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ORIGINAL RESEARCH

Video game-based and conventional therapies in patients of neurological deficits: an experimental study

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ABSTRACT

Purpose: In the past few years, medicine has upgraded its therapeutic techniques and practices, with the use of various modern methods that are due to advancement in technology and sciences. It is recognized that the physical health of the patients is significantly associated to their mental state, their motivation and engagement in overcoming the illness. This paper presents experimental comparison between virtual reality (VR) technology and conventional mode of therapy for physical rehabilitation among patients of neurological deficits. The objective was to explore the effectiveness of VR during physical interactions with different game-like virtual environment and potentially leading to increased mental health (i.e., lower depression, anxiety and stress), self-esteem, social support and intrinsic motivation (task-based competence, choice and interest).

Method: The study sample consisted of thirty-four subjects with Cerebral palsy (CP), Traumatic brain injury (TBI), Spinal cord injury, Stroke and Parkinson's disease; divided into two experimental groups virtual reality exercise group ($n = 17$), and conventional therapy group ($n = 17$); who have upper- or lower-limb impairment.

Results: The outcome measures revealed significant differences across pretest and post-test conditions of both the experimental groups. Findings emerged from the study showed noticeable effectiveness of virtual-reality based rehabilitation in TBI, stroke and CP patients. Relationships between study variables and demographic variables (age and gender) were also presented.

Conclusion: This study opens the way for future researchers, psychologists, physiotherapist and other practitioners to do more extensive work in the domain of virtual reality with different sample, constructs and approaches.

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KEYWORDS
Virtual Reality (VR); MIRA (Medical Interactive Rehabilitation Assistant); physical disability; mental health; self-esteem; motivation

➤ IMPLICATIONS FOR REHABILITATION

- It has become increasing important to introduce new state-to-art technologies in domain of rehabilitation.
- People are reluctant to use all the traditional modes of treatment. As these conventional ways of treatment are least motivating and interesting to indulge the patients without force and burden. It is evident in the present study that addition of virtual reality-based exercise increases the self-motivated balance during functional task in contrast to conventional and task-dependent training participants.
- This study opens the way for future researchers to do more extensive work in this domain.

Introduction

In modern years, the field of virtual reality (VR) has grown immensely. Practical implication for the usage of this application encompass many fields, from aviation training and military applications, to machine operation through industrial training, to medicine, where specialists can be skilled in surgical techniques using VR systems. One of the newest area to benefit from the progress in VR technology is that of remedial rehabilitation.

In spite of the significance of reestablishing postural and motion synchronization abilities, there is an overall lack of knowledge regarding what sorts of interventions are most suitable for patients with physical impairments due to neurological deficit [1]. This population has not been a principal target for experimental (evidence-based) researches, perhaps due to the complex nature of the physical impairments, which makes it challenging to formulate a comparatively standardized (homogeneous) experimental group. It is logically clear that most physical intervention methodologies should take account of the tasks that strengthen multiple body parts to work in an organized manner. Yet, conventional rehabilitation often overlooks the variability and complication of entire body movement organization (coordination), and as an alternative focus on distinct programs for rehabilitation of gait, posture, and upper-limb function. The absence of therapies that concentrate on entire body functioning eventually restricts functional enhancement in activities of daily life and linked return to a productive, constructive and meaningful life. So, the focus of the present study was on whole body co-ordination (i.e., both upper and lower limbs) using virtual reality.

There is a major concern in rehabilitation that patients are not meeting the sufficient "dosage" of movements required to induce neuroplastic adaptations underlying behavioral improvement. Nonadherence with treatment is a noteworthy hindrance in recovery of patients. Recovery is often difficult, time-consuming, costly,

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because it requires continued, intensive rehabilitation. In this perspective, occupational/traditional therapy is identified to encourage healthy behavior by empowering people to accomplish important, meaningful and focused livings like appreciating life, being productive on a social and economic basis, being active part of society and community activities [2].

Another concern is that getting physical therapy facilities or reaching specialists turn out to be difficult or unmanageable for patients because of lack of transport and dependency on caregivers which confines presence at respective therapeutic sessions. Limited therapy sessions, such as arranging weekly or once every two weeks, may not deliver adequate practice for regaining through practicing. Basic principles of neuroplasticity recommend that in order to produce enduring changes in neural networks, leading to long-lasting alteration in motion behavior, a stimulus (practice) should be repeatedly done, within 2–3 days [3]. Practicing at extended intervals maybe not as much of effective or even absolutely ineffective.

Finally, due to old age especially patients of stroke [4] and young sample, as the majority of traumatic brain injury survivors are relatively young [5]; who show lack of enthusiasm to continue monotonous (repeated), boring exercise series based on the out-of-date therapeutic programs that are still commonly used in ataxia treatment. These trainings while physiologically comprehensive and sound, are un-motivating and expected to seem impractical to the clients, with resulting poor agreement (compliance) [6]. So the inadequate access to rehabilitation, and a shortage of scientifically verified and motivating therapeutic strategies; generates a clear prerequisite for performing the evidence-based manageable therapies, integrating state-of-the-art technologies for patients with coordination and postural abnormalities due to neurological deficits.

Qualitative records established from detailed interviews in therapy, from both the therapists and stroke survivors have assisted to recognize absence of motivation as a hindrance (barrier) to adherence (devotion) to therapy [7]. In therapies concerning physical exercise lack of motivation and involvement/engagement are identified as barriers [8] that actually result in nonadherence (disobedience) within therapy [9]. The motivating configuration of video games is a prominent feature to improve nonadherence in physical therapy. Video games are identified for possessing intended participation (i.e., without having necessary requirement participants start playing), prolonged time of play (i.e., participants play games usually 12–20 hours in a week), and games have a greater possibility of repetition [8]. Moreover, video games have diverse genera of games which have been reported to have a constructive effect on cognitions, emotions and motor abilities of the players [10]. So the present study explored the mechanism of video game-based therapy in comparison to conventional therapy, which leads to enhanced self-esteem, better mental health (i.e., alleviation in depression, anxiety and stress), with social support; as a result of high motivation to sustain the treatment and show improvement.

The effectiveness of Video game-based therapy can be explained by Self-Determination Theory [11], which is a meta-theory that attempts to account for two views of causality regarding human behavior: (a) the view that humans act with action and intrinsic motivation, and (b) the view that their actions can be determined or influenced by external factors. SDT provides a framework to integrate observed cases of both phenomena.

Self-determination theory (SDT, 11] is suggested as an appropriate background for understanding motivation for activity behavior [12]. It has also been used for interventions incorporating physical activity [13]. From last 15 years development in research has implicated SDT in studies revealing behavior change associated to health [14,15]. Moreover, for patients with disability a definite challenge can be autonomous (self-directed) functioning and self-determination. Meanwhile, comparatively many cases are in need of help and support both activities of daily life and physical activity. Very little work has been done on this viewpoint. So the current study familiarized physical efficiency using SDT, in patients of physical impairment; with the exclusion of only single study on sample of disabled-athletes exploring the influence of two theoretical frameworks of satisfaction of mental well-being [16]. Hence, utilizing self-determination theory as theoretical background in rehabilitation with diverse sample is strongly needed. Therefore, the self-determination theory is used as a framework in the study.

The present study explored the differences between two experimental groups that are Virtual Reality group and Conventional therapy group; on both pretest and post-test conditions; for measures of physical ability, mental health, self-esteem, social support and motivation. Role of gender, family system, member of family members, types of incidents (causes of disability) and types of disability on all the tendencies were also explored in the present study.

Methods and materials

Research design

The study was conducted through mixed factorial pretest and posttest experimental design. It included the self-reported measures to assess the state conditions of participants as pretesting and then manipulation was used along with the measure presented during pretesting for post-exposure state condition's assessment of participants. The present study explored the effectiveness of both the therapies by exposing the participants to between/Independent group experimental conditions Table 1.

The study included (1) *Experimental Condition I*: Virtual reality exercise manipulation. (2) *Experimental Condition II*: Conventional exercise manipulation.

Additionally, the second variable (Physical ability) was addressed with two levels (i.e., balance assessment by Berg Balance Scale and the upper-limb assessment by Disabilities of Arm, Shoulder and Hand) and other associated study variables at four levels (i.e., mental health, self-esteem, social support, and motivation). Comparison of effects was made on the basis of responses between these groups.

Subjects

Thirty-four patients (mean age = 38.30 years; SD = 19) with traumatic brain injury ($n = 9$), stroke ($n = 10$), spinal cord injury ($n = 10$), cerebral palsy ($n = 3$), and Parkinson's disease ($n = 2$) were included in the study. As participants were recognized, they were quasi/nonrandomly allocated to any of the virtual reality exercise group ($n = 17$) or a conventional stretching/exercise group ($n = 17$). All participants were with upper or lower-limb impairment and were dependent for help with activities of daily living. The two groups were made homogenous on age and sex of participants, as much as possible. Exclusion criteria were patients with mental deficits who cannot comply, comprehend and respond.

Instrumentation

Various outcome clinical measures including physical ability, mental health, self-esteem, social support and motivation were measured for all the subjects at two-point intervals: (1) preceding the therapy; and (2) immediately at the termination of the therapy.

Physical ability

To assess physical ability two measures were used. First was The Berg Balance Scale (BBS) [17], which is utilized to quantitatively define a patient's ability (or inability) to carefully balance throughout a succession of prearranged tasks. It was developed to assess balance among elderly people with loss in balance function and patients with acute stroke [18,19]. It is a 14-item list with each item comprising of a five-point Likert ordinal scale extending from 0 to 4, with 0 representing the lowest level of function and 4 the highest level of function and takes roughly 20 minutes to complete. Cutoff scores are described screening that score of 56 indicates functional balance. A score of $<$ 45 indicates individuals may be at greater risk of falling. A previous study of the BBS, which was completed in Finland, indicates that a change of eight (8) BBS points is required to reveal a genuine change in function between two assessments among older people who are dependent in activities of daily living and living in residential care facilities [20].

The second measure was The Disabilities of the Arm, Shoulder and Hand (DASH). It is a 30-item booklet that assess the ability of a patient to deliver certain activities by upper limb, developed by Hudak et al. [21]. The DASH assesses six domains: daily activities, symptoms, social function, work function, sleep, and confidence. It is a self-report scale that measures an individual's ability to complete tasks, absorb forces, and severity of symptoms on 5 point Likert scale. At least 27 of the 30 items must be answered to compute the total score, which is produced by summing the values of all the completed items and dividing this by the number of items answered, this produces a score out of five, which is transformed to a score out of 100 by subtracting 1 and multiplying by 25. The score ranges from 30 (no disability) to 150 (most severe disability). In DASH higher scores specify a greater level of impairment and severity, however, lower scores specify a lower level of impairment. A variation in a DASH score of 15 points has been stated to be the most perfect change score in terms of differentiating patients who are capable to handle their problem over time from those who cannot [22].

Mental health

Depression anxiety stress scale (DASS-21) was used to assess mental health. It is a set of three self-report scales designed to measure mental health through the emotional states of depression, anxiety and stress; originally developed by Lovibond and Lovibond [23]. Each of the three DASS-21 scales contains 7 items, divided into subscales with similar content. The depression scale assesses dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest/involvement, anhedonia and inertia. The anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect. The stress scale is sensitive to levels of chronic nonspecific arousal. It assesses difficulty relaxing, nervous arousal, and being easily upset/agitated, irritable/over-reactive and impatient. It is a 4 point Likert scale with rating as 0 = Did not apply to me at all (never), 1 = Applied to me to some degree, or some of the time (sometimes), 2 = Applied to me to a considerable degree, or a good part of time (often), 3 = Applied to me very much, or most of the time (almost always). Scores for depression, anxiety and stress are calculated by summing the scores for the relevant items and multiplied by 2 to calculate the final score. The higher the score the more severe the emotional distress is. Recommended cutoff ranges for conventional severity labels (normal, moderate, severe) start from 0 to 28+ for depression, 0 to 20+ for anxiety and 0 to 34+ for stress.

Table 1. The 6 × 2×2 experimental design.

Factors	Levels	Levels
Balance Scale	Virtual reality Exercise Group	Pre-testing
		Post-testing
	Conventional Exercise Group	Pre-testing
		Post-testing
Upper Limb Assessment	Virtual reality Exercise Group	Pre-testing
		Post-testing
	Conventional Exercise Group	Pre-testing
		Post-testing
Mental Health	Virtual reality Exercise Group	Pre-testing
		Post-testing
	Conventional Exercise Group	Pre-testing
		Post-testing
Self-esteem	Virtual reality Exercise Group	Pre-testing
		Post-testing
	Conventional Exercise Group	Pre-testing
		Post-testing
Social Support	Virtual reality Exercise Group	Pre-testing
		Post-testing
	Conventional Exercise Group	Pre-testing
		Post-testing
Motivation	Virtual reality Exercise Group	Pre-testing
		Post-testing
	Conventional Exercise Group	Pre-testing
		Post-testing

Self-esteem

Rosenberg Self-Esteem Scale was developed by sociologist Rosenberg [24], is a self-esteem measure widely used in social-science research. The underlying view of self-esteem on which the scale was founded defines self-esteem as a positive or negative attitude about the self. The scale measures state self-esteem by asking the respondents to reflect on their current feelings. It is a unidimensional, ten-item Likert-type scale with items answered on a four-point scale; from strongly agree to strongly disagree. Five of the items have positively worded statements and five have negatively worded ones. Higher scores indicate higher self-esteem, where a score less than 15 may indicate a problematic low self-esteem.

Social support

The Interpersonal Support Evaluation List-12 developed by Cohen et al. [25] is derived from the long form of the ISEL and contains 12 items that assess the perceived availability of social support on a 4-point scale ranging from 0 (definitely false) to 3 (definitely true). The three subscales representing perceived availability of Appraisal (advice or guidance), Belonging (empathy, acceptance, concern), and Tangible (help or assistance, such as material or financial aid) social support contain four items each. All items are summed to yield a total score (scores range = 0–36). Reverse coded items are 1, 2, 7, 8, 11, and 12. The Appraisal (items 2, 4, 6, 11); Belonging (1, 5, 7, 9); and Tangible subscales (3, 8, 10, 12) range from score 0 to 12. The scoring is kept continuous, higher scores indicate higher particular support.

Table 2. Basic descriptive statistics of the study participants.

	Groups					
	Total (N = 34)		E-1 (N = 17)		E-2 (N = 17)	
Variables	f	%	f	%	f	%
Age						
Childhood	1	2.9	1	5.9	–	–
Adolescence	10	29.4	5	29.4	5	29.4
Young adults	10	29.4	6	35.3	4	23.5
Adulthood/Elderly	13	38.2	5	29.4	8	47.1
No. of family Members						
5 or less	13	38.2	8	47.1	5	29.4
6 or more	21	61.8	9	52.9	12	70.6
Gender						
Male	26	76.5	13	76.5	13	76.5
Female	8	23.5	4	23.5	4	23.5
Family System						
Nuclear	19	55.5	10	58.8	9	52.9
Joint	15	44.5	7	41.2	8	47.1
Disability						
Spinal Cord Injury	10	29.4	1	5.9	9	52.9
Cerebral Palsy	3	8.8	3	17.6	–	–
Stroke	10	29.4	5	29.4	5	29.4
Traumatic Brain Injury	9	26.5	6	35.3	3	17.6
Parkinson's Disease	2	5.9	2	11.8	–	–
Incident (Causes)						
Accident	16	47.1	6	35.3	10	58.8
Trauma	11	32.4	6	35.3	5	29.4
By Birth	3	8.8	3	17.6	–	–
Neurological	4	11.8	2	11.8	2	11.8

Note. E-I: Virtual-Reality Group, E-II: Conventional Group.

Motivation

Intrinsic motivation was assessed by Task Evaluation Questionnaire. It is a 22-item version of the scale that has been used in some lab studies on intrinsic motivation developed by Ryan and Deci [11]. It has four subscales: interest/enjoyment, perceived choice, perceived competence, and pressure/tension. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation with items 1, 5, 8, 10, 14, 17, and 20; perceived choice (items - 3, 11, 15, 19, 21) and perceived competence (items- 4, 7, 12, 16, 22) are theorized to be positive predictors of both self-report and behavioral measures of intrinsic motivation. Pressure tension is theorized to be a negative predictor of intrinsic motivation indicated by items – 2, 6, 9, 13, 18. It is 7-point Likert scale with 1 as "not at all" to 7 as "very true". The items 2, 9, 11, 14, 19, 21 are reversed scored. The higher score on pressure/tension means the person felt more pressured and tense; a higher score on perceived competence means the person felt more competent; and so on.

Demographic sheet

Demographic information was gathered using a demographic questionnaire, which featured items that asked the participants to specify their age, gender, family system, number of family members, Disease, impairment due to (incident), and Duration of Impairment (physical).

Virtual reality

The instrument used to assess the virtual reality exercise was MIRA (Medical Interactive Rehabilitation Assistant). It is a software platform founded by Cosmin Mihaiu and his collegues [26], which uses the Kinect sensor to interact with medical video games created specifically as an aid for physical rehabilitation therapies and diagnosis. The platform provides a patient management application designed for physiotherapists to store patient data related to their condition and diagnosis, create personalized therapy sessions and visualize statistics about their improvement. A dedicated rehabilitation schedule can be created for each patient from the medical games contained by the platform and it can be designed to test, train and measure several types of movements, in order to improve and quantify the range of motion, the coordination and the patient engagement.

Kinect was set-free in 2010 and was believed as revolution in gaming technology. No more does the player require to grip a remote, in its place cameras and motion capturing sensors recognize the player and tracks their motion and exhibit it on the screen. Kinect initiated as a groundbreaking game platform. It uses an infrared-depth sensing camera [27], mass-produced by PrimeSense [28]. The camera captures the users' entire-body motion in 3D space for gaming activities [29]. Microsoft Kinect sensor can be linked to PC through USB permitting data to be loaded from the server. Kinect allows users to control and work together with the game console by using signs rather than game controllers, as the Kinect PrimeSense body sensors are not desired as they would in a lab setting [30]. The PrimeSense senses the players' motion and delivers response regarding the quality of motion hence concludes if the player has prospered in finishing each task. The joints/limbs that can be tracked are: head, shoulder center/right/left, elbow left/right, wrist left/right, hand left/right, spine, hip center/left/right, knee left/right, ankle left/right, foot left/right.

Experimental protocols

Every participant in the study received at least two sessions of exercise for a week over one and a half month. Physiotherapist and psychologist established the series of sequences for skill progression and balance in exercise. A warm-up for 15 minutes followed by 34–40 minutes of real exercise sessions were practiced by both the groups. *VR-Exercise Group:* Multiple scenarios using MIRA (Medical Interactive Rehabilitation Assistant) software platform through Kinect sensors were practiced; that required participants to work on getting, moving within the support of the base, stepping, sitting-to-standing, jumping, skipping and jogging. *Conventional Exercise Group:* Exercise sessions consist of activities on gym exercise machines that help in walking, retrieving objects from the floor, single-vs-double limb positions, moving within the support of the base, sitting-to-standing, reaching, jumping, skipping and jogging.

Data analysis

After end of the data collection, the 34 carefully chosen cases were entered into Statistical Package for Social Sciences (SPSS 21.0 for Windows) computer program for experimental analysis. Viewing the goals of the study, that is to experimentally compare Virtual-Reality and Conventional exercises in Patients of Neurological Deficits; help was taken from different statistical analyses to achieve a number of results. In addition, the present study was aimed to address the effects of demographic variables (gender, family system, number of family members, incidents (causes) of disability, and types of neurological disability) with the outcome measures. Firstly, descriptive characteristics of sample and all the variables (means, standard deviation, skewness, kurtosis, upper and lower limit) were assessed. Secondly, the reliabilities of all the study variables for both the experimental groups

were estimated. Bivariate correlation was used to assess the relationship between the study variables, Paired sample *t*-test was used to find out the difference between pretest and post-test of Virtual-Reality exercise group and Conventional exercise group. Independent *t*-test was used to find out gender, family system and number of family members related differences in both the experimental groups. While, ANOVA was used to find out the age-wise, incident and type of disability related differences.

Results

Basic descriptive statistics of the study participants are presented in Table 2. The age range of the participants was 10–75 years (i.e., E-I = 10–75 years and E-II = 23–65 years). In order to better characterize the sample, the diverse age range was classified according to growth stages: childhood (0 to 10 years), adolescence (11 to 25 years), young adult (26 to 40 years); and late adult and elderly (>40 years) [31]. The duration of illness was high in virtual-reality group as compared to conventional group, because it comprised of children with Cerebral Palsy by birth resulting in 10–15 years of disability. The group-wise differences between all the demographic variables are comprehensively reported in Table 2.

Secondly, the data were distributed normally for pretest and post-test conditions of both the experimental groups as revealed by the values of skewness and kurtosis. Byrne [32] stated that if the skewness value is between −2 to +2, and the kurtosis value is between −7 to +7; multivariate normality of the data could be assumed. Internal consistency was actually assessed for assessing reliability of measures/scales used for measuring the study variables. Most of the subscales were greatly reliable according to Nunnally and Bernstein [33], criteria that is 0.70 and above alpha values means highly reliable and internal consistent. While other above 0.50 and less than 0.70 are moderately reliable. In general, reliabilities of all the subscales were acceptable.

Paired sample *t*-test via SPSS-21 was used to calculate the mean differences across pretest and post-test conditions for both the groups. All seventeen participants improved on the BSS and the DASH after the 6-week intervention period. For virtual reality group the changes in mean scores of BBS for seventeen individuals was 9.92 ($p < .001$) score points; and the change in mean scores of DASH was 17.53 ($p < .001$) points, while for seventeen individuals in conventional group the changes in mean scores of BBS and DASH were 1.47 ($p < .05$) and 4.88 ($p < .01$) points, respectively. For other associated measures that assessed depression, anxiety, stress, self-esteem, social support and motivation; virtual reality group showed significant positive change in all the measures from pretest to post-test condition at 99% confidence interval ($p < .001$). For conventional group improvement was seen only in anxiety, stress and motivation at 95% confidence ($p < .05$). Results reflected that the patients with traumatic brain injury in virtual reality group showed higher significant improvement on BSS ($t[6] = 7.02$, $p < .01$) and DASH ($t[6] = 2.88$, $p < .05$). While Patients with stroke of virtual reality group showed significant mean difference on BSS ($t[5] = 6.91$, $p < .01$) and DASH ($t[5] = 5.84$, $p < .01$) as well. Whereas, in CP patients (virtual reality group) change was only seen in BSS ($t[3] = 11.00$, $p < .01$).

Gender and age differences

Independent sample *t*-test and On-way ANOVA was used to analyze the mean differences. Male patients scored significantly higher on all the social support components than female patients ($t[16] = 2.50$, $p < .05$), while female subjects scored significantly higher than male patients on the interest/enjoyment subcomponent of intrinsic motivation ($t[16] = 2.52$, $p < .05$) in conventional therapy group. In Virtual reality group gender difference was non-significant proving that both males and females were equally benefited from the exercise. As respect to age, post hoc comparison in virtual reality group showed that adolescents scored significantly higher on DASH than elderly patients ($t[16] = 24.20$, $p < .05$).

Discussion

The present nonrandomly assigned/quasi-experimental study was designed to investigate the effect of both virtual reality exercise and conventional exercises on patients of neurological deficits. The research aimed to get in-depth knowledge about the role of mental health, self-esteem, social support and motivation on both virtual reality exercise group and conventional exercise group among the patients. The findings of the present study showed that the study variables revealed significant increase in values from pre-assessment to post-evaluation. Sufficient significant differences were found in both pretest and post-test conditions of experimental group I (Virtual reality exercise group). The virtual-reality sessions have constructive influence on patients in accomplishing the functional objectives and empowering the patient to achieve daily living freely and autonomously [34]. Whereas, paired sample *t*-test across pretest and post-test condition of experimental group II (conventional exercise group), indicated few significant differences as compared to experimental group I, with significant increase in number of sessions. It was reported by the patients that traditional (conventional) exercises are boring, in turn decreasing motivation for continuing treatment [7,35]. These all complications comprise the conventional therapeutic practices in rehabilitation. Video games have the ability to improve nonadherence for the reason that their structure and design are motivating. Moreover, diverse genera of video games are publicized in order to create constructive effect on participants' cognitive, emotional and motion/motor abilities [10].

A study by Sveistrup et al. [34] also evaluated the comparison of flexible Virtual Reality (VR) technology and conventional/traditional approach for motor rehabilitation. Their findings indicated that both the groups showed improvement but focus group discussion did with the participants of the groups and their family member's revealed strong change in balance and mobility of virtual-reality based group [34]. Virtual reality group (experimental group I) in present study also showed higher scores on subscales of motivation regarding exercise (i.e., choice, competence, and interest/enjoyment) as compared to conventional therapy group (experimental group II). The clinical trial conducted by Lloréns et al. [36] gave the evidence for the positive results in balance and movement scores through virtual-reality treatment and also reported that it is a low-cost, practical and motivational treatment approach.

As explored by Weisman [37] on fragile elderly people that video games provide stimulation and challenge as well as the opportunity to enhance self-esteem by mastering new material; concluding that the games encouraged concentration, provided enjoyment and are useful as diagnostic tools. Social motivation approaches are more efficient than individual approaches, especially in older adults [38,39]. Kinect exergames may play a positive role in targeting the physical, mental/cognitive, and psychological/emotional fitness and well-being of various age groups and while also being affordable [40]. Positive effects of gaming

are such as a means to; develop social relationships [41], development skills and multi-tasking [42]; help improve mood and reduce stress [43].

The majority of Traumatic brain injury survivors are relatively young [5]. Who show lack of enthusiasm to continue monotonous (repeated), boring exercise series based on the old therapeutic programs which are still commonly used in ataxia treatment. These trainings while physiologically comprehensive and sound, are un-motivating and expected to seem impractical to the clients, resulting in poor agreement (compliance) [6]. So the scientifically proven and motivating therapeutic approaches like virtual-reality exercise give the patients; abilities and ways for change, encourage them to freely choose between different tasks, and provide support when control and competency related hindrances appear. Patients are not challenged beyond their limits, but actually assisted to practice mastery and skills in respect to change in health behavior, that is involved in improvement [14].

The literature recommends that playing video game can encourage the nature of physical and behavioral changes that are appropriate for intervention [44]. A therapeutic research suggested that video-gaming or video game–based interventions can increase patient scores on clinical instruments associated to motor learning behavior [8]. With respect to mental health and affect, literature proposes that subjects enjoy playing games, and even elderly subjects stated interest/enjoyment playing video games and showed concerns in attaining home-based virtual reality arrangements for personal use [7].

The findings of the present study are supported by the literature that individuals with disabilities were skilled with physical learning consisted of virtual settings [45]; motor learning by disabled individuals in virtual-reality can be replicated to real world comparable motor functional task in numerous cases, and even generalized to other unexperienced tasks [46]; no occurrences of cyber sickness in impaired populations have been reported to date in experiments where VR has been used to train motor abilities [47]. In five studies [48–50] that have reported comparison between virtual-reality setting and real-world physical learning, concluded the benefits of virtual-reality in almost all the cases.

Our study has some limitations. Firstly, the sampling technique was non-probability convenient sampling, which resulted in non-random assignment of patients in both the experimental group. Random assignment under controlled condition can lead to more significant results and consideration of longitudinal design can also help to explore physical and psychological areas of patients extensively. Secondly, small sample which was divided into further categories leading to lack of generalizability and distinct findings. Large sample size will particularly help in exploring mediating effect of motivation and moderating effect of social support on mental well-being and self-esteem in patients of virtual reality exercise. Moreover, there was no record maintained for which type of specific exercise or game was performed by the participants, which of the body part was stressed or focused, what was the improvement graph, if any psychological illness confounded, and no follow-up was planned. More work can be done with diverse users as which types of patients will benefit most from VR treatment (based on different needs and requirements), and what types of training routines will work best.

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Disclosure statement

The authors declare no competing interests.

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The authors confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. The authors further confirm that the order of authors listed in the manuscript has been approved by all of us.

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