Effectiveness of internet-delivered dialectical behavior therapy skills training on executive functions among college students with borderline personality traits: a non-randomized controlled trial

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ABSTRACT

Given the enormous influence of emotions on cognitive processes, individuals with borderline personality disorder (BPD) suffer from marked deficits in higher-order thinking abilities. Considering the prevalence of BPD among college students, this study aimed to investigate the changes in perceived executive functioning among college students with traits/presence of BPD undergoing internet-delivered dialectical behavior therapy skills training (DBT-ST) that included the mindfulness and emotion regulation modules. An internet-delivered version of DBT-ST was opted for, as technological advancements in the present era promote the use of online platforms for psychotherapy. This non-randomized controlled trial consisted of 36 college students with traits/presence of BPD. The intervention group attended 13 sessions of DBT-ST, and the control group attended 13 sessions of behavioral activation. Perceived executive functioning was assessed using the Behavior Rating Inventory of Executive Functions for Adults. A 2-way repeated measures analysis of variance was used to evaluate the treatment impact on the outcome variable. Results showed that the DBT-ST group had larger improvements in their abilities to initiate, plan, and organize current and future-oriented task demands and to organize their everyday environment, compared to the control group. Both, the DBT-ST group and the control group demonstrated improvements in emotional control, working memory, and their abilities to shift and task monitor. Findings suggest that the internet-delivered version of DBT-ST, consisting of the mindfulness and emotion regulation modules, can foster notable improvements in executive functions among college students with traits/presence of BPD. Improved executive functioning is one of the several multifaceted outcomes of dialectical behavior therapy.

Key words: dialectical behavior therapy, skills training, executive functions, borderline personality disorder, college students.

Introduction

Emotions and cognition are deeply connected and strongly linked to each other. Emotions have a significant influence on key cognitive processes, as evidenced by the literature. When it comes to positive emotions, a study conducted by Carvalho and Ready (2010) that aimed at investigating associations between everyday

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Contributions: CVVP, conceptualized the research and drafted the methodology, arranged the resources used in the study, and wrote the original draft of the paper. RBT, performed the formal statistical analyses using SPSS and carried out the investigation. CVVP and RBT, contributed to the data curation, worked on the review and editing of the paper by making several drafts, and also read and approved the final manuscript. RBT, provided expert supervision to CVVP at every stage of writing the paper by providing constructive feedback.

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mood states and executive functions demonstrated that positive affect is associated with higher verbal fluency performance. Similarly, Storbeck and Maswood (2015) examined the influences of emotion on verbal working memory among college students and found that a positive mood enhances the capacity for holding information in working memory while processing task-irrelevant information. Emotion regulation also plays an important role in academic performance. A study conducted by Fabre and Lemaire (2019) on graduate students showed that emotions influence arithmetic performance in terms of which strategy is used and how each strategy is executed for solving a problem. Alternately, negative emotions such as anxiety may have deleterious consequences for executive functions, as evidenced by the review study conducted by Blanchette and Richards (2010). According to this study, anxiety has negative effects on executive functions such as interpretation, attention, judgment, and decision-making. The same study further showed that emotions interact with basic attentional effects, priming of concepts and knowledge structures, computational capacity, and reflective processes. Anxiety also tends to weaken executive functioning compared to a neutral mood (Shields *et al*., 2016). The overall capacity of executive functions can be brought down by high levels of emotional dysregulation, which can further influence thought processes and emotions, creating a vicious cycle (Marceau *et al*., 2018). Borderline personality disorder (BPD) often presents with remarkable difficulties in emotional dysregulation (Linehan, 1993) that can inevitably disrupt effective cognitive processes. Dialectical behavior therapy (DBT) has been regarded as a highly efficacious treatment for BPD, especially with regard to the symptoms related to emotional dysregulation (Neacsiu *et al*., 2014). Building upon the premise of these emotion-cognition interactions, the current study seeks to focus on the DBT-induced changes in executive functions among college students with the traits/presence of BPD.

The biosocial theory of BPD (Linehan, 1993) postulates that symptoms of BPD develop in the face of an invalidating environment for individuals predisposed to a biological vulnerability for emotional dysregulation. Crowell et al. (2009) extended the biosocial theory by suggesting that the development of BPD begins with an early vulnerability, which is expressed initially in the form of trait impulsivity and followed by heightened emotional sensitivity. Impulsivity can be referred to as the predisposition towards rapid, unplanned reactions to internal and external stimuli without regard to the negative consequences of these reactions (Moeller *et al*., 2001). These early biological vulnerabilities for impulsivity and heightened emotional sensitivity may lead to the temperamental and behavioral characteristics of youth on a BPD trajectory. Impulsivity is one of the earliest emerging traits among those who go on to later receive a BPD diagnosis. Trait impulsivity may also influence the action component of emotion. The reciprocal reinforcing transactions between this biological vulnerability and environmental risk, such as an invalidating environment or abuse, potentiate emotional dysregulation that gives rise to negative cognitive and social outcomes (Crowell *et al*., 2009). The scope of the current study is concerned with negative cognitive outcomes. According to a neurobiological model of emotional dysregulation developed by Davidson (2000), the prefrontal cortex (PFC) of the brain receives a major serotonergic projection, which is dysfunctional in individuals demonstrating impulsivity. The orbitofrontal cortex (OFC) and its interconnected structures, such as the dorsolateral prefrontal cortex, the anterior cingulate cortex (ACC), and the amygdala, constitute the core elements of a circuit that underlies emotional dysregulation. While the OFC also plays an important role in response inhibition, the ACC recircuits other neural systems, including the PFC, in response to conflict. The ACC also plays a role in cognitive processing, the evaluation of mood, and affect regulation. Due to deficits in this circuit, individuals with impulsivity and emotional dysregulation may experience executive dysfunction. This model provides a background for not only understanding the deficits in executive functions among individuals with BPD but also the specific interactions between emotions and cognition.

According to Millon *et al*. (2004), individuals appeal to their own internal structure to bring order to the interpretations of ambiguous stimuli in any projective situation. Most human behaviors involve the interaction between situational constraints and individual characteristics. In highly scripted situations such as the social equivalent of a structured test, individuals with BPD are often capable of behaving according to social expectations, thereby appearing more competent/healthy than they actually are. When it comes to unscripted (ambiguous) situations, individuals with BPD have minimal internal structure and hence project fluidity onto ambiguity. In effect, they need to borrow structure from their environment to organize themselves. For example, validation can be seen as one way in which this structure can be integrated into their environment. Validation communicates to an individual in a non-ambiguous manner that one's behavior makes sense and is understandable in the current context. It also involves actively accepting the individual and communicating this acceptance to them. While validating, one's responses are taken seriously rather than discounted or trivialized (Linehan, 1993). Without constant validation, there is a tendency for a breakdown in organized thought processes for individuals with BPD. Without this structure from their environment assured to them through validation, they tend to quickly regress into more primitive ego states. These primitive ego states can interfere with ego functions like integration, concept formation, judgment, realistic planning, *etc*. (Knight, 1953). But more fundamentally, optimal ego functions require intact cognitive capacity (Bellak *et al*., 1973; Pressman, 1969). According to the psychoanalytic theory, ego functions work in the interest of the reality principle, which includes perception of the external world, self-awareness, problem-solving, control of motor functions, adaptation to reality, memory, reconciliation of conflicting impulses and ideas, and regulation of affect (American Psychological Association). Subsequently, the impaired ego functions caused by primitive ego states can also contribute to difficulties in effortful control (Hoermann *et al*., 2005). From a cognitive viewpoint, maladaptive ego functions further deteriorate higher-order thinking capacity. Hence, it can be understood that intact cognitive abilities are required for the adequate operation of ego functions, and poor ego functions can further worsen executive functioning, thereby creating a vicious cycle.

Conceptually, executive functioning refers to general, higher-order cognitive processes that include response inhibition and interference control, working memory, and cognitive flexibility (Diamond, 2013). There is substantial evidence for deficits in different domains of executive functioning among individuals with BPD. Thomsen *et al*. (2017) identified that individuals with BPD mainly display deficits in higher-order thinking abilities that may be aggravated by post-traumatic stress disorder or symptoms of early life trauma. In their study, Zhang *et al*. (2014) showed that adolescents with BPD traits have higher neurological soft signs than adolescents without BPD, which implies that neural abnormality is involved right from the early stage of the development of BPD. A study conducted by Williams *et al*. (2015) showed that BPD patients who engage in more medically lethal self-injurious behaviors display neuropsychological

deficits in problem-solving and response inhibition. Decision-making is one of the most commonly affected neuropsychological functions in BPD (LeGris *et al.*, 2014). Schuermann *et al*. (2011) conducted a study in which individuals with BPD showed impairment in decision-making while performing a modified version of the Iowa Gambling Task, and the authors suggested that this may be related to a dysfunctional use of feedback information, as assessed by feedback-related negativity on the electroencephalogram. In addition to that, Hagenhoff *et al*. (2013) reported in their study that individuals with BPD demonstrate deficits in working memory processes while other sub-domains of executive functions remain unaffected. Contrary to this, a study conducted by Beblo *et al*. (2014) showed that BPD patients reported more subjective memory complaints but did not demonstrate any impairments on objective memory tests. This study provides a strong weightage for understanding the perceived cognitive deficits among individuals with BPD.

The prevalence of BPD ranges from .5% to 32.1% (Meaney-Tavares *et al*., 2016) among college students. Often, college students with BPD and their families fail to differentiate between typical borderline symptoms and problematic behaviors that are part of the normal developmental characteristics associated with this stage of young adulthood. Due to this, BPD is neither adequately identified nor addressed efficiently in this population, despite the high numbers. Most college students suffering from core BPD symptoms are unable to perform to their best capacity in college (Bagge *et al*., 2004), despite high levels of intelligence. College students with BPD also frequently complain of difficulties in coherently organizing and prioritizing their activities, which can potentially decrease their work efficiency. It can be understood that these academic difficulties in BPD may be influenced by the associated neurocognitive deficits (Dinn *et al*., 2004) present in BPD and the strong weight of emotions on cognition. However, the diagnosis of BPD in college students may not be stable, perhaps because of their relative youth or because they are generally highly functioning compared to other populations (Lenzenweger *et al*., 1997). Identifying dysfunctional traits and initiating early interventions for this high-risk population would significantly impact their lives in a positive manner. Therefore, addressing the symptoms of BPD at the earliest, especially with respect to executive functions, can lead to a desirable prognosis.

Many randomized controlled trials (RCTs) have examined the effectiveness and efficacy of DBT. One such RCT conducted by Linehan *et al*. (2006), comparing DBT versus other modes of therapy done by experts, for individuals with suicidal behaviors and BPD, showed that DBT is uniquely effective in reducing suicide attempts. Another RCT conducted by Bohus et al. (2004), which aimed at evaluating the effectiveness of in-patient DBT for BPD, showed that DBT is significantly superior to non-specific out-patient treatment, as DBT demonstrated improvements across a broad range of psychopathological features. DBT skills training (DBT-ST) as a stand-alone treatment has also been widely researched across many populations, including BPD. For example, a study conducted by Kells *et al*. (2020) evaluated a 24-week DBT-ST program for adults with BPD in a community mental health setting and found that there were significant reductions in emotional dysregulation, an increase in mindfulness scores, coping, and DBT skill use.

When it comes to the effectiveness of DBT on college students, Meaney-Tavares and Hasking (2013) conducted a pilot study on university students that used a short-term, modified DBT-ST group, with the background idea that there is definite utility in finding an efficacious, affordable, and cost-effective treatment for college students. The results of this study not only showed a significant reduction in depression, self-harm, and suicide attempts but also an increase in adaptive coping skills among college students. Another study conducted by Robins *et al*. (2019) attempted to investigate the effectiveness, acceptability, and feasibility of an 8-week DBT-ST group among 17 psychology trainees (16 females and 1 male). This study adopted a non-randomized controlled trial in which the controls (n=57) comprised of participants who enrolled for similar degrees across a few universities and completed shorter versions of the same outcome measures. In the experimental condition, participants underwent an 8-week modified DBT-ST group consisting of a 2-hour session each week. The results of this study, which emerged after quantitative and qualitative analyses, showed a significant reduction in study burnout and psychological distress and an increase in study engagement and well-being among psychology trainees following DBT-ST. Another study conducted by Klodnick *et al.* (2020) on young adults diagnosed with serious mental health conditions showed that mindfulness and distress tolerance increased significantly from enrollment in the DBT-ST program to a period of 6 months. The participants also perceived benefits pertinent to enhanced self-awareness, impulse control, communication, and relationship quality. Although the efficacy of DBT-ST has been widely researched, its effectiveness on executive functions among college students with BPD has not yet been adequately investigated.

The effectiveness of DBT on cognitive functions has been studied in many diverse populations, including BPD. On examining the effects of DBT on BPD, Soler *et al*. (2012) and Soler *et al*. (2016) showed that the mindfulness module of DBT-ST can have a desirable effect on attention, impulsivity, tolerance for delayed rewards, and time perception. Smith *et al.* (2018) conducted a study on adolescents between 12 and 18 years old with symptoms of emotional dysregulation and a recent history of deliberate self-harm, who received a 16-week modified version of DBT for deliberate self-harm developed by Miller *et al*. (1997). They attempted to use a single-group pre-post study design to examine the changes in self-reported executive functions as assessed by the Behavior Rating Inventory of Executive Functions-Self Report (BRIEF-SR). The treatment involved an adolescent skills-training group, a parents' skills-training group, a multifamily skills-training group, and individual therapy sessions. The results of this study showed that the adolescents receiving this treatment demonstrated improvements in emotional control, shifting, monitoring subscales, and the global executive composite (GEC) when assessed using BRIEF-SR.

When Afshari *et al*. (2019) investigated the effectiveness of DBT-ST on executive functions, emotion regulation, and mindfulness among patients with bipolar disorder, it was found that the intervention group demonstrated improvements in mindfulness, planning, problem-solving, and cognitive flexibility compared to the waitlist control group. Another study on adult patients with attention deficit hyperactivity disorder (ADHD) conducted by Halmoy *et al*. (2022) showed that patients who completed 14 weeks of DBT-based group treatment demonstrated significant reductions in the Behavior Rating Inventory of Executive Functions for Adults (BRIEF-A), along with sustained improvements for 5 months after treatment completion, compared to a treatment as usual (TAU) group, indicating that DBT is more effective in reducing executive dysfunction among patients with ADHD. Afshari *et al.* (2022) showed that when generalized anxiety disorder patients were randomly assigned to a cognitive behavior therapy (CBT) group or a DBT group, both the groups demonstrated a decline in the anxiety and depressive symptoms post-psychotherapy.

However, when it came to improvements in executive functions, as assessed by the Tower of London task and the Wisconsin Card Sorting task, DBT was found to be more effective than CBT. Rabinovitz and Nagar (2018) carried out a cross-sectional comparative pilot study to understand the pre-post changes following craving induction among three groups of alcohol and cannabis-dependent female adolescents and found that the group that completed 12 months of DBT had significantly lower attentional bias and improved response inhibition under craving conditions compared to a pre-treatment group and a group following four months of DBT treatment. The findings suggested improved cognitive functioning under craving conditions after 12 months of DBT.

The improvement in cognitive functions following a comprehensive DBT program for individuals with BPD, is predominantly backed up by neurological evidence. Rodrigo (2015) examined the neural correlates of patients with BPD who underwent approximately 6 months of DBT using functional near-infrared spectroscopy (fNIRS). The study showed that these patients demonstrated higher activation in the bilateral regions of the PFC and also in the right medial PFC. Apart from providing insights into the neural mechanisms of treatment-related symptom change in BPD, this study also sets a prelude to understanding that higher activation in the bilateral regions of PFC can be linked with improved cognitive functioning (Miotto *et al.*, 2006). Mancke *et al*. (2018) applied voxel-based morphometry for BPD patients undergoing DBT and showed that these patients demonstrated an increment in gray matter volume in the ACC, inferior frontal gyrus, and superior temporal gyrus, in addition to an alteration of gray matter volume in the angular gyrus as well as supramarginal gyrus, compared to patients receiving TAU. The therapy response was also correlated with an increase in gray matter volume in the angular gyrus. It could be implied from the study findings that DBT increased the gray matter volume of brain regions that play a crucial role in higher-order cognitive functions such as mentalizing and emotion regulation. These findings can provide newer pathways for neurobiologically informed therapeutic interventions. A review study conducted by Iskric and Barkley-Levenson (2021) across 9 studies on patients with BPD who underwent DBT showed significant deactivation of amygdala activity and anterior cingulate cortex, increased activity in response to inhibitory control, and decreased activity in the inferior frontal gyrus in response to arousing stimuli when assessed using functional magnetic resonance imaging and fNIRS. Such studies provide evidence for significant brain-related changes after DBT. Although previous studies have shown reasonable evidence for the neurocognitive changes following DBT, no study has specifically investigated the effects of DBT-ST on self-reported psychological measures of executive functioning among college students with BPD.

A wide range of studies in the past have investigated the effectiveness and efficacy of DBT on various symptom domains across several populations. Out of this pool, only a handful of studies have attempted to understand the impact of DBT on cognitive functions. To summarize these studies, BPD participants undergoing DBT showed significant brain-related changes (Iskric & Barkley-Levenson, 2021), as demonstrated by higher activation in the bilateral regions of PFC (Rodrigo, 2015) and increased gray matter volume in brain regions that play a crucial role in higher-order cognitive functions (Mancke *et al*., 2018). The mindfulness module of DBT-ST improved the attention, impulsivity, tolerance for delayed rewards, and time perception of individuals with BPD (Soler *et al*., 2016; Soler *et al.,* 2012). Adolescents with emotional dysregulation showed improvements in emotional control, shifting, and monitoring following DBT (Smith *et al*., 2018). Individuals with bipolar disorder demonstrated improvements in planning, problem-solving, and cognitive flexibility following DBT (Afshari *et al*., 2019). There were reductions in the BRIEF-A scores for individuals with ADHD subsequent to DBT sessions (Halmoy *et al*., 2022). After undergoing DBT, individuals with generalized anxiety disorder showed improvements in set shifting and decision-making (Afshari *et al*., 2022). Alcohol and cannabis-dependent adolescents showed a considerable decrease in attentional bias and an increase in response inhibition under craving conditions (Rabinovitz & Nagar, 2018). Reviewing these studies suggests that research in this area is still at a preliminary stage due to a few methodological and contextual limitations of previous research. Methodological limitations point out that there is a dire need for studies employing more strenuous experimental research designs in attempting to investigate the cognitive outcomes of DBT. A study conducted by Secrist (2014) that examined the role of executive functions in the treatment of BPD using DBT, had methodological limitations as evidenced by type 1 and type 2 errors and the usage of complex analyses on a moderately sized sample. The study conducted by Smith *et al*. (2018) used only a single-group pre-post study design. Since this study was a naturalistic clinical study, there was no random assignment of participants, nor was there a control or comparison group. These issues can pose a serious threat to the validity of the experimental designs used. Some of the most common methodological limitations of the previous studies include the small sample size (Rodrigo, 2015; Secrist, 2014) and the exclusion of males (Rodrigo, 2015; Smith *et al.*, 2018) in the research designs. Also, studies that used standard neuropsychological tests to evaluate the improvement in cognitive functions following DBT have focused on purely objective ways of assessing the improvement, and self-report measures have not yet been adequately investigated. Contextual limitations specify that studying just one of the modules of DBT-ST, such as mindfulness (Soler *et al*., 2016; Soler *et al*., 2012), may limit the scope of DBT research. At the same time, many studies have evaluated DBT by including all the modes of treatment (Rodrigo, 2015; Secrist, 2014; Smith *et al*., 2018), which can make the scope more expansive but non-specific. Considering that DBT-ST by itself is highly comprehensive, organized, and systematic, it would be worthwhile to understand the outcomes of DBT-ST as a stand-alone treatment. Although many studies have focused on the effect of DBT on cognitive functions across multiple disorders, such as bipolar disorder (Afshari *et al*., 2019), multiple scleroses (Abdolghaddri *et al*., 2019), and ADHD (Fleming *et al*., 2015), only very few studies have investigated the effect of DBT on cognitive functions among individuals with BPD, which points to a gap in the literature. All these methodological and contextual limitations of previous studies assert the need for understanding the specific ways in which DBT-ST can bring about changes in executive functions among college students with the traits/presence of BPD.

A self-report measure for executive functions was chosen for this study as opposed to standard neuropsychological tests because self-report measures would reflect the improvements personally experienced by individuals undergoing the intervention in terms of how they perceive their executive functioning capacities. Self-report measures are beneficial in this regard, as first-hand reports concerning one's improvements can be obtained from the same person who actually experiences the improvement. The idea behind this step is that the practical effectiveness of psychotherapy depends largely on how much improvement is truly perceived by the person undergoing psychotherapy. Also, individuals with both

borderline personality traits and BPD were included in the current study, as previous studies have shown that DBT is not only beneficial for individuals with diagnosable BPD but also for individuals having borderline personality traits (Andreasson *et al*., 2016; Johnstone *et al*., 2021). Furthermore, the innovative element of the current study includes an internet-delivered mode of DBT-ST. Many studies have attempted to make online adaptations of DBT-ST (Siste *et al*., 2022; Wilks *et al*., 2017). Even though the best results for DBT can be expected with face-to-face DBT-ST sessions, technological advancements in the present era promote the use of online platforms for psychotherapy, considering the emergence of unforeseen circumstances such as the COVID-19 pandemic (Hyland *et al*., 2022; Jain, 2022), especially when lockdown becomes inevitable. To add further, in-person interactions were not feasible during the study period due to the COVID-19 pandemic.

Individuals with BPD have deficits in executive functions, as evidenced by the aforementioned studies. Considering the efficacy of DBT and the vulnerability of the college population with BPD complaining of deficits related to executive functioning, the present study used DBT-ST to target improvements in the ability to regulate emotions, with the idea that this improvement could possibly be generalized to improved executive functioning among college students with the traits/presence of BPD. Taking into account that positive emotions have a tendency to improve cognitive functions (Carvalho & Ready, 2010; Storbeck & Maswood, 2015) and negative emotions may adversely affect cognitive functions (Blanchette & Richards, 2010; Shields *et al*., 2016), the present study seeks to enhance executive functioning by means of improving emotion regulation. Given this premise, the current study aimed at investigating the changes in perceived executive functioning among college students with the traits/presence of BPD undergoing internet-delivered DBT-ST that included the mindfulness and emotion regulation modules. The hypothesis of the study was that participants in the DBT-ST group would demonstrate a larger reduction in the self-report of executive functions across all the subscales of BRIEF-A, from pre-intervention to post-intervention, than those in the control group.

Methods

Participants

The target population included both male and female college students from different universities in India, aged between 18 and 25, diagnosed with the presence of BPD or traits of BPD by a licensed clinical psychologist, based on the findings of the Millon Clinical Multiaxial Inventory-III (MCMI-III), which was further corroborated by a routine intake interview. Using the routine intake interview, the clinical psychologist obtained information pertinent to the participants' sociodemographic details, presenting complaints (in detail) and duration, significant past history (physical and psychiatric), medication history, family history and family dynamics, relevant childhood history, familial and social support, general problem solving and coping strategies, current socio-occupational functioning, daily routine, and possible patterns in personality functioning.

A final sample size of 36 college students with the presence or traits of BPD was selected for the study using a combination of snowball and convenience sampling. Since BPD can cooccur with other Axis 1 conditions such as anxiety and depression (Zimmerman & Mattia, 1999), participants with the presence or traits of BPD experiencing mild anxiety and depressive symptoms were also included in the study, as long as psychiatric treatment was not required. The level of severity of the anxiety and depressive symptoms was evaluated based on the International Classification of Diseases and related health problems, 10th revision (World Health Organization, 2016). Average or above-average intellectual functioning based on the socio-demographic details as well as the clinical psychologist's clinical judgment was a prerequisite to being selected for the study. The ability to read, write, and speak English was also an essential criterion to be included in the study. Participants were allowed to take part only if they were pursuing graduation or postgraduation during the study period from colleges situated in India.

Participants with any co-morbid Axis 1 psychiatric diagnosis requiring psychiatric treatment/medications during the study period were excluded from the study. Participants with a history of taking psychiatric medications or attending any form of psychological intervention in the last year prior to enrollment in the study or during the study period were also excluded from the study. Participants with a past history of attempts to self-harm or suicide in the last 6 months prior to enrollment in the study or with severe tendencies for self-harm or suicidal ideation or attempts to self-harm or suicide during the study period based on a routine intake interview and scores on the Scale for Suicide Ideation (SSI), were planned to be disqualified from the study. It was essential to exclude such participants as they would have required a more intensive or alternate form of treatment, and including them may have changed the treatment targets in ways that would have deviated from the scope of the current study. A detailed protocol for self-harm was laid out to deal with such participants. However, no participant in the current study engaged in acts of self-harm or reported tendencies for self-harm during the study period. None of the participants had suicidal ideations or made suicide attempts. Participants exposed to any trauma or significant life events in the last 6 months prior to enrollment in the study were also not included in the study. If a participant was found to have comorbidities that required psychiatric evaluation, they were referred to a psychiatrist. Participants who did not meet the diagnostic criteria and those who required another form of psychotherapeutic intervention (other than DBT and behavioral activation) were also referred to appropriate treatment providers, depending on the need.

Study design

The current study employed a non-randomized controlled trial with 2 arms: one intervention group (DBT-ST) and one control group (behavioral activation). Included participants were allocated to either the DBT-ST arm or the behavioral activation arm (control group) based on their responses to open e-invites that were circulated on web-based social media platforms. Participants of both groups were tested once before the beginning of the respective interventions, once after 6 weeks into the respective interventions, and finally after 13 weeks from the start of the respective interventions, which marked the end of the treatment. The independent variables in this study were i) treatment group (DBT-ST, behavioral activation) and ii) time (pre-treatment, mid-treatment, and post-treatment). The current study was part of a larger study that focused on two primary outcome variables. The present study is concerned with one such primary outcome (dependent) variable, represented by the BRIEF-A scores, which assessed the self-report of executive functions. The total raw scores of BRIEF-A were utilized for the outcome analyses.

Measures

Semi-structured proforma

A semi-structured proforma was designed to collect the clinical and socio-demographic details.

Modified Mini-International Neuropsychiatric Interview

Modified Mini-International Neuropsychiatric Interview (MINI) (Lecrubier *et al*., 1998) was used to screen for psychiatric diagnoses, if any, during the initial evaluation. It was also used to rule out co-morbid psychiatric disorders requiring psychiatric treatment. Modified MINI is a short structured diagnostic interview designed to meet the necessity for a brief but accurate structured psychiatric interview for multicenter clinical trials and epidemiology studies. k coefficient, sensitivity, specificity, interrater, and test-retest reliability are good for all diagnoses on MINI (Lecrubier *et al*., 1997).

Millon Clinical Multiaxial Inventory-III

MCMI-III (Millon *et al*., 2009) was used to identify the presence or traits of BPD. This assessment was used as an adjunct along with a routine intake interview to clarify the diagnosis. MCMI-III is a frequently used objective measure of personality. It provides information about the traits and the presence of personality disorders, as well as the presence and prominence of clinical syndromes. It is a 175-question true/false psychological instrument used for individuals 18 years and older. Dyer and McCann (2000) showed that MCMI-III has acceptable internal consistency reliability, as shown by coefficients that exceed .80 on most scales of the instrument. Dyer (1997) has noted that MCMI-III has excellent content validity when matched against DSM-IV criteria.

Scale for Suicide Ideation

The SSI (Beck *et al*., 1979) was used to screen for suicidal risk and the systematic gathering and quantification of data relevant to participants' thoughts, plans, and wishes about suicide. It is a 19-item clinical research instrument designed by Beck *et al*. (1979) for the purpose of quantifying and assessing suicidal intention. This scale exhibits high internal consistency and moderately high correlations with clinical ratings of suicidal risk. It also has adequate construct validity. Each item has three alternative statements graded from 0 to 2. The total score is calculated by adding the individual item scores. The possible scores range from 0 to 38. The SSI is administered by a clinician based on the participants' answers in a semi-structured interview. In the current study, the SSI was administered by the primary investigator, who is a clinical psychologist.

Behavior Rating Inventory of Executive Functions for Adults

Self-report of executive functions was assessed using BRIEF-A (Roth *et al*., 2005), which is a 75-item scale developed to measure the self-reported behaviors associated with executive functions. This instrument can be scored as an overall measure (GEC), or broken into two domains: the behavioral regulation index, including i) inhibition; ii) shift; iii) control; and iv) self-monitor; and the metacognition index, including i) initiate; ii) working memory; iii) plan/organize; iv) task monitor; and v) organization of materials. Higher scores in BRIEF-A indicate higher levels of executive dysfunction. While the behavioral regulation index is concerned with an individual's ability to maintain adequate regulatory control of one's own behavior and emotional responses, the metacognition index is concerned with the ability to systematically find solutions to problems through planning and organization, while sustaining these task-completion efforts in active working memory (Roth *et al*., 2005). BRIEF-A has moderate to high internal consistency across all its subscales (.73-.90 for clinical scales; .93-.96 for indexes and GEC). Test-retest correlations across the clinical scales ranged from r=.82-.93 for the self-report form over a 4-week period. When it comes to validity, BRIEF-A has been found to be an ecologically sensitive measure of executive functioning across various conditions and age groups. The current study used GEC, inhibit, shift, control, self-monitor, initiate, working memory, plan/organize, task monitor, and organization of materials scores to measure executive dysfunction (Roth *et al*., 2005).

All the psychological tests for both screening and outcome measures were administered online. According to a study conducted by Riva *et al*. (2003), there are no significant differences in the response sets of online participants compared to the participants who complete a paper survey. The manner in which the tests were administered in the present study precisely followed the instructions as per the test manuals, with no deviations. Moreover, the tests were administered in real time by having both the test administrator and the participant keep their cameras turned on throughout the sessions. Privacy during the sessions was guaranteed by making sure that the treatment provider and participant were the only individuals present in their respective rooms. These measures ensured that the online testing protocol mimicked the ideal offline administration of the tests. Links to the online forms were sent to the personal emails of participants or by using one-time URL links shared during the online sessions at scheduled time points.

Procedure

General ethical considerations

Before the beginning of this study, the institutional ethics committee clearance was obtained. The study was carried out in accordance with the ethical standards based on the Declaration of Helsinki. The study protocol was also pre-registered with the Clinical Trials Registry-India (protocol code CTRI/2021/01/030484, 15 January 2021), which is a part of the International Clinical Trials Registry Platform by the World Health Organization (CTRI). In keeping with these high ethical standards, participation in this study was strictly voluntary, and participants were allowed to decline participation at any point during the study. Only the data of participants who completed all the sessions of therapy and attempted all the phases of testing were considered for analyses in both groups. Participants who dropped out were contacted once by the researcher, and the reasons for dropping out were recorded. However, participants from both groups were requested to enroll in the study only if they could commit to the completion of the full course of intervention and testing.

After a preliminary screening based on phone calls, emails, and inquiries, individuals willing to participate were recruited only after obtaining written informed consent. The informed consent form and participant information sheet (PIS) were handed over to the participants before initiating the assessment session. PIS provided the participants with a brief description of the study. Details regarding the plan of action, duration of the study, the role of par-

ticipants, and the risks and benefits to the participants were also mentioned in the PIS. Once selected, participants were educated regarding their assessment findings and possible personality difficulties. At this stage, another informed consent form in the form of a therapeutic contract was provided to the selected participants, which consisted of information regarding the details of psychotherapy, including the number of sessions, the psychotherapy approach, cancellation and rescheduling, maintenance of a professional relationship with the treatment provider, and dealing with acts of self-harm or tendencies toward self-harm. Confidentiality of information, including name, address, medical records, and findings of the tests, was assured, and this information was stored and reviewed only by the research team. Anonymity was ensured by assigning code numbers to participants. This step was taken to remove their personally identifiable information. There was no monetary benefit to the research team whatsoever for providing treatment to the participants. None of the participants were charged for any of the psychotherapy sessions.

Psychotherapy sessions for both groups were conducted by a licensed clinical psychologist who is registered with the Rehabilitation Council of India and has over 3 years of experience working in hospitals as a clinical psychologist. As a part of her qualifying degree for licensing, she received adequate training from highly experienced and qualified supervisors in conducting psychological assessments, conceptualizing psychodiagnostic and psychotherapeutic formulations, and carrying out various forms of psychotherapies. She received additional training in the treatment of personality disorders, that placed a special focus on DBT. She also received four sessions of psychotherapy supervision for the current study from another licensed clinical psychologist who is a practicing consultant with over 10 years of experience in the treatment of BPD. The assessments for both groups were also administered by the same clinical psychologist who conducted the intervention.

Internet-related security

The therapy sessions were not audio/video recorded to ensure that participants felt comfortable and less guarded during the treatment. Nevertheless, therapy notes were securely maintained with confidentiality for each participant. These notes were stored and reviewed only by the primary researcher and the research supervisor. Some case-related discussions based on the therapy notes were carried out with the psychotherapy supervisor when necessary.

All the electronic data were stored only in password-protected folders created by the primary researcher, which were also made accessible to the research supervisor. An operating antivirus software was installed in the treatment provider's system. Privacy during the sessions was assured by making sure that the treatment provider and participant were the only individuals present in their respective rooms. Participants were advised to strictly use personal devices with reliable antivirus software while participating in the study to ensure that their data was not misused by a third party. They were also advised to keep their login credentials private, carefully pick and maintain passwords, and choose an email that only the participants could access. During the sessions, they were also advised to close all other browsers to limit access to their data. Data related to testing and therapy notes would be stored by the primary researcher for 5 years (University of Virginia, 2020) after the completion of the research. During this period, data will remain accessible only to the primary researcher and the research supervisor. After the completion of these 5 years, all the electronic data pertinent to the study will be permanently erased using commercial software applications designed to remove all the data from both storage devices and the cloud. Physical data would be destroyed using a paper shredder. The findings of the current study were used for publication in a scientific journal. However, the confidential data pertinent to individual therapy notes and testing for each participant remained anonymous.

Participant recruitment and data collection

An open e-invite regarding the DBT-ST sessions was shared *via* web-based social media platforms, targeting college students with emotional difficulties across various colleges situated in India. Interested students contacted the investigator by filling out a Google Form. During the first consultation, the informed consent form and PIS were provided to the participants, who were also given the opportunity to clarify any doubts related to the research. Once this was completed, screening tests (semi-structured proforma, modified MINI, and SSI) were administered to the participants. A routine intake interview followed the screening tests. They were then administered MCMI-III to establish the traits/presence of BPD. Those who did not meet the necessary inclusion criteria were eliminated from the study. Subsequently, participants were recruited into the intervention group only if they met the diagnostic criteria of having the traits/presence of BPD based on the results of the MCMI-III, corroborated with the routine intake interview.

For the DBT-ST group, the first therapy session involved a detailed psychotherapy intake, psychoeducation of the results of MCMI, and discussion of the therapeutic contract and goals. Once the therapeutic contract was drawn, BRIEF-A was administered before the start of the DBT-ST intervention. The DBT-ST protocol was then carried out for 13 weeks. The mindfulness module consisted of 6 sessions, and the emotion regulation module consisted of 7 sessions. BRIEF-A was administered again at the end of the mindfulness module, that is, after 6 weeks, followed by an administration of the test at the end of the emotion regulation module, that is, after 13 weeks from the start of therapy, which marked the end of the intervention.

On a parallel basis, an open e-invite regarding the behavioral activation sessions was shared *via* web-based social media platforms, targeting college students with emotional difficulties across various colleges situated in India. Interested students contacted the investigator by filling out a Google Form. During the first consultation, the informed consent form and PIS were provided to the participants, who were also given the opportunity to clarify any doubts related to the research. Once this was completed, screening tests (semi-structured proforma, modified MINI, and SSI) were administered to the participants. A routine intake interview followed the screening tests. They were then administered MCMI-III to establish the traits/presence of BPD. Those who did not meet the necessary inclusion criteria were eliminated from the study. Subsequently, participants were recruited into the control group only if they met the diagnostic criteria of having the traits/presence of BPD based on the results of the MCMI-III, corroborated with the routine intake interview.

For the behavioral activation group, the first therapy session involved a detailed psychotherapy intake, psychoeducation of the results of MCMI, and discussion of the therapeutic contract and goals. They were also informed regarding the access and usage of the behavioral activation videos, homework assignments, follow-up phone calls, and online face-to-face consultations. Once the therapeutic contract was drawn, BRIEF-A was

administered before the start of behavioral activation. The behavioral activation protocol was then carried out for 13 weeks using pre-recorded therapy videos. Similar to that of the intervention group, BRIEF-A was again administered to the control group after 6 weeks of behavioral activation and again at the end of 13 weeks from the start of behavioral activation, which marked the end of this protocol.

Internet-delivered treatment protocol

DBT-ST was conducted for the participants in the intervention group, based on the *DBT Skills Training Manual* by Linehan (2015). Although the standard DBT consists of 4 modes of treatment (individual therapy, group or individual skills training, between-session skills coaching, and a therapist consultation team), the current study focused only on individual skills training as a stand-alone treatment for college students with the traits/presence of BPD, which corresponds to some studies conducted in the past (Cavicchioli *et al*., 2019; Muhomba *et al*., 2017). Individual skills training was chosen as opposed to group skills training since the sample consisted of college students with possible sensitive issues. This population tends to be more guarded and self-conscious compared to other age groups. They are also more susceptible to peer pressure (Costello & Zozula, 2018), especially in group settings. A meta-analysis on the psychological treatment of depression among college students conducted by Cuijpers *et al*. (2015) showed that the effect sizes were significantly larger when students received individual therapy versus group therapy. Hence, considering the vulnerability of this population, personalized individual sessions were adopted to ensure that they could freely express themselves and thoroughly utilize the sessions for fulfilling personal therapeutic goals.

Since the scope of the current study primarily centers around enhancing emotion regulation as a means to improve cognitive functions, only the mindfulness and emotion regulation modules were carried out for the participants. According to Chapman and Gratz (2015), mindfulness and emotion regulation skills play a major role in decreasing vulnerability to intense emotions, especially anger. The interpersonal effectiveness module and distress tolerance module were not included in the current study's treatment protocol, as their primary goals do not involve the regulation of emotions, although improving interpersonal effectiveness and distress tolerance may have an additive effect in enhancing emotion regulation. A study done by Dixon-Gordon *et al*. (2015) aimed at characterizing the effect sizes of the DBT emotion regulation (DBT-ER) group compared to the DBT interpersonal effectiveness (DBT-IE) group. The study found that the DBT-ER group demonstrated large effect sizes for improved self-reported reactivity to an emotional stressor following treatment. Significant decreases in non-suicidal self-injury and improvements in mindfulness were found only in the DBT-ER group. The findings of this study suggest that DBT-ER skills are more effective than DBT-IE for regulating emotions. Based on the findings along these lines, interpersonal effectiveness skills were eliminated from the protocol. Also, the goals of distress tolerance skills first and foremost include surviving crisis situations without making them worse, accepting reality as it is in the moment, and becoming free from cravings (Linehan, 2015), which do not primarily focus on enhancing emotion regulation. Therefore, the current study's protocol included only the Mindfulness and Emotion Regulation modules from DBT-ST.

Although administering all 4 modules of DBT-ST would take about 24 weeks as per the standard DBT-ST protocol (Linehan, 2015), the current study only focused on the mindfulness and emotion regulation modules, in accordance with its scope. Hence, the mindfulness module consisted of 6 sessions, and the emotion regulation module consisted of 7 sessions. Even though 2 sessions of mindfulness training are conducted intermittently after each module in the standard DBT-ST protocol, amounting to a total of 6 sessions, the current study consisted of a detailed mindfulness module that was conducted altogether at the beginning for 6 sessions, followed by 7 sessions of emotion regulation. The sessions were reorganized in this manner, as this study only focused on two DBT-ST modules. Although the standard DBT-ST is conducted for 2.5 hours each week, the current study modified the weekly sessions to suit 1.5 hours (Berzins & Trestman, 2004; Mochrie *et al*., 2020) on a one-to-one basis. The duration of each session was shortened as the sessions were conducted on an online platform, and thus, paying attention to a virtual medium for a continuous period of 2.5 hours would have caused mental and physical strain for the participants. Since the sessions were carried out on an individual basis, focused attention was provided to each participant. On that account, there was no compromise on the content, despite shortening the duration of each session. Handouts and homework assignments were also provided to the participants. DBT diary cards were incorporated when needed. The 1.5-hour-long session included 10 minutes of general review of the previous week, 10 minutes of discussion of the previous week's homework, 55 minutes of learning new skills, and 15 minutes of clarifications and concluding remarks, followed by the assignment of homework for the next week.

The DBT-ST sessions were held online using Google Meet. The content for mindfulness and emotion regulation modules was retained as prescribed in the DBT-ST manual developed by Linehan (2015). The detailed treatment protocol for the intervention group is outlined in Table 1. The general DBT strategies, including the dialectical approach, acceptance versus change strategies, problem-solving strategies, validation, and communication strategies, were applied across all the DBT-ST sessions. Techniques like chain analysis and missing-link analysis were used when necessary. Furthermore, technological supplements using various online platforms, such as Microsoft PowerPoint, PDF documents, Word documents, *etc*., were used for providing audio-visual aids. The internet-delivered version of DBT-ST was approved by another licensed clinical psychologist who is a practicing consultant with over 13 years of experience in clinical settings.

The behavioral activation protocol was implemented for the control group based on the manual formulated by Lejuez and Hopko (2013). The 13-week treatment protocol consisted of pre-recorded weekly sessions in the form of therapy videos that lasted for 10-15 minutes each, along with 3 one-to-one online consultation sessions. The intervention was conducted by the same clinical psychologist who carried out the DBT-ST sessions. Private URL links were sent to the personal emails of the selected participants, which directed them to the videos. These videos were sent to participants' emails on a weekly basis, and each session was made available to them for only 1 week to ensure treatment compliance. Homework assignments were also prescribed as a part of the behavioral activation sessions. A postgraduate psychology trainee made regular phone calls to the participants to keep track of progress, review homework, and address any immediate concerns if they arose. The 1st, 7th, and 13th sessions of behavioral activation also included one-to-one online consultations with the same clinical psychologist in order to guarantee at least minimal therapist contact, in an attempt to promote the therapeutic alliance. The one-to-one online consultation included a general review of the

participants, clarification of concerns/doubts about the behavioral activation treatment, discussion of progress based on homework assignments, discussion of values, goals, activities of importance/enjoyment/mastery, and lifestyle, based on the manual by Lejuez and Hopko (2013).

Statistical analyses

For all the treatment completers, pre-treatment group differences were assessed using chi-square across the demographic and clinical variables. An independent samples *t*-test was used for analyzing the pre-treatment group differences across the outcome variable. The data were screened for outliers for all the variables, and statistical assumptions were evaluated. Outliers were assessed by examination of studentized residuals for values greater than ±3 standard deviations. Normality was assessed using Shapiro-Wilk's test of normality on the studentized residuals ($p>.05$). To evaluate the treatment impact on self-report of executive functions, 2-way repeated measures analysis of variance (ANOVA) was performed, entering each of the BRIEF-A subscale scores as dependent variables, the treatment arms (DBT-ST and behavioral activation) as the between-subject factor, and time (pre-intervention testing, mid-intervention testing, and post-intervention testing) as the within-subject factor. The 2-way repeated measures ANOVA determined whether there was a statistically significant 2-way interaction between a treatment*time interaction on each subscale of BRIEF-A. Mauchly's test of sphericity indicated whether the assumption of sphericity was met for the two-way interaction. The main effect of treatment showed whether there was a statistically significant difference in the BRIEF-A scores between treatment groups. The main effect of time showed whether there was a statistically significant difference in the BRIEF-A scores between time points. If there was a statistically significant 2-way interaction between treatment and time, *post-hoc* group comparisons using simple main effects were computed. Data was analyzed using Statistical Package for the Social Sciences (SPSS), version 29 (IBM, Armonk, NY, USA), compatible with Windows.

Results

Sample characteristics, pretreatment comparability and statistical assumptions

Table 2 presents the pre-treatment comparability data for treatment completers across the demographic and clinical variables as a function of the treatment group. There were no statistically significant pretreatment differences across any demographic and clinical variables. Table 3 presents the pretreatment comparability data for treatment completers across the study outcome variable. There were no statistically significant pre-treatment differences across any subscales of the outcome variable. When data was screened for outliers across all variables, no univariate (z scores: >3.29, $p<.001$) or multivariate outliers (Mahalanobis distance; $p<.001$) were found. All the BRIEF-A subscale scores were normally distributed ($p>.05$), except for the post-test scores of DBT intervention ($p=.021$) in the Emotional Control subscale, mid-test scores of DBT intervention ($p=.046$) in the self-monitor subscale, pre-test scores of the control group ($p=.022$) in the task monitor subscale, mid-test scores ($p=.042$) and post-test scores ($p=.002$) of DBT intervention in the organization of materials subscale, and mid-test scores of DBT intervention ($p=.038$) in the GEC subscale, as assessed by Shapiro-Wilk's test of normality on the studentized residuals. Mauchly's test of sphericity indicated that the assumption of sphericity was met across all the subscales of BRIEF-A for examining the 2-way interaction.

Table 1. Dialectical behavior therapy skills training treatment protocol.

Session no.	Session theme	Session content
1	General orientation and introduction to mindfulness	Understanding the meaning of "dialectics"; the DBT assumptions and approach; introduction to the concept of mindfulness
2	Mindfulness	Goals of the mindfulness module; the concepts of emotion mind, reasonable mind, and wise mind
3	Mindfulness	Wise mind practices
4	Mindfulness	"WHAT" skills of mindfulness – observe, describe and participate
5	Mindfulness	"HOW" skills of mindfulness – non-judgmentally, one-mindfully, and effectively
6	Concluding mindfulness	Wise mind: the middle path between extremes – synthesis of doing mind and being mind, desire for change and radical acceptance, self-denial and self-indulgence
7	Introduction to emotion regulation	Goals of emotion regulation module; nature of emotions; complexity of regulating emotions; characteristics of emotions; components of emotions; primary and secondary emotions
8	Emotion regulation	Healthy perspectives on emotions; observing, describing, and naming emotions; differentiating between thoughts, emotions, and behaviors; identifying primary emotions; strength-building self-statements; obstacles in observing and describing emotions
9	Emotion regulation	Changing emotional responses – checking the facts
10	Emotion regulation	Changing emotional responses – opposite action
11	Emotion regulation	Changing emotional responses – problem-solving
12	Emotion regulation	Reducing vulnerability to emotional mind – ABC PLEASE skills
13	Concluding emotion regulation	Mindfulness of current emotions; managing extreme emotions – crisis survival skills; troubleshooting emotion regulation skills

DBT-ST, dialectical behavior therapy skills training; DBT, dialectical behavior therapy.

Enrollment and participant retention

A total of 77 participants were screened for enrollment eligibility, out of which the final treatment-completer sample sizes were 18 each in both groups (treatment and control group) at the end of 13 weeks of assigned conditions. Out of the 25 eligible participants originally allotted to the DBT-ST group, the researcher lost contact with 2 eligible participants following the first consultation (intake and assessment) session, even before initiating the intervention. Out of the 20 eligible participants originally allotted to the control group, 2 eligible participants declined to participate following the first consultation (intake and assessment) session, as they did not prefer sessions in the form of pre-recorded therapy videos. Finally, 23 eligible participants initiated DBT-ST in the treatment group, and 18 eligible participants initiated behavioral activation in the control group. Among the DBT-ST group, there were 3 participant dropouts during the mindfulness module (2 dropouts after the 2nd session and 1 dropout after the 6th session) and 2 participant dropouts during the emotion regulation module (1 dropout after the 7th session and 1 dropout after the 12th session). Out of all the 5 participants who dropped out during DBT-ST, only 1 participant (a participant who dropped out after the 7th session during the Emotion Regulation module) provided the reason for dropping out, stating that he had other commitments due to which he was unable to continue the therapy. The researcher made one attempt to contact the remaining 4 participants who dropped out but was unable to connect with them. There were no participant dropouts during the behavioral activation treatment in the control group. See Figure 1 for a complete description of the enrollment procedures. Recruitment began in November 2021 and ended in August 2022; post-treatment assessments were completed by November 2022.

Self-report of executive functions

A 2-way repeated measures ANOVA was conducted to determine whether there was a statistically significant 2-way interaction between a treatment*time interaction on each subscale score of BRIEF-A. Table 4 shows the means, standard deviations, and 2-way repeated measures ANOVA statistics for executive functioning variables. There was a statistically significant 2-way interaction between treatment and time for the initiate subscale as shown by $F(2, 34)=4.11$, $p=.025$, plan/organize subscale as shown by $F(2, 34)=4.62$, $p=.017$, and organization of materials subscale as shown by $F(2, 34)=3.78$, $p=.033$. Therefore, simple main effects were computed for initiate, plan/organize, and organization of materials.

Mean initiate scores showed a statistically significant difference over time in the DBT intervention trial, $F(2, 34)=14.23$, $p<.001$. There was a decrease in the initiate scores from pre-in-

Table 2. Pre-treatment comparability across demographic and clinical variables as a function of treatment group.

	DBT (n=18), n (%)	BA (n=18), n (%)	χ^2	p value
Gender				
Male	4 (36.4)	7 (63.6)	1.17	.27
Female	14 (56)	11 (44)		
Past psychiatric treatment				
No	16 (48.5)	17 (51.5)	.36	.54
Yes	2 (66.7)	1 (33.3)		
History of past psychotherapy				
No	13 (43.3)	17 (56.7)	3.20	.07
Yes	5 (83.3)	1 (16.7)		
History of psychological trauma				
No	5 (62.5)	3 (37.5)	.64	.42
Yes	13 (46.4)	15 (53.6)		

DBT, dialectical behavior therapy group; BA, behavioral activation group.

Table 3. Pre-treatment comparability across study outcome variables as a function of treatment group.

	DBT (n=18), Mean (SD)	BA (n=18), Mean (SD)	t	p value
Inhibit	15.33 (2.97)	16.27 (2.49)	-1.03	.31
Shift	12.94 (2.04)	12.27 (2.51)	.87	.39
Emotional control	21.77 (5.39)	23.72 (3.84)	-1.24	.22
Self-monitor	11.00 (2.19)	11.61 (1.94)	-.88	.38
Initiate	17.83 (3.48)	16.38 (3.10)	1.32	.19
Working memory	16.61 (3.31)	15.66 (2.89)	.91	.36
Plan/organize	19.72 (4.67)	17.83 (4.14)	1.28	.20
Task monitor	12.38 (2.37)	12.66 (2.30)	-.35	.72
Organization of materials	15.27 (3.95)	14.83 (3.27)	.36	.71
Global executive composite	142.88 (19.05)	141.27 (15.12)	.28	.78

DBT, dialectical behavior therapy group; BA, behavioral activation group; SD, standard deviation.

tervention to 6 weeks into the DBT intervention, as shown by a statistically significant mean decrease of 3.11, 95% confidence interval (CI) [.64, 5.58], p=.012, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 4.17, 95% CI [2.19, 6.14], p<.001. There was a decrease in the initiate scores from mid-intervention to post-intervention, as shown by a mean decrease of 1.05, 95% CI [-.93, 3.04], which was not statistically significant (p=.528). However, there was no statistically significant effect of time on initiate scores in the control trial; F(2, 34)=2.78, p=.076. In other words, mean initiate scores did not change over time in the control trial; F(2, 34)=2.78, p=.076. Initiate subscale scores were not statistically significantly different in the control group compared to the intervention group at the pre-intervention, F(1, 17)=1.53, p=.232, as shown by a difference of 1.44, 95% CI [-.017 to 3.906]. Initiate subscale scores were not statistically significantly different in the control group compared to the intervention group at the midlevel-intervention, F(1, 17)=.45, p=.835, as shown by a difference of -.28, 95% CI [-3.043 to 2.487]. Initiate subscale scores were not statistically significantly different in the control group compared to the intervention group at the post-intervention, F(1, 17)=1.25, p=.279, as shown by a difference of -1.61, 95% CI [-4.649 to 1.426]. Figure 2 shows the significant two-way interaction effects between treatment × time for the initiate subscale.

Mean plan/organize scores showed a statistically significant difference over time in the DBT intervention trial, F(2, 34)=11.56, p<.001. There was a decrease in the plan/organize scores from pre-intervention to 6 weeks into the DBT intervention, as shown

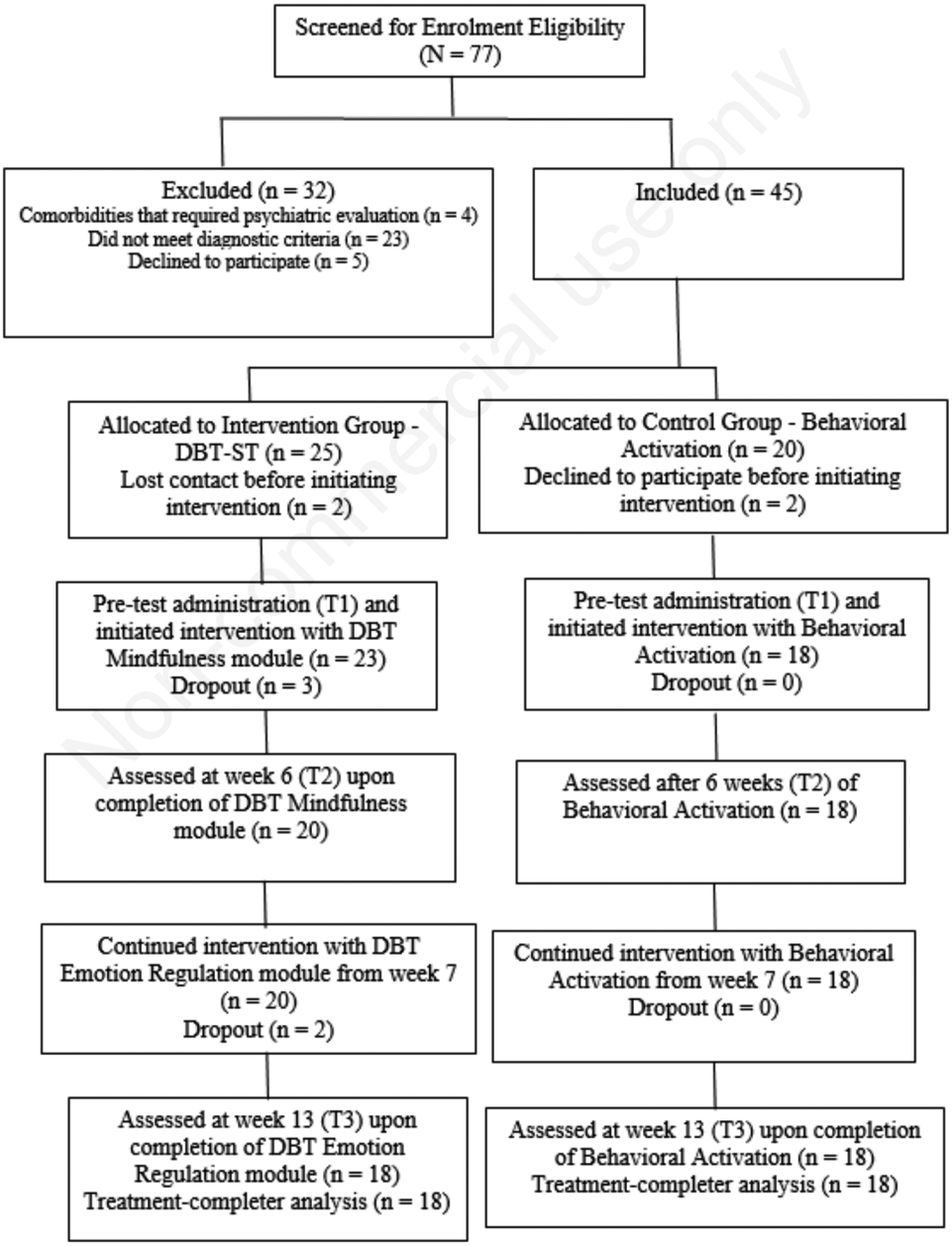

Figure 1. Flowchart of the participant enrollment procedures.

by a statistically significant mean decrease of 2.61, 95% CI [.34, 5.18], p=.046, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 4.33, 95% CI [1.70, 6.96], p<.001. There was a decrease in the plan/organize scores from mid-intervention to post-intervention, as shown by a mean decrease of 1.72, 95% CI [-.24, 3.68], which was not statistically significant (p=.098). However, there was no statistically significant effect of time on plan/organize scores in the control trial, F(2, 34)=1.52, p=.234. Plan/organize subscale scores were not statistically significantly different in the control group compared to the intervention group at the pre-intervention, F(1, 17)=1.76, p=.202, as shown by a difference of 1.89, 95% CI [-1.114 to 4.892]. Plan/organize subscale scores were not statistically significantly different in the control group compared to the intervention group at the midlevel-intervention, F(1, 17)=.068, p=.798, as shown by a difference of .39, 95% CI [-2.766 to 3.544]. Plan/organize subscale scores were not statistically significantly different in the control group compared to the intervention group at the post-intervention, F(1, 17)=1.44, p=.247, as shown by a difference of -1.56, 95% CI [-4.291 to 1.180]. Figure 3 shows the significant two-way interaction effects between treatment × time for the plan/organize subscale.

Mean organization of materials scores showed a statistically significant difference over time in the DBT intervention trial, F(2, 34)=10.22, p<.001. There was a decrease in the organization of materials scores from pre-intervention to 6 weeks into the DBT intervention, as shown by a mean decrease of 1.39, 95% CI [-.82, 3.60], which was not statistically significant (p=.341), and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 3.44, 95% CI [1.18, 5.71], p<.001. There

Table 4. Means, standard deviations, and 2-way repeated measures analysis of variance statistics for executive functioning variables.

Variable	DBT (n=18)		BA (n=18)		ANOVA			
	M	SD	M	SD	Effect	F ratio	*df*	η^2
Inhibit								
Time 1	15.33	2.97	16.27	2.49	G	5.49*	1, 17	.244
Time 2	12.77	2.75	14.27	3.08	T	28.40***	2, 34	.626
Time 3	12.05	1.89	14.39	3.43	G×T	1.22	2, 34	.308
Shift								
Time 1	12.94	2.04	12.27	2.51	G	.082	1, 17	.005
Time 2	11.27	3.56	11.77	2.66	T	16.77***	2, 34	.497
Time 3	9.88	2.21	10.66	2.20	G×T	1.65	2, 34	.088
EC								
Time 1	21.77	5.40	23.72	3.84	G	2.37	1, 17	.123
Time 2	19.66	6.00	20.55	4.17	T	13.00***	2, 34	.416
Time 3	17.16	4.90	19.94	4.98	G×T	.826	2, 34	.046
SM								
Time 1	11.00	2.19	11.61	1.94	G	6.12*	1, 17	.265
Time 2	8.72	1.77	10.44	3.38	T	17.09***	2, 34	.501
Time 3	8.44	1.72	10.00	2.56	G×T	1.25	2, 34	.068
Initiate								
Time 1	17.83	3.48	16.38	3.10	G	.016	1, 17	.001
Time 2	14.72	3.52	15.00	4.21	T	17.07***	2, 34	.501
Time 3	13.66	3.97	15.27	4.25	G×T	4.11*	2, 34	.195
WM								
Time 1	16.61	3.31	15.66	2.89	G	.072	1, 17	.004
Time 2	14.11	3.66	14.44	3.79	T	10.06***	2, 34	.372
Time 3	13.05	3.35	14.33	3.97	G×T	3.04	2, 34	.152
PO								
Time 1	19.72	4.67	17.83	4.14	G	.037	1, 17	.002
Time 2	17.11	4.12	16.72	4.56	T	11.39***	2, 34	.401
Time 3	15.38	4.06	16.94	4.18	G×T	4.62*	2, 34	.214
TM								
Time 1	12.38	2.38	12.66	2.30	G	.22	1, 17	.013
Time 2	11.00	2.65	11.38	2.56	T	11.23***	2, 34	.398
Time 3	10.55	1.85	10.88	3.02	G×T	.011	2, 34	.001
OM								
Time 1	15.27	3.95	14.83	3.27	G	.286	1, 17	.017
Time 2	13.88	3.77	14.11	3.81	T	9.67***	2, 34	.363
Time 3	11.83	3.55	13.77	4.19	G×T	3.78*	2, 34	.182
GEC								
Time 1	142.88	19.05	141.27	15.12	G	.95	1, 17	.053
Time 2	123.27	25.23	128.72	23.92	T	28.31***	2, 34	.625
Time 3	112.05	20.05	126.22	26.83	G×T	3.23	2, 34	.160

M, mean; SD, standard deviation; Df, degree of freedom; EC, emotional control; SM, self-monitor WM, working memory; PO, plan/ organize; TM, task monitor; OM, organization of materials; GEC, global executive composite; DBT, dialectical behavior therapy group; BA, behavioral activation group; ANOVA, analysis of variance; G, group; T, time; *p<.05; ***p<.001.

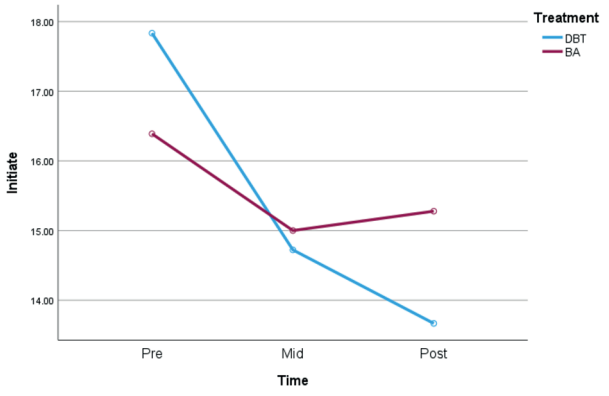

Figure 2. Significant 2-way interaction effects between treatment×time for the initiate subscale. DBT, dialectical behavior therapy group; BA, behavioral activation group.

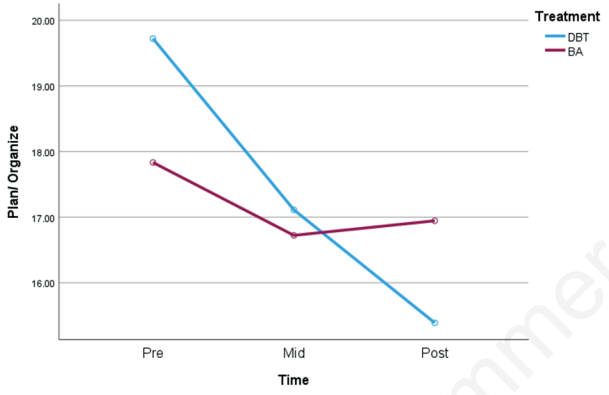

Figure 3. Significant 2-way interaction effects between treatment×time for the plan/organize subscale. DBT, dialectical behavior therapy group; BA, behavioral activation group.

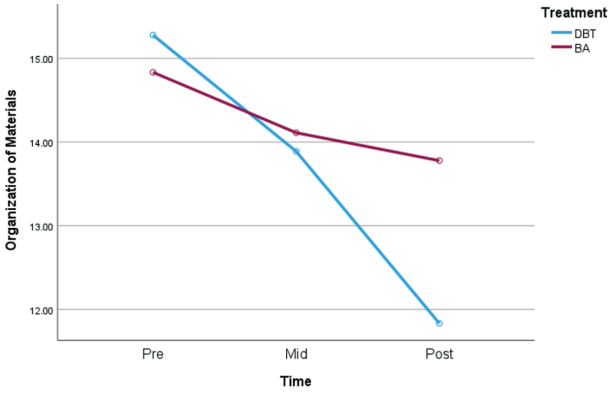

Figure 4. Significant 2-way interaction effects between treatment×time for the organization of materials subscale. DBT, dialectical behavior therapy group; BA, behavioral activation group.

was a decrease in the organization of materials scores from mid-intervention to post-intervention, as shown by a statistically significant mean decrease of 2.05, 95% CI [.50, 3.61], p<.001. However, there was no statistically significant effect of time on the organization of material scores in the control trial, F(2, 34)=1.72, p=.194. The organization of materials subscale scores were not statistically significantly different in the control group compared to the intervention group at the pre-intervention, F(1, 17)=.145, p=.708, as shown by a difference of .44, 95% CI [-2.017 to 2.906]. Organization of materials subscale scores were not statistically significantly different in the control group compared to the intervention group at the midlevel-intervention, F(1, 17)=.030, p=.864, as shown by a difference of -.22, 95% CI [-2.92 to 2.50]. Organization of materials subscale scores were not statistically significantly different in the control group compared to the intervention group at the post-intervention, F(1, 17)=2.97, p=.103, as shown by a difference of -1.94, 95% CI [-.434 to 4.323]. Figure 4 shows the significant two-way interaction effects between treatment × time for the organization of materials subscale.

There was no statistically significant 2-way interaction between treatment and time for the subscales: inhibit as shown by F(2, 34)=1.22, p=.308, shift as shown by F(2, 34)=1.65, p=.207, emotional control as shown by F(2, 34)=.83, p=.446, self-monitor as shown by F(2, 34)=1.25, p=.301, working memory as shown by F(2, 34)=3.04, p=.061, task monitor as shown by F(2, 34)=.01, p=.989, and GEC as shown by F(2, 34)=3.23, p=.052. However, the subscales shift, emotional control, working memory, task monitor, and GEC showed a statistically significant main effect for time but not treatment. For the shift subscale, the main effect of time showed that there was a statistically significant difference in shift scores between time points, F(2, 34)=16.77, p<.001. There was a decrease in the shift scores from pre-intervention to mid-intervention, as shown by a statistically significant mean decrease of 1.08, 95% CI [.014, 2.15], p = .046, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 2.33, 95% CI [1.40, 3.26], p<.001. There was a decrease in the shift scores from mid-intervention to post-intervention, as shown by a statistically significant mean decrease of 1.25, 95% CI [.054, 2.45], p=.039. For the emotional control subscale, the main effect of time showed that there was a statistically significant difference in emotional control scores between time points, F(2, 34)=12.10, p<.001. There was a decrease in the emotional control scores from pre-intervention to mid-intervention, as shown by a statistically significant mean decrease of 2.64, 95% CI [.523, 4.75], p=.012, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 4.19, 95% CI [2.12, 6.27], p<.001. There was a decrease in the emotional control scores from mid-intervention to post-intervention, as shown by a mean decrease of 1.556, 95% CI [-1.075, 4.18], which was not statistically significant, p=.405.

For the working memory subscale, the main effect of time showed that there was a statistically significant difference in working memory scores between time points, F(2, 34)=10.06, p<.001. There was a decrease in the working memory scores from pre-intervention to mid-intervention, as shown by a statistically significant mean decrease of 1.86, 95% CI [.383, 3.34], p=.012, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 2.44, 95% CI [.88, 4.00], p<.01. There was a decrease in the working memory scores from mid-intervention to post-intervention, as shown by a mean decrease of .58, 95% CI [-.91, 2.08], which was not statistically significant, p=.945. For the task monitor subscale, the main effect of time showed that there was a statistically significant difference in task

monitor scores between time points, F(2, 34)=11.23, p<.001. There was a decrease in the task monitor scores from pre-intervention to mid-intervention, as shown by a statistically significant mean decrease of 1.33, 95% CI [.332, 2.33], p=.008, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 1.81, 95% CI [.63, 2.98], p<.01. There was a decrease in the task monitor scores from mid-intervention to post-intervention, as shown by a mean decrease of .47, 95% CI [-.48, 1.43], which was not statistically significant, p=.622. For the GEC subscale, the main effect of time showed that there was a statistically significant difference in GEC scores between time points, F(2, 34)=28.31, p<.001. There was a decrease in the GEC scores from pre-intervention to mid-intervention, as shown by a statistically significant mean decrease of 16.08, 95% CI [8.70, 23.46], p<.001, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 22.94, 95% CI [14.26, 31.62], p<.001. There was a decrease in the GEC scores from mid-intervention to post-intervention, as shown by a mean decrease of 6.86, 95% CI [-1.93, 15.65], which was not statistically significant, p=.161.

The inhibit and self-monitor subscales showed statistically significant main effects for treatment and time but showed no significant interaction effects. For the inhibit subscale, the main effect of treatment showed a statistically significant difference in inhibit scores between the treatment groups, F(1, 17)=5.49, p=.032. There was a difference in inhibit scores between the DBT and the control group, as shown by a statistically significant mean difference of 1.593, 95% CI [-3.03, -.16], p<.05. The main effect of time for inhibit showed that there was a statistically significant difference in inhibit scores between time points, F(2, 34)=28.40, p<.001. There was a decrease in the inhibit scores from pre-intervention to mid-intervention, as shown by a statistically significant mean decrease of 2.28, 95% CI [1.30, 3.26], p<.001, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 2.58, 95% CI [1.60, 3.56], p<.001. There was a decrease in the inhibit scores from mid-intervention to post-intervention, as shown by a mean decrease of .306, 95% CI [-1.33, .72], which was not statistically significant, p=1.00. For the self-monitor subscale, the main effect of treatment showed a statistically significant difference in self-monitor score between the treatment groups, F(1, 17)=6.12, p=.024. There was a difference in self-monitor scores between DBT and the control group, as shown by a statistically significant mean difference of 1.29, 95% CI [-2.40, -.19], p<.05. The main effect of time for self-monitor showed that there was a statistically significant difference in self-monitor scores between time points, F(2, 34)=17.09, p<.001. There was a decrease in the self-monitor scores from pre-intervention to mid-intervention, as shown by a statistically significant mean decrease of 1.72, 95% CI [.82, 2.63], p<.001, and pre-intervention to post-intervention, as shown by a statistically significant mean decrease of 2.08, 95% CI [.98, 3.18], p<.001. There was a decrease in the self-monitor scores from mid-intervention to post-intervention, as shown by a mean decrease of .361, 95% CI [-.66, 1.38], which was not statistically significant, p=1.00.

Discussion

The current study used a non-randomized control group design to examine the changes in perceived executive functioning among college students with the traits/presence of BPD undergoing internet-delivered DBT-ST that included the mindfulness and emotion regulation modules. BRIEF-A was administered to assess the changes in the self-report of executive functions. After the pre-intervention testing, DBT-ST was initiated for the treatment group, and behavioral activation was initiated for the control group. The length of both the interventions (DBT-ST and behavioral activation) was 13 weeks. Both the groups underwent mid-intervention testing after the 6th session (after 6 weeks). Both the groups completed post-intervention testing after the 13th session (after 13 weeks from the start of the intervention), which marked the end of the respective interventions. Compared to the control group, the DBT-ST group showed considerable improvements in 3 key domains of the self-report of executive functions, as evidenced by the significant 2-way interactions between treatment and time for the initiate, plan/organize, and organization of materials subscales of BRIEF-A.

The findings partially proved the hypothesis of the study, which stated that participants in the DBT-ST group would demonstrate a larger reduction in the self-report of executive functions across all subscales of BRIEF-A, from pre-intervention to post-intervention, than those in the control group. *Post hoc* analysis subsequent to the identification of the significant 2-way interactions between treatment and time, revealed that the DBT-ST group was unique only in demonstrating larger reductions in the initiate, plan/organize, and organization of materials scores from pre-intervention to mid-intervention, pre-intervention to post-intervention, and mid-intervention to post-intervention, while the control group showed no such reductions over time. Larger improvements for the DBT-ST group in the initiate, plan/organize, and organization of materials subscales are inferred by comparing the DBT-ST group's changes in the pre-mid-post intervention scores with those of the control group's changes in the pre-mid-post intervention scores. However, there were no significant differences between the DBT-ST group and the control group in the post-treatment phase across any of the dimensions of BRIEF-A. Even though the shift, emotional control, working memory, task monitor, and GEC subscale scores of BRIEF-A did not show any significant two-way interaction between treatment and time, significant main effects for time were found across the treatment and control group. This implies that both, the DBT-ST and the control group exhibited improvements in the shift, emotional control, working memory, task monitor, and GEC subscales of BRIEF-A, from pre-intervention to mid-intervention, pre-intervention to post-intervention, and mid-intervention to post-intervention. Significant main effects for treatment and time were found for the inhibit and self-monitor subscales, with no interaction effects.

DBT-ST had a significant effect on the perceived ability to initiate, compared to the control group, as indicated by the capacity to begin a task or activity and to independently generate ideas, responses, or problem-solving strategies (Roth *et al*., 2005). The perceived ability to plan/organize significantly improved in the group receiving DBT-ST compared to the control group, as indicated by the capacity to manage current and future-oriented task demands within a situational context. The plan component is concerned with the ability to anticipate events in the future, implement instructions, and develop appropriate steps ahead to carry out the task, which involves stringing together a series of actions or responses. The organize component is concerned with the ability to bring order to information, materials, or actions to achieve an objective (Roth *et al.*, 2005). DBT-ST also had a significant effect on the perceived ability to organize materials compared to the control group, as indicated by the capacity to organize the everyday environment with respect to the orderliness of work, living, and storage spaces, such as closets,

desks, and bedrooms. This domain is different from plan/organize, which primarily focuses on the cognitive task-oriented aspects of organization (Roth *et al*., 2005).

Initiate, plan/organize, and organization of materials subscales are dimensions under the metacognition index of BRIEF-A (Roth *et al*., 2005). Metacognition can be referred to as the knowledge and regulation of one's own cognitive processes (Jia *et al*., 2019). Hence, awareness and the ability to initiate, plan, and organize can be viewed as metacognitive skills. The DBT-ST group's distinctive improvements in these dimensions directly indicate that participants in the DBT-ST group had larger improvements in their abilities to problem-solve actively in a variety of contexts by cognitively managing attention (Roth *et al*., 2005). Studies in the past have suggested the possible interconnectedness between mindfulness and metacognition (Jankowski & Holas, 2014; Kudesia, 2019). Previous studies have also shown that mindfulness training can enhance metacognitive skills (Mitsea *et al*., 2022; Sanger & Dorjee, 2016). Along the same lines of these studies, the present study's findings, which highlighted DBT-ST's uniqueness in improving the 3 dimensions of the metacognition index (initiate, plan/organize, and organization of materials), suggest that the mindfulness and emotion-regulation modules of DBT-ST can be effective in improving certain domains of metacognitive functioning.

The participants of both DBT-ST group and behavioral activation group showed improvements in their abilities to shift (in the context of executive function), as indicated by their capacity to make transitions, problem-solve flexibly, switch or alternate attention, and change their mindset from one topic to another. The participants in both DBT-ST group and behavioral activation group showed improvements in emotional control, as indicated by the manifestation of executive functions within the emotional realm and the ability to modulate emotional responses. The participants of both DBT-ST group and behavioral activation group showed improvements in working memory, as indicated by the capacity to actively hold information in mind for the purpose of completing a task or generating a response. Participants in both the groups showed improvements in their ability to task monitor, which is concerned with the extent to which one keeps track of his or her own problem-solving success or failure. Both the groups also demonstrated lower scores in the GEC by the end of 13 weeks of treatment. GEC is a score that incorporates all the clinical subscales of BRIEF-A and can be viewed as an accurate reflection of executive dysfunction (Roth et al., 2005). The shift, emotional control, working memory, task monitor, and GEC subscales of BRIEF-A did not show any significant main effects for treatment.

The overall findings can be comparable to the study conducted by Halmoy *et al.* (2022), which showed that ADHD patients who completed 14 weeks of DBT-based group treatment had significant reductions in BRIEF-A, highlighting DBT's effectiveness in reducing executive dysfunction. The current study's findings also corroborate the research done by Smith *et al*. (2018), which demonstrated that adolescents receiving a comprehensive DBT intervention improved in emotional control, shifting, monitoring subscales, and GEC scores of BRIEF-SR. The findings of the current study are on similar lines as studies that previously tested the effects of DBT on cognitive functions among other populations, such as bipolar disorder (Afshari *et al*., 2019) and generalized anxiety disorder (Afshari *et al*., 2022) which showed commendable improvements in executive functions. The current study's findings also align with the studies conducted by Soler *et al.* (2012) and Soler *et al.* (2016), which showed that the DBT mindfulness module greatly impacts executive functions that include attention, tolerance for delayed rewards, time perception, and impulsivity variables.

Contrasting to the current study, Zargar *et al.* (2019) showed that when DBT and routine medications were provided to patients with type 1 bipolar disorder, the executive functions of these patients did not significantly differ from the control group (no treatment other than routine medications) during the post-intervention period, and only a modest and non-significant change was observed. It is critical to note that this study was conducted with patients diagnosed with bipolar 1 disorder who were under the influence of psychiatric medications, and the mechanisms of change in this population are drastically different from those of the current study's population. Another study by Secrist (2014) on individuals with BPD reported results conflicting with the current study, which showed only slight improvements across all of the executive functioning ratings (figural fluency, verbal fluency, inhibition) following one year of DBT. The author of this study reported Type I and II errors resulting from running several analyses on a moderately sized sample. In the current study, the occurrence of such errors was minimized by developing a methodologically sound research design. Moreover, both studies (Secrist, 2014; Zargar *et al*., 2019) used standard neuropsychological testing as measures of executive functions, while the current study used a self-report of executive functions, and hence, these studies should be compared to the current study with caution.

Previous studies have showcased the general effectiveness of DBT as a transdiagnostic treatment and demonstrated improvements in cognitive functions. These cognitive changes have been measured through neuropsychological tests, self-report measures, and neuroimaging techniques (Vijayapriya & Tamarana, 2023). Some of the previous studies have used standard neuropsychological measures to assess the improvements in cognitive functions following DBT. Soler *et al*. (2012) used Conners' Continuous Performance Test-2 to show that BPD participants undergoing the DBT mindfulness module demonstrated significant improvements in commissions, hit reaction time, and detectability scores, as well as on the composite scores of inattention and impulsivity, compared to BPD participants who only received general psychiatric management. Soler *et al*. (2016) used Conners' Continuous Performance Test-2 for assessing response inhibition, the 2-Choice Impulsivity Paradigm and Single Key Impulsivity Paradigm for assessing tolerance for delayed awards, and the Time Paradigm Test for assessing time estimation. This study found that BPD participants undergoing the DBT mindfulness module improved their abilities to delay their gratification and demonstrated changes in time perception, which was also consistent with a decrease in impulsivity. The study conducted by Fleming *et al.* (2015) used Conners' Continuous Performance Test-2 to show that ADHD patients receiving DBT group skills training demonstrated greater treatment response rates and clinical recovery rates on executive functions. Afshari *et al.* (2019) reported that patients with bipolar disorder showed significant improvements in planning, problem-solving, and cognitive flexibility following DBT, as assessed using the Tower of London and Wisconsin Card Sorting tests. To add further, Abdolghaddri *et al*. (2019) used the Wechsler Memory Scale and Computerized Complex Stroop Test to show DBT's effectiveness in improving the memory and attention of patients with multiple sclerosis.

The current study's findings obtained through a self-report measure (BRIEF-A), follow a similar trajectory as another study conducted by Smith et al. (2018), which also used a self-report measure (BRIEF-SR) to show that adolescents with emotional

dysregulation receiving DBT demonstrated improvements in the emotional control, shifting, monitoring, and GEC subscales of BRIEF-SR. The findings of the study done by Halmoy et al. (2022) on patients with ADHD also correspond with the findings of the present study, which is apparent in the way that both studies demonstrated significant reductions in the BRIEF scores following DBT. The findings of the current study suggest improvements in executive functioning following internet-delivered DBT-ST sessions, based on data obtained through a self-report measure. However, self-report measures can only offer subsidiary supporting evidence for the effectiveness of DBT-ST and cannot serve as a fundamental verification or provide a principal substantiation for the true effectiveness of DBT-ST on executive functioning. While BRIEF-A is a self-report clinical scale that allows for the examination and interpretation of executive functioning in a daily life setting (Roth *et al.*, 2005), standard neuropsychological tests use objective performance-based methods to assess cognitive functioning and can be more useful for collecting diagnostic information, differential diagnostic information, assessment of treatment response, and prediction of functional potential and functional recovery (Harvey, 2012). Hence, the present study's findings can only function as a corollary to the evidence of improvement in executive functions as assessed using objective neuropsychological measures.

As evidenced by the current study's significant interaction effects, it was found that DBT was unique in improving the abilities to initiate, plan, and organize current and future-oriented task demands and to organize everyday environment among college students with the traits/presence of BPD. The core techniques used in DBT-ST, based on mindfulness and emotion regulation, may have specifically targeted these dimensions of executive functioning. The principle of mindfulness grounds a person to the present in such a way that this orientation seeks to place focus on the task at hand. The healthy balance, or middle path, brought out by the concept of a wise mind decreases the tendency for a person to become overwhelmed by emotions, especially in situations that have pressing cognitive demands. The "participate" skill from the WHAT skills can possibly enhance the ability to initiate and engage in activities. The "one-mindfully" and "effectively" skills from the HOW skills aim at doing one task at a time and effectively doing what works best to achieve a goal. These skills can improve one's cognitive capacity to perform tasks, especially those related to planning and organizing. Emotion regulation skills can help a person become less vulnerable to emotion mind, thereby making them cognitively more efficient. Awareness of the myths and healthy perspectives of emotions can bring about more effective ways to handle overwhelming emotions. Changing emotional responses by checking facts, opposite action, and problem-solving, as well as the ABC PLEASE skills, can provide practical ways to apply emotion regulation skills, which can further enhance the operation of executive functions. Overall, the "dialectical" philosophy increases the likelihood of more balanced and integrated responses "to the moment" that can aid adept cognitive functioning. As evidenced by the significant main effects for time, it was found that both, the DBT-ST group and the behavioral activation group improved their capacities for emotional control, working memory, shifting, and task monitoring. Although a number of factors may contribute to this improvement, which is discussed later, the behavioral activation treatment by itself may have played a part in improving executive functions. Identification of goals and values, setting up of an activity schedule, and a switch to a healthy lifestyle can possibly structure a person's life in such a way that enhances these aspects of executive functioning. Moreover, the dimensions in which the DBT-ST group showed unique improvements (initiate, plan/organize, and organization of materials) belong to the metacognition index of the BRIEF-A. Two of the dimensions in which both groups showed improvements (shift and emotional control) belong to the behavioral regulation index of BRIEF-A. This indicates that while both groups showed improvements in their abilities to maintain appropriate regulatory control of their behaviors and emotional responses, the DBT-ST group showed larger improvements than the control group in their abilities to cognitively manage attention and problem-solve following treatment (Roth *et al*., 2005).

Strengths and limitations

The current study has several strengths, as evidenced by important factors that enhanced the internal and external validity of the findings. Firstly, the study did not deviate from the intended interventions, and there were no non-protocol interventions (such as psychiatric medications or adjunct psychotherapy) that were provided for the intervention or the control group. Hence, the findings can be attributed solely to the effects of the psychotherapy that was carried out in both groups. In the current study, non-specific factors of psychotherapy, such as therapeutic alliance and the therapist's competence (Chatoor & Krupnick, 2001), may have been potential confounding variables had they not been proactively controlled. Such therapist-related variables were prospectively held constant (Gravetter & Forzano, 2015) by having the same treatment provider carry out the therapy sessions for both the intervention and the control group. Uniform environmental variables were also assured by having identical and standardized testing procedures as well as online therapy set-ups for both the intervention group and the control group. Both groups had weekly sessions, ensuring that the frequency of the sessions was also uniform across both conditions. Although the study may have been subject to assignment bias due to the non-randomized assignment of participants to both groups, both the groups were homogenous and equivalent, as shown by their pre-treatment compatibility of demographic, clinical, and outcome variables. Both the groups had participants with similar characteristics, with no significant individual differences at the pre-treatment level.

This study included college students with borderline personality traits as well as BPD. Since the sample consisted of college students with varying levels of BPD symptom severity, the study can be generalized to all college students with both borderline personality traits and BPD. Despite the homogeneity in the sample, the current study consisted of participants across a diverse and wide demographic (with respect to participants coming from different cities, colleges, and cultural backgrounds). Hence, the findings can also be extended to other college students with traits/presence of BPD, coming from diverse backgrounds. Since DBT-ST (mindfulness and emotion regulation) was carried out as a standalone treatment for the intervention group, the findings are free from bias related to multiple treatment interference and can be generalized to other procedures using DBT-ST (mindfulness and emotion regulation) as a standalone treatment. Some features of the study contributed to the statistical validity of the results. The findings of the current study are based on sound statistical analyses that found no univariate or multivariate outliers in the data. Only a small but required number of statistical tests were run on the data, which substantially reduced the type 1 error.

Despite its strengths, the current study is not devoid of limitations. The study used a non-randomized method to assign participants to the intervention and the control group. Participants in

the DBT-ST group were first recruited with the help of posters that provided details about the nature of this intervention. Following this, participants in the behavioral activation group were then recruited with the help of posters that provided details about the nature of this intervention. Participants and the treatment provider were neither blinded to the allotted groups nor were they blinded to the assigned intervention. These factors may have contributed to bias related to randomization and bias related to participants' expectations from therapy based on their awareness of the nature of the therapy. Generally, in interventions such as the DBT, which heavily focuses on the understanding of the concept of dialectics, it is not customary to blind the treatment providers or participants about the nature of the therapy, and hence, a certain amount of such bias related to the non-blinding of participants is inevitable. While the inclusion of individuals with borderline personality traits, as well as BPD in the sample, can be a strength in terms of the study's generalizability, it can also be a limitation in terms of lack of homogeneity, as evidenced by the variations in severity across BPD symptomatology, which can threaten the internal validity of the study. Another limitation is that the psychological testing and psychotherapy were carried out by the same clinical psychologist. This may have led to a certain amount of latent bias related to the treatment/testing procedure. However, taking into account that all the test protocols were only scored after the termination of therapy sessions for all participants, especially using a very objective scoring method, there is a possibility that this bias may have been minimized. The DBT-ST protocol used in this study excluded the interpersonal effectiveness and distress tolerance modules, which can question the overall treatment integrity of DBT-ST, that originally intends to incorporate all the 4 DBT-ST modules. Moreover, the effectiveness of any intervention can only be estimated with certainty through the comparison of the pre-mid-post intervention scores and the comparison of the post-intervention scores between all the groups involved (between-group differences). However, in the current study, there were no significant differences between the DBT-ST group and the control group at the post-treatment phase across any of the dimensions of BRIEF-A. Another important limitation can be pointed out as the low sample size, which may have increased the type 2 error.

The intervention group and the control group demonstrated improvements across all the BRIEF-A subscales except initiate, plan/organize and organization of materials. These statistically significant findings can be partially attributed to therapist factors, considering that the same therapist carried out interventions for both groups. On the other hand, though the standards of testing and treatment administration were uniform across both groups, each session of DBT-ST was conducted on a one-on-one basis for the intervention group, whereas the control group primarily attended the therapy sessions through pre-recorded therapy videos as well as only three one-on-one sessions with the psychotherapist, and weekly phone consultations with a postgraduate psychology trainee. Hence, it may have been possible that the DBT-ST group had a stronger therapeutic alliance with the therapist than the behavioral activation group, which may have partially influenced the slightly larger improvements in executive functions among the DBT-ST group. Apart from the possible effects of the respective treatments, there could be other reasons for the control treatment effects. The participants of this study were volunteers who were highly enthusiastic about taking part in the psychotherapy sessions and thus engaged actively in their efforts to show improvements. The influence of such expectancy effects may have also contributed to the significant findings. Some of these effects may also be ascribed to the Hawthrone effect, test-retest effects, and the reactivity of measurement bias. Measurement issues may have also caused significant improvements across both groups. Regression to the mean effect may have drifted the post-test scores toward the mean of the distribution of scores (Becker *et al*., 2003). These issues can reduce the internal validity of the study findings.

A nonprobability sampling procedure using web-based social media platforms was used to recruit participants into the study, which may have led to a possible selection bias that could question the accuracy of whether the participants truly represented the population. Only college students between the ages of 18 and 25 with the traits/presence of BPD were included in the study, and the sample largely consisted of females. This restricted the range of participants, and hence, the findings may not be generalizable to individuals with the traits/presence of BPD outside the applied age and gender demographics. It may also not be generalizable to individuals with other gender identities except for cisgendered males and females. Though the efficacy of DBT has been studied across several disorders, the findings of the current study may also not be generalizable to individuals with other physical or psychiatric diagnoses other than BPD. The findings of the current study cannot be generalized to objective measures of neuropsychological testing as the current study used a self-report measure of executive functions. An accurate performance-based neuropsychological profile cannot be drawn based on self-reported measures. Typically, an objective measurement of executive functions is essential in order to validate a treatment as effective, and hence future studies can focus on using neuropsychological measures alongside self-reported measures to assess executive functions. The findings also cannot be generalized to other modes of DBT apart from DBT-ST (mindfulness and emotion regulation modules). The current study did not use a follow-up measure. Therefore, the study findings cannot be generalized to a future period in terms of the maintenance of improvement due to the uncertainty of DBT-ST's effectiveness increasing or decreasing with time. These factors may reduce the external validity of the study.

Lastly, this research did not include a waitlist or a treatment-as-usual group due to feasibility issues. Taking into consideration that the current study is an effectiveness study, treatment-as-usual or traditional treatment is the ideal standard against which an intervention should be evaluated, given that effectiveness studies focus on the benefits that arise as a result of undergoing the intervention in real-world settings (Green *et al*., 2019). Previous studies have shown that the components of treatment-as-usual for BPD can be heterogeneous, which include combinations of individual therapy, group therapy, psychopharmacological treatment, and hospitalizations (Finch *et al*., 2019). However, treatment-as-usual is commonly used in psychotherapy research to refer to psychotherapies conducted outside a research context (Halvorsen *et al*., 2017). Effectiveness studies expect that the contrast for a treatment group should be normal standard of care (Green *et al.*, 2019).

Conclusions

This study is the first of its kind to investigate the effectiveness of internet-delivered DBT-ST in improving the perceived executive functions of college students with the traits/presence of BPD, using a non-randomized controlled trial design. The main findings of the study show that DBT-ST was unique in improving participants' abilities to initiate, plan, and organize current and future-oriented task demands and to organize their everyday environment. Improved capacity to initiate may have enhanced the

planning and organizing of task demands as well as the everyday environment. Goal-oriented achievements arising from such an organizational capacity may have further encouraged and motivated the DBT-ST participants to initiate activities. Both DBT-ST and behavioral activation were found to be effective in improving participants' abilities to shift and task monitor. Both therapies were also effective in improving participants' emotional control and working memory.

Implications

The current study showed that the mindfulness and emotion regulation modules of DBT-ST considerably improve different facets of executive functions among college students with the traits/presence of BPD. In view of the extent to which college students with traits/presence of BPD suffer from deficits in executive functions, the current study sets the tone for using DBT-ST as an appropriate form of psychotherapy to improve executive functions among this population. Clinicians can use DBT-ST either as a standalone treatment or in combination with another form of treatment to possibly improve the executive functions of patients. Out of all the favorable outcomes derived from DBT, improvement in executive functions adds another jewel to the crown. Also, the internet-delivered version of DBT-ST is adequately feasible to produce favorable outcomes with respect to executive functions. Although the non-specific factors of therapy were controlled for to a certain extent, the study cannot completely rule out the effect of therapist factors such as therapeutic alliance, therapist empathy, positive regard, genuineness, and client expectations in fostering improvements among both, the DBT-ST group and the behavioral activation group.

Future directions

The current study examined the effects of only the mindfulness and emotion regulation modules of DBT-ST on executive functions. It would be worthwhile to also examine the combined effects of all the DBT-ST modules by including the interpersonal effectiveness and distress tolerance modules on similar outcome measures. Future studies can replicate the findings of the current study in other countries using different measures, different modes of administration, and different therapists, which can help generalize the findings of the current study. A follow-up measure would also help in generalizing findings to a future time period in terms of the maintenance of improvement. Future studies can use objective measures of assessing executive functions to study the changes in executive functions. Standard neuropsychological tests would provide a richer and more objective profile of the executive functions. Using additional measures to assess the changes in prototypical BPD symptoms such as emotional dysregulation, feelings of emptiness, impulsivity, *etc*. following DBT-ST would have significant implications for clinical practice. Even though metacognition was not the primary variable of interest in the current study, the present study's findings highlighted DBT-ST's uniqueness in improving 3 dimensions of the metacognition index (initiate, plan/organize and organization of materials) of BRIEF-A, which sets the stage to further investigate the effectiveness of DBT-ST on metacognitive functioning. Future studies can also compare the DBT-ST group against a treatment-as-usual/waitlist/traditional treatment group, since this broadly accepted convention can produce a common control group across studies, against which all interventions are compared. This can also pave the way for metanalytic studies in the future (Green *et al*., 2019). Future studies can adopt research designs using mediation analysis to investigate if emotion regulation plays the role of a mediator variable in bringing out improvements in executive functions as a result of DBT-ST. Future studies can additionally use probability sampling methods for recruiting participants and employ randomized controlled trial designs that could possibly elevate the quality of the research.

Researchers can further investigate ways in which the inevitable Hawthrone effect, test-retest effects, reactivity of measurement bias, measurement issues, volunteer bias, expectancy effects, and novelty effects can be eliminated. The Hawthrone effect can possibly be overcome by first and foremost foreseeing that it exists in every study and then designing the study with its effect in mind. Another way to reduce this effect is to use participants who are unaware of being studied (Ayanyemi, 2022). However, this can lead to ethical controversies. To deal with test-retest effects, future studies can also utilize a Solomon 4-group design, to avoid the influence of pretesting on subsequent post-test results (Braver & Braver, 1988). Some of the ways in which the reactivity of measurement bias can be minimized are as follows: i) identifying whether such bias is likely to be a problem in the study; ii) deciding whether to collect further data to decide whether this bias is likely to be a problem for a particular study; and iii) designing studies to minimize the likelihood of bias from measurement reactivity (French *et al*., 2021). Volunteer bias may be overcome by aiming for a larger sample or by adopting random sampling methods to ensure that the sample is more representative of the population (Ayanyemi, 2021). Expectancy effects may be minimized by employing a double-blind design in which neither the participants nor the experimenters are aware of the assigned groups (The Decision Lab). Novelty effects may possibly be overcome by having longer durations for intervention (Shin *et al*., 2018) or testing procedures.

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