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Computer-Assisted Cognitive Remediation in Schizophrenia-Review

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Abstract

Introduction: Schizophrenia is considered a multifactorial brain disorder, as both biological and psychosocial factors are implicated in its etiopathogenesis. It is characterised by a distortion of reality, prominent disturbances in perception as well as the structure and content of thoughts, symptoms across all mental functions as well as cognitive deficits. Cognitive deficits, along with the leading and accompanying symptoms of schizophrenia, are responsible for the significant difficulties patients face in their occupational, social and interpersonal functioning and prevent patients' smooth social integration. A key hypothesis is that improving patients' cognitive deficits would contribute to a better quality of life and would improve their functioning and autonomy.

Purpose: The literature review at hand aims to investigate computer-assisted cognitive rehabilitation in patients suffering from schizophrenia. In recent years, interest has shifted to the use of various programs for cognitive rehabilitation as a key method in the rehabilitation and reintegration of these patients.

Method: The method used consisted of searching and reviewing literature generated on the PubMed platform using the keywords "computerized OR computer assisted AND cognitive rehabilitation OR cognitive remediation AND schizophrenia NOT elderly".

Results: Forty four articles published between 2010 and 2021 from all over the world were selected. The results indicated that 3410 patients between the ages of 18 and 50 had participated in the studies and were administered computer-based cognitive rehabilitation tests through computer software.

Study Results: The results suggest that computer use constitutes an interesting proposal for cognitive rehabilitation. It seems to have a positive effect and to improve cognitive deficits in attention, logic, memory, executive functioning and social skills.

Keywords: Computer Assisted Rehabilitation; Computer Assisted Remediation; Cognitive Enhancement; Schizophrenia

Introduction

Kraepelin dubbed schizophrenia as "dementia praecox" and described it as a progressive neurodegenerative disease leading to cognitive deficits [1]. Indeed, numerous studies followed that demonstrated the gradual decline in the neurocognitive function of individuals on the schizophrenic spectrum. Cognitive deficits commence with or predate the onset of the disease. However, due to the intensity of psychotic symptoms, such as hallucinations, cognitive issues

are often overlooked until the patient is stabilized and the "fragments" the psychotic episodes have left in their wake begin to emerge. A drop in school performance could be a first sign of the disease onset for an adolescent, but it is not uncommon to be overlooked as a random occurrence [2]. A decline is often observed in both cognitive functioning and in general intelligence, as well [3]. Additionally, a decrease in social functioning, withdrawal, and an inability to process information properly seem to be some other cognitive characteristics that predate the first psychotic episode. Impairments in memory, attention, processing speed as well as visual and verbal learning are important cognitive deficits which seem to exhibit a higher prevalence along with the leading and accompanying symptoms of schizophrenia and which account for the significant difficulties patients face in their daily life and social functioning.

Therefore, as antipsychotic treatment alone does not seem to improve neurocognitive function, researchers are looking into alternative approaches such as Cognitive Rehabilitation Therapy (CRT), which constitutes an evidence-based, non-pharmacological treatment aimed at improving functionality in daily tasks, including those of school, work, social interactions, and independent living [4]. Cognitive rehabilitation is considered to be a method that can achieve functional improvement of patients. Technological advancements of recent years lead to an evolvement of the ways that these exercises are carried out and the creation of specialized computer programs which facilitate the prosses. Furthermore, as it is indicated in the program's specifications, the CogMed cognitive rehabilitation program is based on the utilization of neuroplasticity and the belief that the brain can reorganize and change itself when you work with it [5]. For this reason, it is equally important that the individuals who operate and implement these programs are well trained.

Methodology

The academic and scholarly search engine PubMed was used to retrieve relevant literature of the last decade. The keywords used were "computerized OR computer assisted AND cognitive rehabilitation OR cognitive remediation AND schizophrenia NOT elderly". An important criterion was that all studies selected were performed using a computer program rather than the traditional "pen and paper" method. The reason behind this choice is the growing trend towards the modernization of diagnostic and treatment methods in healthcare and beyond. However, at the same time, it is important to determine whether the "new" intervention methods are effective. Thus, studies which tackled cognitive rehabilitation or cognitive recovery in more general terms and without any intervention were excluded from the present study. Furthermore, studies which were not exclusively conducted on people suffering from schizophrenia—i.e., control group and experimental group did not consist of people with schizophrenia—were excluded from the present study. The reason for this set limitation was to exclusively study and approach—as far as possible—this category of patients. It was, therefore, deemed necessary by the present authors to limit the search to this category.

Results

As it emerged from the current literature review, the number of articles collected—written between 2010 and 2021—was 44, whereby a total of 3410 patients took part in a computer-based cognitive rehabilitation procedure. The programs used were CogniPlus [6,7], SocialVille Training Program (Posit Science) [8], REHACOM [9-11], PSSCogRehab [12], COGPACK/Brain Fitness Program (Posit Science)/ MRIGE [13], Jcores [1], CCRT [14], CIRCuiTS [15], COGPACK, NeuroPersonalTrainer® Mental Health [16], FesKits [17], Computerized Drill Training (CDT)/ Computerized facial affect recognition training [18], Gexpert/ Soft Tools/ Copia [19], X-Cog® [20], Cog-trainer [21], Posit Science [22], and Brain Fitness Program [23]. These programs are either the product of a company that distributes them or developed by researchers as in the case of CCRT in Fan's study. In their majority, the programs are user-friendly, make use of image and sound and have varied levels of difficulty. They also offer specific exercises for each cognitive function.

The samples consisted of males and females with an average age of 37 years. All the participants were patients suffering from schizophrenia and, at the time of the research, they were receiving medication with the exception of Siu's study, where no relevant information is reported, and Rass' study, where only three out of a total of 44 patients were not receiving any medication. Furthermore, the participants consisted of both outpatients and inpatients in the respective facilities where the respective research was conducted and, in some cases, they were given the opportunity to participate in the process from their own homes.

In all the studies, the aim was to enhance cognitive and executive functions. The common denominator seems to have been the enhancement of (working and long-term) memory, attention, concentration, problem-solving and auditory processing. Additionally, in many studies, the goal was social empowerment through exercises targeting aspects such as community functioning and symptoms, concentration and topological memory, naturalistic executive function (shopping), everyday self-efficacy and independent living skills and planning, facial emotion recognition and emotion management [1,11,12,15,19,20,24-27]. Moreover, there were a few studies examining the effects of cognitive rehabilitation combined with vocational rehabilitation on vocational outcomes with follow up periods from 11 months to 3 years

but only one of them found significant improvements in the combination group [28-30].

The average practice period was three months. Sessions were held once or twice on a weekly basis, depending on the study and the average duration of the intervention amounted to 31 hours per patient. The shortest intervention was found in Bryne's study, at 624 minutes per patient, 12 sessions in 6 weeks. This was followed by Mak's study, where the intervention lasted 640 minutes across 16 sessions. Contrastively, Lindenmayer's study, involved a total intervention time of 6,480 minutes across 36 sessions; namely, there were 2 sessions of 3 hours held every week.

The results showed that there was a general improvement in cognitive functions even though the intervention time was limited. More specifically, improvement was noted in verbal logical learning and memory, speed of processing, executive functioning, and visual memory, executive organizational skills for effective encoding, reasoning and problem solving. Improvement was also noted in social cognition and social functioning, as well as in neuropsychological performance.

In contrast, moderate improvement for all neuropsychological domains tested was noted but with no statistical difference between groups. Still, while there seemed to be improvement on the training tasks, this was not transferred to primary outcome measures, tests or daily life. A similar conclusion was reached in Murthy's study, where although significant improvement of processing speed was noted, this was not generalized beyond the exercise. Fan's study also results in short-term neurocognitive improvement. In Byrne's study, small improvements of social functioning were noted, but in general no improvement was noted in the 6 week study. In conclusion, while there was improvement in cognitive functions, this was not enough to enable participants to improve their daily life.

Cognitive improvement has been confirmed in treatment follow ups even years after the intervention [31], but different treatment choices follow up periods and numbers of patients are no help to determine ways of increasing durability. Although domain specific cognitive training, targeting working memory and processing speed was designed to produce long term effects [32], lead to no significant changes in real situation functionality over time [33]. Moreover, Best et al., in a randomized controlled trial comparing Executive functioning Training to Perceptual Training concluded that whereas perceptual training improves neurophysiology and neurocognition at the time of the treatment, executive training techniques have more social "implementations" which actually facilitate an ongoing functional improvement after the end of the treatment [34]. Thus improvement in functioning could be affected more by some changes in neurocognitive domains and less by others [35].

It has been observed that using cognitive remediation, even over a short period of time and standard rehabilitation treatment at the same time leads to improvements in cognitive functions and real-life functioning which persist longer [36]. CR models utilizing therapeutic alliance, social cognition on top of computer programs and addressing the problems of emotional stress may facilitate relapse prevention and the reduction of negative symptoms [37-39]. Also, it is suggested that cognitive remediation could be more efficacious during the early stages of the disease by improving negative symptoms and social functioning and play a neurobiologic protective role, thus leading to improved long-term cognitive outcomes [38,40-42]. However, there are opposing data depicting no association between CR and reduction of negative symptoms or improvements in functional capacity in first-episode schizophrenia patients but in the same study there were positive outcomes in social and global cognition as well as processing speed [43].

It should be pointed out that in a study examining possible adverse effects of CR and cognitive behavioral therapy the rate of severe adverse events (suicides, suicide attempts, suicidal crises) and severe symptom exacerbations over a period of 12 months after inclusion in the study was not as high as it was expected concerning the severity of the disorder and it was comparable between the two treatment approaches [44].

In a multicenter randomized trial with 138 participants comparing specific (Computer-assisted) to general (pen and pencil) cognitive remediation for executive functioning in schizophrenia no evidence suggested that one approach was superior to the other with both improving cognitive functioning and positively affecting symptomatology and awareness of cognitive problems [45]. However, today the immense progress of technology facilitates new approaches that greatly enhance the effects of computer assisted cognitive remediation.

In 2014 an iPad-assisted cognitive training on cognitive rehabilitation among young adults suffering from schizophrenia found improvements in cognition consistent with prior studies, this pilot study was the first randomized controlled trial to investigate the effects of iPads in computer assisted cognitive remediation [46]. In 2018 a study of 290 patients (191 study groups) tested the MONEO smartphone platform for telemedicine treatment reporting positive outcomes, reduction of deterioration symptoms; no serious adverse events were reported. However, improvements were noticed in the placebo group as well which was using a limited functionality platform suggesting that only the possession of that device was enough to initiate an improvement in the

condition [47].

In 2021 another study attempted to evaluate the feasibility of remotely accessed cognitive remediation with participants being randomized to a group of clinic- computer assisted cognitive remediation and a group of clinic-plus-remote therapy, which both were under the supervision of the clinic staff. Despite lacking computer access outside the clinic, limited computer skills, outdated technological infrastructure of the clinic facilities both groups were benefited by the programs. It should be pointed out that in the face of adversities the participants were not discouraged but felt satisfied finding a solution where it was possible. Also the same study supported that the learning experience, associations with peers and therapeutic approaches should be individualized in accordance with the different needs of every patient and technology could offer us a path towards the best treatment outcomes [48].

Discussion

It becomes clear that cognitive rehabilitation in people who have been diagnosed with schizophrenia can have positive effects. Upon collecting the results of the studies under scrutiny, it appears that there was greater enhancement in verbal learning, memory and reasoning. Improvement was also noted in attention and problem-solving and, generally, in skills related to social interaction. One of the key benefits of cognitive rehabilitation is the individual's enhancement in daily activities, as the decline in a person's functionality is evident after the onset of the illness. The nature of schizophrenia, therefore, and the resulting deficits appear to be crucial in the affected individual's socialization and autonomy. The fact that the studies collected come from different regions ensures better representativeness despite cultural differences. Furthermore, a positive development is that new platforms for the cognitive rehabilitation of patients are emerging, while "pen and paper" methods are becoming increasingly limited. However, it emerged that not much could be put into practice in the daily life of the participants e.g. while in the context of the study the patient could memorize a supermarket shopping list, in real time and under real conditions, the same individual could not perform the same task with efficacy. We could assume that the short intervention time was a decisive factor for this. We, therefore, note that there were a number of limitations worth mentioning.

Among the main limitations seem to be the small sample size [7,8,10,13-19]; the short follow up period or no follow up [9,11,13-16,22]; the fact that the studies not fully blinded or single blind [6,7,11,13,19,22], while in [1,23], there was no control group . More specifically, in Nahum's study 39 out of 105 participants did not complete the study. In Gomar's study, 17% of participants also did not complete it, while in Byrne's study, it was reported that participants did not understand the instructions to several tasks and what they were supposed to do. Finally, the overall number of studies collected over these 11 years and, consequently, the total number of patients is relatively small.

However, as it emerged, one of the main problems encountered was the inability to complete the study or carry out a follow-up, which in some cases did not take place at all or took place in a short period of time. This could possibly be attributed precisely to the reasons mentioned above—i.e. the difficulty in concentration and attention needed for the completion of a project and compliance with a process over a long period of time. However, in the studies where feedback was provided, there was noticeable difference compared to those who received no intervention. Even in studies where there was no significant difference between control group and experimental group, it may have been due to the short duration of the intervention and the short interval before the follow-up took place [49-54].

Finally, we conclude that it is important to pursue further research with this group of patients and with the aim of their cognitive rehabilitation, with early intervention taking place from the first psychotic episode, as maintaining and enhancing cognitive functions have an impact on the course and development of their lives. Further research is needed in the field, including more patients and longitudinal follow-up.

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