback. Out of 28 Likert-type questions, 2 questions, "How much of your time during online class was spent actively listening to the faculty?" and "How much of your time during online class was spent in other activities such as email, Facebook, Instagram, etc.," were found to be similar, so the latter was excluded from the factor analysis.

Furthermore, students may run into issues in connecting to an online class because of the lack of technology available to them, including a slow connection, no connection, or nonavailability of a computer (17). Unfortunately, these hurdles are commonly faced by students from economically weaker sections or living in remote areas. One suggestion for overcoming these issues is by using an asynchronous approach to teaching. This style uses many "modes" of teaching, including audio only, downloadable files, and/or a direct online presentation. These multimodal styles are often recommended as a method of getting around many of the hurdles that technology can place in front of online learning because of their flexibility (18, 19). Additionally, just as many educators are struggling with learning a new way of interacting, students may also be technically challenged when faced with new and foreign software. In the present study, major feedback from the students was that all the lectures should be saved and available online in case they miss the sessions. Most of the students wanted more interactive sessions and suggested including some student presentations since online classes do not have a real student-teacher interaction and hence the classes become monotonous. Since medical educators have been pushed inevitably to rely on technology-based learning (2, 3), they should not only embrace it but also develop and evaluate its sustainability and application in a preclinical and clinical setting. A study conducted in Nepal suggested that training teachers and students about online classes might create effectiveness of e-learning (20). Furthermore, the government needs to provide free internet services to remote areas and students of lower economic conditions since a large margin of the population are struggling with economic burdens (20). Meanwhile, the students, whose medical education is stuck in the pandemic time, should realize that there is no bigger teacher than first-hand experience.

Conclusions

Our study suggests that virtual physiology teaching of undergraduate medical students after the COVID-19 pandemic has only a moderate level of effectiveness. Validation through principal components and factor analysis has revealed that the application of online teaching is not an effective method owing to certain limitations compared with the traditional classroom teaching methods. Classroom teaching ensures better quality of learning and student-teacher interaction in medical education.

DATA AVAILABILITY

Data will be made available upon reasonable request.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

N.A., B.M., K.K.D., and R.B. conceived and designed research; N.A., B.M., K.K.D., and R.B. performed experiments; N.A., A.K., B.M., and K.K.D. analyzed data; N.A., A.K., and R.B. interpreted results of experiments; N.A. and A.K. prepared figures; N.A., A.K., B.M., and R.B. drafted manuscript; N.A., A.K., B.M., and R.B. edited and revised manuscript; N.A., A.K., and R.B. approved final version of manuscript.

REFERENCES

1. **Schmidt SM**, **Ralph DL.** The flipped classroom: a twist on teaching. *Contemp Issues Educ Res* 9: 1–6, 2016. doi:10.19030/cier.v9i1.9544.
2. **Torda A.** How COVID-19 has pushed us into a medical education revolution. *Intern Med J* 50: 1150–1153, 2020. doi:10.1111/imj.14882.
3. **Stoehr F**, **Müller L**, **Brady A**, **Trilla A**, **Mähringer-Kunz A**, **Hahn F**, **Düber C**, **Becker N**, **Wörns MA**, **Chapiro J**, **Hinrichs JB**, **Akata D**, **Ellmann S**, **Huisman M**, **Koff D**, **Brinkmann S**, **Bamberg F**, **Zimmermann O**, **Traikova NI**, **Marquardt JU**, **Chang DH**, **Rengier F**, **Auer TA**, **Emrich T**, **Muehler F**, **Schmidberger H**, **Baeßler B**, **Dos Santos DP**, **Kloeckner R.** How COVID-19 kick-started online learning in medical education—The DigiMed study. *PLoS One* 16: e0257394, 2021. doi:10.1371/journal.pone.0257394.
4. **Oliver BL.** The semantic differential: a device for measuring the interprofessional communication of selected accounting concepts. *J Account Res* 12: 299–316, 1974. doi:10.2307/2490378.
5. **Masic I.** E-learning as new method of medical education. *Acta Inform Med* 16: 102–117, 2008. doi:10.5455/aim.2008.16.102-117.
6. **Gillingham M**, **Molinari C.** Online courses: student preferences survey. *Internet Learn* 1: 36–45, 2012.
7. **Bradbury NA.** Attention span during lectures: 8 seconds, 10 minutes, or more? *Adv Physiol Educ* 40: 509–513, 2016. doi:10.1152/advan.00109.2016.
8. **AlQhtani A**, **AlSwedan N**, **Almulhim A**, **Aladwan R**, **Alessa Y**, **AlQhtani K**, **Albogami M**, **Altwairqi K**, **Alotaibi F**, **AlHadlaq A**, **Aldhafian O.** Online versus classroom teaching for medical students during COVID-19: measuring effectiveness and satisfaction. *BMC Med Educ* 21: 452, 2021. doi:10.1186/s12909-021-02888-1.
9. **Syed S**, **Rastogi A**, **Bansal A**, **Kumar A**, **Jindal A**, **Prakash A**, **Agarwal G**, **Varshney M.** Future of e-learning in medical education—perception, readiness, and challenges in a developing country. *Front Educ* 6: 598309, 2021. doi:10.3389/feduc.2021.598309.
10. **Gormley GJ**, **Collins K**, **Boohan M**, **Bickle IC**, **Stevenson M.** Is there a place for e-learning in clinical skills? A survey of undergraduate medical students' experiences and attitudes. *Med Teach* 31: e6–e12, 2009. doi:10.1080/01421590802334317.
11. **Abbasi S**, **Ayoob T**, **Malik A**, **Memon SI.** Perceptions of students regarding E-learning during COVID-19 at a private medical college. *Pak J Med Sci* 36: S57–S61, 2020. doi:10.12669/pjms.36.COVID19-S4.2766.
12. **Kapasia N**, **Paul P**, **Roy A**, **Saha J**, **Zaveri A**, **Mallick R**, **Barman B**, **Das P**, **Chouhan P.** Impact of lockdown on learning status of undergraduate and postgraduate students during COVID-19 pandemic in West Bengal, India. *Child Youth Serv Rev* 116: 105194, 2020. doi:10.1016/j.childyouth.2020.105194.
13. **Li CH**, **Rajamohan AG**, **Acharya PT**, **Liu CS**, **Patel V**, **Go JL**, **Kim PE**, **Acharya J.** Virtual read-out: radiology education for the 21st century during the COVID-19 pandemic. *Acad Radiol* 27: 872–881, 2020. doi:10.1016/j.acra.2020.04.028.
14. **Liang ZC**, **Ooi SB**, **Wang W.** Pandemics and their impact on medical training: lessons from Singapore. *Acad Med* 95: 1359–1361, 2020. doi:10.1097/ACM.0000000000003441.

15. **Avinash S**, **Ram KP**, **Vikas G**, **Abhishek S.** Principal components analysis of educational resources usage among undergraduate medical students during the COVID-19 pandemic in Southern Haryana, India. *J Sci Soc* 47: 99–104, 2020. doi:10.4103/jss.JSS_41_20.
16. **Margolis AR**, **Porter AL**, **Pitterle ME.** Best practices for use of blended learning. *Am J Pharm Educ* 81: 49, 2017. doi:10.5688/ajpe81349.
17. **Gillett-Swan J.** The challenges of online learning: supporting and engaging the isolated learner. *J Learn Des* 10: 20–30, 2017. doi:10.5204/jld.v9i3.293.
18. **Dahlstrom-Hakki I**, **Alstad Z**, **Banerjee M.** Comparing synchronous and asynchronous online discussions for students with disabilities: the impact of social presence. *Comput Educ* 150: 103842, 2020. doi:10.1016/j.compedu.2020.103842.
19. **Fencl HS.** Focusing on learning as a marker of success for underrepresented students. *J Coll Sci Teach* 48: 6–7, 2019.
20. **Chaudhary GP**, **Khadka RB**, **Lamichhane A**, **Dhakal B**, **Das N**, **Tharu NS**, **Karki K**, **Pandey J.** Impact of COVID-19 pandemic on learning status of student in Nepal. *J Educ Health Promot* 11: 314, 2022. doi:10.4103/jehp.jehp_354_22.