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Emotional Working Memory Training Treatment for Young Adult Problem Online Sports Bettors: A Preliminary Randomized Controlled Trial

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Abstract

One of the key features of gambling disorder (GD) is impairment in cognitive-emotional control. Considering the negative consequences of GD, the present study investigated the effectiveness of emotional working memory training (eWMT) in improving cognitive control, attention, working memory capacity, and cognitive emotion regulation strategies (CERS) among young adults with GD compared to a placebo group. Following the initial assessment in the pre-test phase, eligible participants were randomly assigned to one of two groups: experimental ($n=34$) and placebo ($n=30$). These groups completed eWMT and a feature matching task for 20 sessions respectively. The post-test and follow-up measures indicated that eWMT significantly improved cognitive control, attention, working memory capacity, and the use of maladaptive cognitive emotion regulation strategies, but it had no significant effect on adaptive CERS. The promising results of the present study suggest the use of eWMT as a new intervention to improve cognitive-emotional control among individuals with online gambling problems.

Keywords Online gambling · Cognitive control · Cognitive emotion regulation strategies · Emotional working memory training · Human computer interactions

Introduction

Theoretical background

Gambling disorder (GD) is characterized by compulsivity, loss of control, and persistence despite negative effects (American Psychiatric Association, 2013, Clark, 2014). Previously classified as an impulse control disorder in the DSM-III (American Psychiatric Association [APA], 1980) and DSM-IV (APA, 1994), GD is now recognized as a behavioural addiction in the DSM-5 (APA, 2023). It also shares neurobiological similarities with substance use disorders (García-Castro et al., 2023; Limbrick-Oldfield et al., 2017). Online gambling refers to gambling through internet-connected digital devices (Lelonek-Kuleta & Bartczuk, 2021). In recent years, the increasing accessibility of the internet has led to the increase in online gambling, also known as e-gambling (Lelonek-Kuleta & Bartczuk, 2021). Online gambling markets have proliferated including casino

games, poker, and sports betting, with sports betting gaining popularity among young men with higher incomes and education (Lee et al., 2011; Leng et al., 2022; Newall, 2023).

A number of factors contribute to the increasing popularity of online compared to other forms of gambling. These include the ease of access to the internet, which provides convenient access to gambling sites (Lang et al., 2022); the widespread marketing of online gambling in online spaces; and the structural features of online games, which increase the likelihood of developing conditioned responses to gambling stimuli by continuously exposing online users to gambling (Davoudi et al., 2022; McCormack & Griffiths, 2013; McCormack et al., 2014). Other reasons for the popularity of online gambling include ease of use, social acceptance, speed, better regulation of operations, and the attractiveness and structure of the games (McCormack & Griffiths, 2013; Davoudi et al., 2022). While gambling is a safe recreation for most individuals, the possible consequences of disordered gambling can cause financial, relationship, health and educational problems (Brown et al., 2017; Cameron & Ride, 2023). Estimates suggest that problematic gambling ranges from 0.7% to 6.5% globally (Calado & Griffiths, 2016; Guillou-Landreat et al., 2021).

Research on the development and maintenance of behavioural addiction highlights an imbalance between limbic/reward pathways and prefrontal control functions (PFCs) as the underlying mechanism (Brand et al., 2019). PFCs plays a critical role in behavioural addictions (Brand et al., 2016; Han et al.,2011), with the dorsolateral sector and anterior cingulate cortex associated with 'cold' cognitive processes such as working memory, response inhibition, task switching and attention (Badre & D'esposito,2009; Gläscher et al., 2012; Yan et al., 2014), while the ventral and medial sectors are more associated with reward and emotion-related functions, including valuation, emotion regulation, and decision-making (Gläscher et al., 2012; Peters, & Büchel, 2010; Rangel et al., 2008; Yan et al., 2014). The ventromedial/orbital frontal cortex is crucial for decision-making based on emotions or values in complex situations involving both positive and negative emotional outcomes (Bechara et al., 2000; Yan et al., 2014). Understanding the interplay between these functions in GD is essential for identifying effective interventions.

Online gambling and cognitive control

Reduced cognitive control is an important factor associated with the tendency to engage in gambling activities (APA, 2013). Cognitive control involves sub-processes such as impulsivity, response inhibition, and risky decision-making (Moccia et al., 2013; Morton et al., 2011; Sharif-Razi et al., 2019). Impulsivity and poor response inhibition play a crucial role in addictive behaviours, including GD (Adinoff et al., 2007; Goudriaan et al., 2008). Studies on disordered gamblers using the go/no-go task suggest defective inhibitory control (Lee et al., 2012; Mallorquí-Bagué et al., 2018). The opposite of response inhibition is impulsive response, or 'disinhibition' which occurs when individuals react quickly without considering consequences (Aron, 2007; Emadi Chashmi et al., 2023; Wegmann et al., 2020). Deficits in response inhibition and high impulsivity increase gambling participation and unsuccessful attempts to stop gambling (Brevers & Noël, 2013; Hodgins & Holub, 2015).

Risky decision-making involves favouring specific choices based on possible outcomes (Koechlin & Summerfield, 2007; Moccia et al., 2017). Individuals with GD engage in risk-taking processes for immediate gratification, disregarding long-term consequences (Brevers et al., 2013; Schluter

& Hodgins, 2021). Cognitive control involves different prefrontal areas, including the ventrolateral prefrontal cortex (VLPFC), anterior cingulate cortex (ACC), supplementary motor area (pre-SMA), dorsolateral prefrontal cortex (DLPFC), and inferior parietal cortex (Rubia et al., 2001; Moccia et al., 2017). Impairment of the DLPFC has been reported among individuals with GD (Moccia et al., 2017; Ngetich et al., 2023). Interventions targeting this brain network can reduce cognitive control deficits in GD.

Online gambling, attention and working memory

Attention involves prioritizing relevant information and disregarding irrelevant information (Corbetta & Shulman, 2002; Knudsen, 2007). GD is associated with attention deficits (Frodl, 2010; Park et al., 2011; Stark et al., 2011 Theule et al., 2019). Potenza (2008) noted that altered dopamine activity during chronic gambling can lead to desensitization and impaired cognitive performance, which can impair the performance of problem gamblers on a continuous performance task. Other studies also suggest that high levels of impulsivity among gambling addicts may lead to more errors on the Continuous Performance Test (CPT) because they tend to lose concentration or respond to stimuli too quickly (Leeman & Potenza, 2012). From a neurological perspective, sustained attention is maintained by distributed neural circuits, including the right frontal parietal areas (Grant et al., 2015), and disordered gambling can lead to structural and functional changes in these areas. These changes may impair the ability to effectively engage in tasks such as CPT, which rely heavily on sustained attention and cognitive control (Knutson & Greer, 2008).

Some studies suggest that individuals with GD exhibit diminished working memory capacity, which is crucial for the temporary storage and manipulation of information in the domains of behavioural regulation, problem-solving, and decision-making (Leiserson & Pihl, 2007; McClernon et al., 2016; Zhou et al., 2016). Attentional deficits lead to irrelevant gambling-related information being stored in working memory instead of focusing on current tasks (Kubler et al, 2005; Ngetich et al., 2023; Hoven et al.,2023). Those with working memory (WM) deficits, particularly in the posterior dorsolateral prefrontal cortex (DLPFC), experience difficulties in maintaining and shifting between goals in an effective manner. This difficulty results in the manifestation of disorganised and perseverative behaviours, such as the pursuit of losses in gambling scenarios (Leiserson & Pihl, 2007). Consequently, deficit in WM capacity may be a predisposing factor in the engagement of individuals with GD (Brevers, et al., 2014).

Online gambling and cognitive emotion regulation

Individuals with GD also experience serious emotional distress (Mallorquí-Bagué et al., 2018; Wong et al., 2013). Emotion regulation encompasses various strategies, with cognitive emotion regulation being a common approach that focuses on controlling emotionally triggering information (Garnefski & Karaij, 2001). Individuals with GD often struggle with emotion regulation and employ ineffective strategies such as rumination, suppression, and avoidance (Emadi Chashmi et al., 2023; Marchica et al., 2019). Research has also indicated a strong association between emotion regulation strategies and working memory capacity, where higher working memory capacity has been associated with better management of negative emotions through adaptive strategies such as reappraisal (Pan et al., 2022; Pe et al., 2013; Schmeichel et al., 2008). This association arises from the shared brain regions responsible for emotion regulation and working memory, primarily situated in the dorsolateral frontal lobe (Etkin et al., 2015; Pan et al., 2022).

This overlapping neural circuitry indicates that enhanced working memory may facilitate better emotional control (Lee et al., 2018; Pan et al., 2022). Among people with higher working memory capacity, information can be retained and manipulated, which is necessary for the implementation of complex emotional strategies such as reappraisal (Joormann & Gotlib, 2008). This increases the ability to assess situations more effectively and use adaptive strategies, thereby improving emotional outcomes (Joormann & Stanton, 2016; Schmeichel, 2007). Deficits in cognitive control can also lead to problems in handling and processing new information, preventing the use of more adaptive strategies (Joormann, 2010). Individuals with emotion regulation deficits resort to activities that provide immediate pleasure to cope with negative emotions (Emadi Chashmi et al., 2023). Difficulties in regulating emotions, particularly adverse and distressing feelings, contribute to the increased vulnerability to developing and perpetuating addictive behaviours (Marchica et al., 2019).

Emotional working memory training

Existing interventions for GD, including pharmacological interventions (Dowling et al., 2022), self-help manuals (Campos et al, 2016), motivational interviewing (Josephson et al., 2016), virtual reality (Bouchard et al., 2017), and cognitive behavioural therapy (Ede et al., 2020), vary in effectiveness, duration of therapeutic effects, and rates of treatment dropout, relapse, and non-compliance (Challet-Bouju et al., 2017; Eriksen et al., 2023; Merkouris et al., 2016). The limited effectiveness of existing GD treatments can be attributed to cognitive-emotional control (Challet-Bouju et al., 2017; Merkouris et al., 2016). Some studies have investigated working memory training to reduce GD symptom severity because WM capacity is crucial for other cognitive functions as well as emotion regulation, and improving working memory capacity is expected to improve these components (Kim et al., 2021; Melby-Lervåg & Hulme, 2013; Pan et al., 2022).

However, the impact of working memory training (WMT) on emotional performance remains inconclusive (Leone et al., 2016). While some studies suggest positive effects of WMT on emotional dimensions (Sari et al., 2016), others contradict this claim (Schweizer et al., 2011; Wanmaker et al., 2015;).To address this, Schweizer et al. (2011) introduced emotional WMT, which incorporates emotional stimuli, such as facial expressions and emotional words, into WMT. The aim of eWMT is to facilitate greater mental control over emotional stimuli, including negative thoughts and the emotions. It has been demonstrated that emotional stimuli are more effective at capturing attention than neutral stimuli. This is due to the fact that emotional stimuli are processed more deeply and are more likely to be remembered (Dolcos et al., 2004, 2011). Consequently, when the conventional approach to working memory training is integrated with emotional stimuli, it presents participants with more demanding tasks, necessitating the regulation of emotions while maintaining cognitive control (Schweizer et al., 2011, 2013). The emotional stimuli employed in eWMT are designed to closely resemble the types of emotional challenges that individuals typically encounter in their daily lives. Therefore, the incorporation of emotional stimuli into the WMT enhances the probability that individuals will be able to effectively transfer their emotion regulation abilities to real-world contexts. (Schweizer et al., 2011; 2013; Du Toit et al., 2020).

The present study

This study represents the first investigation into the effects of eWMT on cognitive-emotional control in GD. Neuroimaging studies of GD suggest dysfunction in prefrontal cortex regions like

DLPFC, ACC, and OFC (Moccia et al., 2017; Ngetich et al., 2023). Deficits are also observed in the striatum, nucleus accumbens, ventral tegmental area, inferior frontal gyrus, and dorsal anterior cingulate cortex (Luquiens et al., 2019; Zilverstand et al., 2016). Therefore, strategies that restore normal functioning of these areas and improve cognitive and emotional control may be beneficial, given their key role in cognitive and emotional control in GD and the brain's plasticity (Takeuchi et al., 2017).

In the present study, eWMT was employed to improve the activity of these brain areas. Previous studies indicate that eWMT can change the functional brain network (Jolles et al., 2013; Langer et al., 2013; Pan et al., 2020; Takeuchi et al., 2013). Regular eWMT sessions can improve frontoparietal neural circuits involved in cognitive-emotional control, including dorsolateral prefrontal cortex (PFC), inferior parietal, and anterior cingulate cortex (Banich et al., 2009; Schweizer et al., 2013). These circuits are crucial for cognitive functions and emotion regulation. They involve the amygdala and midbrain nuclei from lateral and medial PFC components, including the anterior dorsal and subgenual cingulate (sgACC) (Etkin et al., 2011; Ochsner & Gross, 2005; Schweizer et al., 2013; Wager et al., 2008).

Cognitive neuroscience advances suggest that targeted computer training can improve emotional cognitive control in psychiatric disorders, including behavioural addictions, with fewer human and financial resources than existing interventions for GD (Emadi Chashmi et al., 2023; Shahrajabian et al., 2023). The anonymity and low cost of online interventions make them appealing for treating GD. To date, no previous research has investigated the potential of eWMT in GD intervention. Therefore, the present study is the first to investigate the effects of eWMT on cognitive-emotional control in GD. Compared to placebo intervention, it was hypothesized that eWMT would (i) decrease maladaptive cognitive emotion regulation strategies (MCERS) (H_1), (ii) increase adaptive strategies (ACERS) (H_2), (iii) decrease impulsivity (H_3), (iv) decrease risky decision-making (H_4), (v) improve response inhibition (H_5), (vi) improve attention (H_6), and (vii) improve working memory (H_7).

Methods

Participants and design

The present study was approved by Kharazmi University's ethics committee. The study's inclusion criteria required participants to be aged between 18 and 26 years, fluent in Farsi, willing to participate in research, have at least 12 months of experience in sports gambling sites, and meet the diagnostic criteria for GD as outlined in the DSM-5. Exclusion criteria included a diagnosis of any mental health disorder other than GD by a clinical psychologist. The sampling method used was non-random convenience sampling.

Participants were randomly assigned to one of two conditions: the intervention group (eWMT) or the control group (placebo). On the basis of the effect size (0.25), α (0.01), power (0.95), number of groups (n=2), number of measurements (n=3), and statistical test (mixed design ANOVA), the appropriate sample size for the trial was estimated using *G∗Power* software (Faul et al., 2009) to be 58 participants. However, 70 participants were recruited due to the possibility of participant attrition. Because of dropout, the final sample size was 64 participants, 34 in the intervention group and 30 in the placebo group. Demographic characteristics of the groups and total sample are shown in Table 1. There were no significant age and sex differences between the two groups. Finally, it

is important to note that the trial was randomized and single-blind, which means that only the research team was aware of the difference between the participating groups, not the participants themselves.

Table 1. Demographic characteristics of the two study groups

Variable		Intervention group (n=34)	Placebo group (n=30)	t/χ	p
Age (M, SD)		20.47 (1.73)	20.63 (1.56)	0.39	0.70
Sex (n, %)	Male	20 (58.8)	20 (66.7)	0.42	0.35
	Female	14 (41.2)	10 (33.3)		
	Diploma	2 (5.88)	3 (10.00)		
Education (n, %)	Bachelor	27 (79.41)	22 (73.3)	0.46	0.79
	Master's	5 (14.70)	5 (16.7)		
Marital status (n, %)	Married	6 (16.7)	6 (11.1)	0.81	0.53
	Single	28 (83.3)	24 (88.9)		

Procedure

Step 1 (Participant recruitment and screening). In the first step, an advertisement was designed to invite individuals to participate in the research. The advertisement clearly stated that eligible participants would receive a gift in the form of a mobile phone SIM card. Social media pages were used that focused on sports events that indirectly advertised betting sites, due to the illegality of gambling in Iran. The average number of followers on these pages was approximately 10,000. Participants were assured that their data would be treated confidentially and that they could participate anonymously. To enhance communication with applicants, the advertisement provided contact information including a telephone number, *Telegram* ID, and *Instagram* ID of the clinical psychologist carrying out the initial interview. Following this, all research volunteers underwent a diagnostic interview with a clinical psychologist to determine if they met the criteria for gambling disorder in the DSM-5. The interview was conducted using *Google Meet,* allowing participants to turn off their cameras if desired. Those who met the criteria proceeded to the next stage of study.

Step 2 (Pre-test). Following the initial diagnosis of GD in the first stage, the participants were randomly assigned to either the training group or the placebo group. All the participants responded to the psychometric scales and tasks described below.

Step 3 (Experimental design). During the third step, the treatment group was engaged in regular eWMT exercises, with each session lasting between 30 and 45 minutes. The placebo group performed shape matching tasks for 20 sessions (three sessions per week). The training programs were installed on the participants' personal computers, and the research team monitored each session through the AnyDesk software to ensure correct and regular implementation. Some participants were removed due to irregular attendance in the training sessions by the end of the 20 sessions. Additionally, some participants chose not to continue the sessions due to the negative connotations of specific words in the eWMT, despite being informed of the safety of the content (Figure 1).

Step 4 (Post-test). In the fourth step, after completing the training sessions, participants completed the measurement instruments again to assess changes in the functions.

Step 5 (Follow-up). During the follow-up phase, participants were encouraged to undertake a third set of measures three months later.

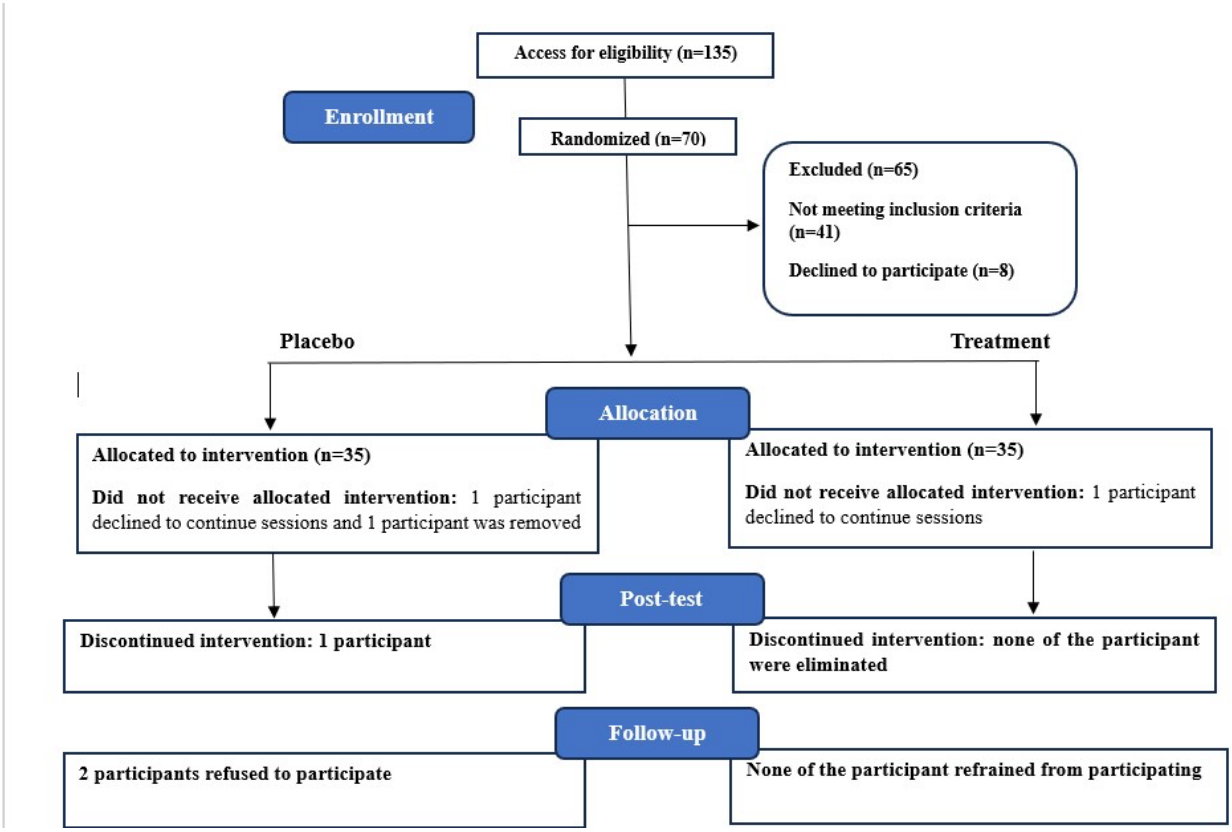

Figure 1. Consort flow diagrams of study development

eWMT Intervention. The eWMT intervention included a dual n-back task derived from Schweizer et al. (2011). This task aimed to enhance active memory by requiring participants to remember the location of a square on a screen and the corresponding alphabet letter heard through headphones simultaneously. Stimuli were presented randomly, either individually or simultaneously. Participants were asked to press the letter 'L' on the keyboard if the visual stimulus had previously been presented to them and the letter 'A' if the auditory stimulus had previously been presented to them, and to press both 'A' and 'L' simultaneously if both stimuli had previously been presented. The procedure involved the presentation of a face (500ms on a 4x4 grid on a computer screen) and a word (500ms over headphones). Following each picture-word item, participants had a 250 ms pause to identify whether one or both of the items matched those displayed n trials earlier (where n is a variable number), and they indicated their response by pressing a key. Two-thirds of the words and faces were negative, such as 'death', 'rape', 'anger', 'fear', or 'sorrow', while the remainder were neutral, such as 'desk' and 'glass'. One visual and one auditory item (n=1) was presented at the starting point of training. Participants who accurately recognized 60% or more of the items were advanced to the next level, whereas those with less than 20% accuracy were demoted. During the training, audio and visual feedback were provided. Incorrect responses to auditory stimuli were accompanied by an unpleasant sound, while correct responses elicited a pleasant sound. Similarly, a green happy emoji appeared when participants responded correctly to

the visual stimuli, whereas a red sad emoji appeared for incorrect responses. An outline of the process is presented in Figure 2.

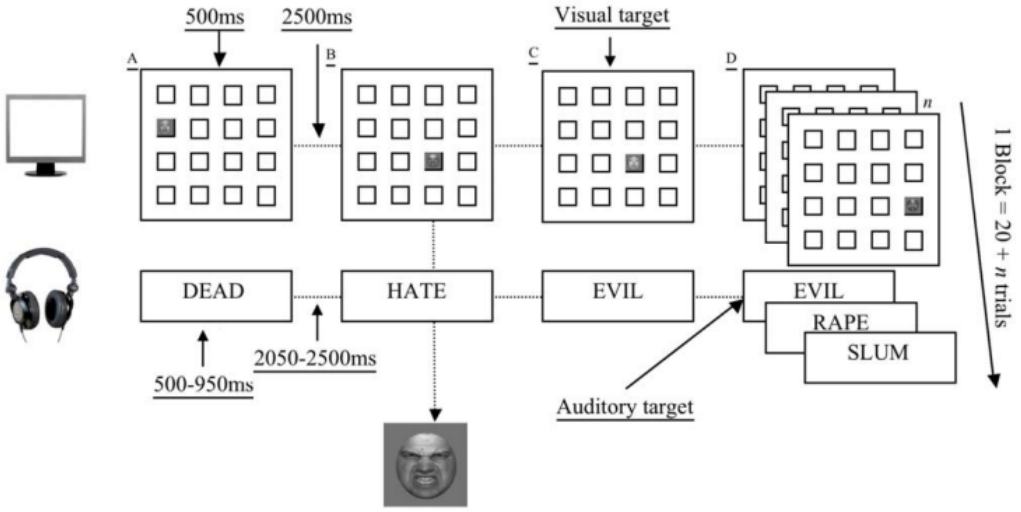

Figure 2. Reviewing the Affective Dual N-Back Task (Schweizer et al., 2011)

Placebo intervention training. During the placebo training, participants in this group were presented with two sets of geometric shapes on a screen. The participants were given instructions to remember three shapes from the upper panel by selecting them. Moreover, each panel showed between five and 13 distracting forms next to the target forms. The number of distracting items included with the targets was randomized rather than based on performance.

Measures

Diagnostic interview

The DSM-5 diagnostic criteria for gambling disorder. A clinical psychologist conducted a diagnostic interview with the participants based on DSM-5 criteria for GD. GD was diagnosed if at least four criteria were met in a 12-month period (American Psychiatric Association, 2013).

Paper and pencil measures

Barratt Impulsiveness Scale-11 (BIS-11; Patton et al., 1955, H_3). The BIS-11 was used to assess impulsivity. It comprises 30 items (e.g., *"I do things without thinking"*) graded on a four-point scale from 1 (*never*) to 4 (*almost always*). It consists of three sub-scales: cognitive, motor, and non-planning. Individuals with an average score of 64 or higher are classified as impulsive (Patton et al., 1995). A Cronbach's alpha of 0.81 was reported by Javid et al. (2012). The BIS-11 in the present study had good internal consistency (Cronbach's α=0.86).

Cognitive Emotion Regulation Questionnaire (CERQ-short; Garnefski et al., 2006; H_1 and H_2). The CERQ-Short was used to assess emotion regulation. It comprises 18 items and nine subscales. These subscales represent both non-adaptive strategies (catastrophizing, rumination, other-blame, self-blame) and adaptive strategies (refocusing on planning, positive reappraisal, positive refocusing, acceptance, perspective taking). Items (e.g., *"I feel that I am the one to blame for it"*) are graded on a five-oint scale from 1 (*almost never*) to 5 (*almost always*). A high score in each

subscale indicates a greater use of that particular strategy (Garnefski et al., 2006). Hasani (2011) reported that the Persian version of CERQ has good internal consistency for the nine subscales (Cronbach's alpha ranges from 0.64 to 0.92). The subscales of the CERQ-short in the present study had adequate to excellent consistency (α=0.68 to 0.94).

Computer tasks

Go/No-go Task (Kelly et al., 2004; H_5). The Go/No-go task was used to assess response inhibition. Participants respond to colour changes of rectangular shapes on a computer screen. For this trial, 40 rectangular shapes were used, each presentation lasting between 0.2 and 3 seconds, with an intervening interval of between 1 and 5 seconds. If the right rectangle turns green, participants press the '?' key; if the left rectangle turns green, they press the 'z' key. The task includes 70% 'Go' stimuli (Fassbender, 2004; Kelly et al., 2004). Errors in responding to 'No-go' stimuli, and the number and omission errors are recorded (Khodadadi et al., 2014)

Balloon Analog Risk Task (BART: Lejuez et al., 2000; H_4). The BART was used to assess real-life risk-taking. Participants inflate 30 balloons on a computer screen, earning 50 points for each click. They can store their points by pressing 'collect' or continue inflating until the balloon bursts, losing the points. Risk-takers inflate more balloons despite the risk of explosion. The BART score, inversely related to a high-risk decision-making style, is based on overall score and number of balloon bursts.

Continuous Performance Test (CPT, H_6). The CPT was used to assess attention maintenance. Participants respond to a visual stimulus on a computer screen ('4' among other numbers) by pressing a key. The test consists of 150 stimuli, with 20% being the target stimulus. Each stimulus is presented for 150 milliseconds, with a 500-millisecond interval. Scores are based on errors, omission errors, and correct answers (Rosvold et al., 1956; Persian version: Khodadadi et al., 2014).

Wechsler Digit Span Test (WDST, H_7). The WDST was used to assess working memory (Wechsler, 1997). The task consists of four stages (Khodadadi & Amani, 2020). The initial two stages involve auditory presentation of numbers, requiring participants to memorize and enter them in order or reverse. The last two stages present numbers visually, with the same ordering tasks.

Statistical analysis

The data were analysed using IBM SPSS software version 24.0. Assumptions of mixed-design ANOVAs were checked and met: (i) no significant outliers in any cell of the design (box plot); (ii) normality (Shapiro-Wilk normality test); (iii) homogeneity of variances (Levene's test); (iv) sphericity (Mauchly's test) and (v) homogeneity of covariance (Box's M). Participants with scores above 5% were excluded because of the random pattern of missing data (Tabachnick et al., 2018). When checking for outliers, it was found that one participant in the treatment group and five participants in the placebo group had more than 5% missing data and were subsequently excluded. Consequently, the final analysis included data from 64 participants, with 34 in the experimental group and 30 in the placebo group.

For each hypothesized outcome, separate analyses were conducted for participants with completed measures at T0 (baseline), T1 (post-intervention) and T2 (three-month follow-up). Mixed-design

ANOVAs were used to consider differences between T0 vs. T1 and T0 vs. T2 as the main outcomes. All mixed-design ANOVAs considered time (T0, T1 and T2) as the within-participant factor, group (intervention and placebo) as the between-participant factor, and cognitive emotion regulation strategies (H_1 and H_2), impulsivity (H_3), risky decision-making (H_4), response inhibition (H_5), attention (H_6) and working memory (H_7) as dependent variables. To investigate differences in trajectories between the intervention and placebo groups, mixed models were used, with response inhibition, impulsivity, risky decision-making, attention, working memory and CERS scores as the dependent factors, and group (intervention and placebo), time (T0-T2), and the interaction between time and group as independent factors (fixed effects).

Results

The effect of eWMT on cognitive emotion regulation and impulsivity

The results of the present study indicated that the effect of eWMT on cognitive emotion regulation strategy and impulsivity did not support H_2, but did support H_1 and H_3. The mixed-design ANOVAs testing the hypotheses showed significant main effects of time and time*group interaction effects across all outcome measures, which included adaptive cognitive emotion regulation, maladaptive cognitive emotion regulation and impulsiveness measures. The results of the multivariate tests (Wilks λ) regarding time and time*group interactions are presented in Table 2.

Table 2. Results of multivariate tests (Wilks λ) according to time and time*group interactions

Scale	Subscale	Time			Time* Group		
		Wilks λ	F (2, 61)	η^2	Wilks λ	F (2, 61)	η^2
CERQ	Maladaptive	0.73	11.34***	0.27	0.68	14.58***	0.32
	Adaptive	0.89	3.66*	0.10	0.87	4.52**	0.13
	No planning	0.90	3.47*	0.10	0.72	11.77***	0.28
Impulsiveness	Motor	0.85	5.27***	0.15	0.55	24.77***	0.45
	Attentional	0.97	0.88	0.03	0.74	10.77***	0.26

Note: CERQ= Cognitive emotion regulation questionnaire, **MCERS=** Maladaptive cognitive emotion regulation strategies, **ACERS**= Adaptive cognitive emotion regulation strategies, * = $p < 0.05$; ** = $p < 0.01$*** = $p < 0.001$.

These differences required further inquiry since they did not show which group differed from the other group in terms of the interest variables. Further findings are presented in Table 3.

Table 3. Means, standard deviations of outcome variable scores, and results of mixed design ANOVAs

Scale	*Measures*	Experimental group (n=34)	Placebo group (n=30)	Time		Group		Time* Group	
				F (1, 62)	η^2	*F* (1, 62)	η^2	*F* (1, 62)	η^2
CER	T0	24.18 (5.34)	24.97 (5.07)	19.51***	0.24	103.19***	0.62	29.36***	0.32
	T1	16.85 (1.86)	24.80 (4.79)						
	T2	16.97 (1.78)	25.70 (4.03)						
ACERS	T0	28.12 (6.58)	32.30 (5.56)	7.12**	0.10	0.51	0.008	7.29**	0.10
	T1	32.67 (5.31)	31.56 (6.87)						
	T2	33.56 (4.45)	32.26 (5.24)						
BIS-11 No planning	T0	23.97(5.97)	22.47 (5.64)	6.59***	0.10	34.67***	0.36	23.92***	0.28
	T1	18.29(2.68)	23.80 (2.72)						
	T2	18.09(2.78)	24.30 (2.87)						
BIS-11 Motor	T0	31.12 (7.94)	28.46 (7.43)	8.44***	0.12	62.68***	0.50	48.05***	0.44
	T1	20.70 (2.74)	32.17 (3.62)						
	T2	21.26 (2.90)	32.50 (4.20)						
BIS-11 Attentional	T0	10.85 (3.16)	10.13 (2.77)	1.73	0.03	38.89***	0.37	21.76***	0.26
	T1	8.23 (1.60)	11.53 (2.01)						
	T2	8.23 (1.57)	11.60 (1.90)						

Note: MCERS= Maladaptive cognitive emotion regulation strategies, **ACERS**= Adaptive cognitive emotion regulation strategies, **T0**=pre-intervention, **T1**=post-intervention, **T2**=three-month follow-up, *= $p < 0.05$; ** = $p < 0.01$*** = $p < 0.001$.

All within-participant effects (i.e., time of measurement) for all outcomes were significant except for attentional impulsiveness. Moreover, the effect of the interaction of two independent variables (group) and the number of measurements (T0, T1 and T2) were significant. Regarding between-participant effects, the effects of group (i.e., the effects of the experimental intervention) on all outcomes were significant except for adaptive cognitive emotion regulation strategies (ACERS).

To examine trajectories of outcome variables in the experimental and placebo groups, paired-samples *t*-tests were conducted in the two groups from T0 to T1 and T0 to T2 for all outcome variables (Table 4). The paired-samples *t*-tests revealed significant changes in all outcome variables in the experimental group from T0 (baseline) to T1 (post treatment) and T2 (three-month follow-up), but not in the placebo group.

Table 4. Paired-samples *t*-tests in intervention group and placebo group for trajectories of outcome variables

Subscale	Experimental group (n=34)								Placebo group (n=30)							
	T0 vs. T1				T0 vs. T2				T0 vs. T1				T0 vs. T2			
	t (33)	Cohen's *d*	Effect size	*p*	*t* (33)	Cohen's *d*	Effect size	*p*	*t* (29)	Cohen's *d*	Effect size	*p*	*t* (29)	Cohen's *d*	Effect size	*p*
MCERS	7.51	2.61	0.79	0.001	7.00	2.44	0.77	0.001	0.12	0.04	0.02	0.90	-0.71	-0.26	0.13	0. 48
ACERS	-3.34	1.62	0.50	0.002	-3.71	1.29	0.54	0.001	0.47	0.17	0.09	0.64	0.024	.001	0	0.98
No planning	4.68	1.63	0.63	0.001	5.34	1.89	0.68	0.001	-1.12	-0.41	0.20	0.27	-1.63	-0.60	0.29	0.14
Motor	7.37	1.29	0.54	0.001	6.74	2.35	0.76	0.001	-2.50	-0.93	0.42	0.02	-3.00	-1.11	0.49	0.16
Attentional	3.89	1.35	0.56	0.001	4.52	1.57	0.62	0.001	-2.04	-0.76	0.35	0.81	-2.21	-0.82	0.38	0.163

Note. MCERS = Maladaptive cognitive emotion regulation strategies; ACERS = Adaptive cognitive emotion regulation strategies, T0 = pre-intervention, T1 = post-intervention, T2 = three-month follow-up.

Finally, to assess the superiority of the experimental group compared to the placebo group, direct pairwise comparisons (independent *t*-tests) between groups at each time (T0, T1, T2) were calculated (Table 5).

Table 5. Independent-samples *t*-tests of experimental group compared to placebo group in relation to variables of interest

Subscale	T0				T1				T2			
	t (62)	Cohen's *d*	Effect size	*p*	*t* (62)	Cohen's *d*	Effect size	*p*	*t* (62)	Cohen's *d*	Effect size	*p*
MCERS	-0.60	0.12	0.08	0.56	-8.90	2.26	0.75	0.001	-11.24	2.85	0.82	0.001
ACERS	-2.72	0.69	0.32	0.73	0.73	0.18	0.09	0.51	1.06	0.27	0.13	0.24
No planning	1.03	0.26	0.13	0.62	-8.14	-2.07	0.72	0.001	-8.97	-2.27	0.75	0.001
Motor	1.37	0.35	0.17	0.19	-14.38	-3.65	0.88	0.001	-12.56	-3.19	0.84	0.001
Attentional	0.93	0.24	0.12	0.28	-7.30	-1.85	0.68	0.001	-7.73	-1.96	0.70	0.001

Note. MCERS = Maladaptive Cognitive Emotion Regulation Strategies, ACERS = Adaptive Cognitive Emotion Regulation Strategies, T0 =pre-intervention, T1 = post-intervention, T2 = three-month follow-up.

As shown in Table 5, at baseline (T0) there were no significant differences between the experimental group and the placebo group. However, in the post-intervention period (T1) and three-month follow-up period (T2), the treatment intervention group was superior to the placebo group in all outcomes. In sum, the findings indicated the superiority of the eWMT intervention to the placebo.

The effect of treatment intervention on risky decision-making, response inhibition, attention, and working memory

The findings of the present study indicated that eWMT improved risky decision-making, improved response inhibition, improved attention, and improved working memory (and therefore supported H_4 to H_7). A mixed design ANOVA was used to investigate the major effects of the treatment intervention compared to the placebo. The mixed design ANOVAs showed overall significant main effects of time and time*group interaction effects in all outcomes except the time effect of commission in Go-No-go Task. The results of multivariate tests (Wilks λ) are presented in Table 6 with regard time and time*group interactions, and means are presented in Table 7.

Table 6. Results of multivariate tests (Wilks λ) according to time and time*group interactions

Scale	Subscale	Time			Time* Group		
		Wilks λ	F (2, 1)	η^2	Wilks λ	F (2, 61)	η^2
BART	Total	0.87	5.07***	0.14	0.73	11.51***	0.27
	Expulsion	0.58	21.73***	0.42	0.88	4.41**	0.12
	FDS	0.54	25.71***	0.46	0.88	4.02*	0.12
WM	BDS	0.80	7.55***	0.20	0.83	6.35**	0.17
	COM	0.93	0.22	0.007	0.72	11.83***	0.28
Go-No-Go	OMI	0.38	50.68***	0.62	0.66	15.97***	0.34
	INH	0.38	50.13***	0.62	0.46	36.01***	0.54
	COM	0.82	6.52***	0.18	0.64	17.47***	0.36
CPT	OMI	0.68	14.18***	0.32	0.75	10.05***	0.25
	Hit	0.64	17.17***	0.36	0.60	20.63***	0.40

Note: BART = Balloon Analog Risk Task, WM= Working memory; CPT= Continuous Performance Test; FDS= Forward Digit Span; BDS= Backward Digit Span; COM= Commission; OMI= Omission; INH= Inhibition. ***p<0.001.

These differences required further investigation because they did not indicate which group differed from the other group in terms of the study variables. The results presented in Table 7.

Table 7. Means, standard deviations of executive functions, and results of mixed design ANOVAs groups

Scale	Subscale	Group	T0	T1	T2	Time		Group		Time* Group	
			M (SD)	M (SD)	M (SD)	F (1, 62)	η^2	F (1, 62)	η^2	F (1, 62)	η^2
RDM		TIP	6159.70 (1092.12)	7402.65 (891/88)	7509.12 (1022.86)	10.09***	0.14	35.94***	0.37	21.69***	0.26
		PG	5953.00 (1147.83)	5558.00 (1258.26)	598.00 (1272.37)						
WM		TIP	15.29 (4.45)	7.82 (3.75)	8.00 (3.33)	38.81***	0.38	4.84**	0.07	7.69***	0.11
		PG	13.93 (5.55)	10.93 (4.89)	11.13 (5.02)						
	FDS	TIP	6.76 (2.62)	10.70 (1.97)	10.67 (1.98)	44.27***	0.42	39.66***	0.39	5.07**	0.08
		PG	6.23 (2.72)	7.80 (2.18)	8.17 (1.97)						
	BDS	TIP	5.97 (3.05)	9.70 (2.41)	9.50 (2.45)	13.81***	0.18	7.54***	0.11	7.80***	0.11
		PG	6.07 (3.49)	7.10 (2.73)	7.56 (2.32)						
Go/No-go	COM	TIP	3.61 (3.73)	1.12 (1.12)	1.03 (1.08)	0.03	0.001	72.35***	0.54	19.58***	0.24
		PG	3.86 (3.90)	7.00 (3.86)	6.66 (3.53)						
	OMI	TIP	15.91 (7.32)	1.47 (2.09)	1.15 (1.67)	87.92***	0.59	85.89***	0.58	27.83***	0.31
		PG	15.47 (6.39)	11.40 (4.52)	11.33 (4.79)						
	INH	TIP	20.47 (6.99)	37.41 (2.71)	37.79 (2.34)	99.26***	0.62	152.73***	0.71	66.43***	0.52
		PG	20.66 (6.01)	21.47 (6.21)	22.40 (5.93)						
	COM	TIP	8.50 (5.25)	2.00 (1.72)	1.88 (1.53)	9.39***	0.13	59.58***	0.49	34.98***	0.36
		PG	7.47 (4.96)	8.43 (4.64)	9.57 (3.83)						
CPT	OMI	TIP	12.44 (7.87)	2.15 (2.67)	2.09 (2.72)	26.19***	0.30	42.86***	0.30	19.72***	0.24
		PG	11.76 (7.43)	10.56 (6.92)	11.03 (5.25)						
	Hit	TIP	129.06(11.29)	145.85 (3.50)	146.03 (3.33)	30.76***	0.33	70.70***	0.53	41.49***	0.40

	PG	130.67 (9.20)	131.06 (8.33)	129.50 (7.82)

Note. RDM = Risky decision-making WM=Working memory; CPT = Continuous Performance Test; FDS = Forward Digit Span; BDS = Backward Digit Span; COM = Commission; OMI = Omission; INH= Inhibition; T0 = pre-intervention; T1= post-intervention; T2 = three-month follow-up; ***p<0.001.

To examine the trajectories of outcome variables in the treatment intervention and placebo groups, paired-samples *t*-tests were applied in two groups from T0 to T1 and T0 to T2 for all outcome variables. These paired comparisons are presented in Table 8. The paired-samples *t*-tests showed significant changes in all outcome variables in the treatment intervention group from T0 (baseline) to T1 (post treatment) and T3 (three-month follow-up), but not in the placebo group.

Table 8. Paired-samples *t*-tests in treatment intervention group and placebo group for trajectories of outcome variables

Subscale	Treatment intervention group (n=34)						Placebo (n=30)					
		T0 vs. T1		T0 vs. T2			T0 vs. T1			T0 vs. T2		
	t (33)	Cohen's *d*	Effect-size *r*	*t* (33)	Cohen's *d*	Effect-size *r*	*t* (29)	Cohen's *d*	Effect-size *r*	*t* (29)	Cohen's *d*	Effect-size *r*
Total	-5.08	-1.77	0.66	-5.44	-1.89	0.69	1.52	0.56	0.27	1.08	0.40	0.20
Expulsion	6.83	2.38	0.76	7.74	2.69	0.80	2.36	0.88	0.40	2.06	0.76	0.36
FDS	-7.14	-2.48	0.78	-6.43	2.24	0.74	-2.42	0.90	0.41	-3.06	1.14	0.49
BDS	-6.25	2.17	0.74	-5.13	1.78	0.67	-0.04	0.02	0.01	-0.59	0.22	0.11
COM	3.87	1.35	0.56	4.10	1.42	0.58	-3.08	1.14	0.50	-2.59	0.96	0.43
OMI	11.20	3.89	0.89	11.70	4.07	0.90	2.99	1.11	0.48	2.58	0.96	0.43
INH	-13.64	4.75	0.92	-13.99	4.87	0.92	-0.48	-0.18	0.09	-1.17	0.4	0.21
COM	6.58	2.29	0.75	6.75	2.35	0.76	-0.80	0.30	0.15	-1.89	0.70	0.33
OMI	7.51	2.61	0.79	6.99	2.43	0.77	0.62	0.23	0.11	0.46	0.17	0.08
Hit	-8.70	3.02	0.83	-8.15	-2.83	0.82	0.12	0.04	0.02	0.68	0.25	0.12

Note. WM=Working memory; CPT = Continuous Performance Test; FDS = Forward Digit Span; BDS = Backward Digit Span; COM = Commission; OMI = Omission; INH = Inhibition; T0 = pre-intervention; T1= post-intervention; T2 = three-month follow-up; T0 = pre-intervention; T1 = post-intervention; T2 = three-month follow-up.

To test the superiority of the treatment intervention group compared to the placebo group, direct pairwise comparisons (independent *t*-tests) between groups at each time (T0, T1, T2) were applied. These results are presented in Table 9.

Table 9. Independent-samples *t*-tests of treatment intervention group compared to placebo group in relation to executive functions

	T0			T1			T2		
Subscale	*t* (62)	Cohen's *d*	Effect-size *r*	*t* (62)	Cohen's *d*	Effect-size *r*	*t* (62)	Cohen's *d*	Effect-size *r*
	0.73	0.18	0.09	6.83	1.73	0.65	6.30	1.60	0.62
	1.09	0.28	0.14	-2.87	-0.73	0.34	-2.93	-0.74	0.35
FDS	0.79	0.20	0.10	5.58	1.42	0.58	5.08	1.29	0.54
BDS	-1.34	0.34	0.17	4.06	1.03	0.46	3.22	0.82	0.38
COM	-0.26	0.07	0.03	-8.49	2.1	0.73	-8.86	2.25	0.5
OMI	0.26	0.07	0.03	-11.49	2.92	0.83	-11.62	-2.95	0.83
INH	-0.12	0.03	0.01	13.58	3.45	0.86	13.98	3.55	0.87
COM	0.81	0.20	0.10	-7.53	1.91	0.69	-10.77	2.73	0.81

OMI	0.35	0.09	0.04	-6.57	1.67	0.64	-8.70	2.21	0.74
Hit	-0.65	0.16	0.08	9.45	2.40	0.77	11.23	2.85	0.82

Note. WM = Working memory; CPT = Continuous Performance Test; FDS = Forward Digit Span; BDS = Backward Digit Span; T0 = pre-intervention; T1 = post-intervention; T2 = three-month follow-up.

At baseline there were no significant differences between the treatment intervention group and the placebo group (see Table 9). However, in the post-intervention period (T1) and three-month follow-up period (T2), the treatment intervention group was superior to the placebo group in executive functions. In sum, the findings indicated the superiority of the eWMT treatment intervention to the placebo.

Discussion

The role of cognitive-emotional control in mental health disorders, including gambling disorder (GD), necessitates an intervention method that targets the improvement of cognitive-emotional control to bring about lasting changes among individuals with GD. Therefore, present study employed eWMT to regulate emotions and improve cognitive functions among individuals with GD who engaged in online sports betting. Results showed that 20 eWMT sessions improve cognitive control, attention and working memory. It also led to a reduction in MCERS, but no significant effect was observed on ACERS. These finding align with previous research demonstrating improvements in executive functions through eWMT among individuals with mental health disorders, including anxiety (Du Toit et al., 2020), attention deficit hyperactivity disorder (Wei et al., 2017), and PTSD (Schweizer et al., 2017), as well as improvements in executive function among healthy individuals (Schweizer et al., 2013).

Additionally, studies have shown that eWMT improves cognitive and emotional control and increases the efficiency of the prefrontal network among individuals with problematic internet use (Emadi Chashmi et al., 2023; Shahrajabian et al., 2023). The mechanism underlying eWMT involves the improvement of frontal cortex functioning and activation of the frontoparietal emotional control network (Banich et al., 2009; Schweizer et al., 2011; Wager et al., 2008). Regular eWMT sessions facilitate the development of new skills and the reorganisation of emotional strategies, resulting in increased eWM capacity.

eWMT and cognitive control

The present study's findings supported H_1, H_2, and H_3, because eWMT improved response inhibition, reduced impulsivity, and reduced risky decision-making. These findings align with prior research demonstrating the positive impact of eWMT on cognitive and emotional inhibition among healthy individuals and those with emotional disorders (Schweizer et al., 2011, 2013). Moreover, eWMT has been shown to improve cognitive control constructs, such as response inhibition, impulsivity, and risky decision-making among individuals with problematic internet use (Emadi Chashmi et al., 2023; Shahrajabian et al., 2023).

The training structure of eWMT engages individuals in activities involving distractions and emotional stimuli while requiring them to retain information in working memory. This mental exercise strengthens emotional working memory capacity, leading to improved cognitive control (Schweizer et al, 2017). eWMT may increase the flexibility of relevant brain areas and improve neural substrates, such as the activity of the prefrontal-parietal-temporal cortex related to cognitive

control, including response inhibition, impulsivity, and risky decision-making (Krause-Utz et al., 2020). Therefore, improving cognitive control among individuals with GD involves enhancing their ability to inhibit responses and reduce impulsivity. This enables participants to act appropriately in situations involving emotional stimuli, avoid risk-taking, and make sound decisions (Emadi Chashmi et al., 2023).

5.2. eWMT, attention and working memory

The present study's findings supported H_4 and H_5, indicating that eWMT can enhance attention and increase working memory capacity among individuals with GD. These findings are consistent with previous studies demonstrating the positive effects of eWMT on working memory capacity and attention (Schweizer et al., 2013; Shahrajaban et al., 2023; Wei et al., 2017). In terms of possible mechanisms, eWMT requires individuals to actively pay attention to visual and auditory stimuli, leading to improved attention allocation, inhibition of irrelevant stimuli, and increased working memory capacity (Hasani et al., 2017; Pan et al., 2022). This improvement in WM capacity, which plays an essential role in other cognitive functions, subsequently improves executive functions among individuals with GD (Luerding et al., 2008). From a neurocognitive perspective, eWMT improves the functioning of the frontal-parietal-temporal cortex and hippocampus, resulting in improved attention and working memory capacity among individuals with GD (Krause-Utz et al., 2014; Schweizer et al., 2013).

It can therefore be argued that by enhancing attention and WM capacity, individuals are better equipped to focus on long-term goals rather than immediate rewards, which often leads to impulsive decision-making. This enables individuals to make more deliberate choices (Emadi Chashmi et al., 2023). It is thought that this will likely reduce individuals' vulnerability to GD (Leiserson & Pihl, 2007; Brevers, et al., 2014). eWMT may also improve the ability to focus on relevant information and inhibit irrelevant stimuli, which may reduce impulsive choices.

eWMT and cognitive emotion regulation strategies

Although the research aimed to improve cognitive-emotional control, the main focus was to investigate the possibility of transferring the therapeutic effects of eWMT to improving emotional control in GD. The present study's findings supported H_6, demonstrating the effectiveness of eWMT in reducing MCERS. However, no significant changes were observed in ACERS. These results contrast with a previous study indicating the improvement of ACERS through eWMT among healthy adults (Schweizer et al., 2013). However, the present study's findings align with studies that demonstrate eWMT reduces MERS but does not increase AERS (Emadi Chashmi et al., 2023; Siegle et al., 2014).

This finding is encouraging because emotion dysregulation is considered to be at the core of many mental health disorders (Aldao et al., 2010). eWMT is simple and easy to implement, with the potential for easy dissemination. It can be used to improve CERS among a wide variety of populations, including clinical and at-risk groups (Schweizer et al., 2013). This finding is encouraging because emotion dysregulation is at the core of many mental disorders (Aldao et al., 2010). The eWMT method is simple and easy to implement, with the potential for easy dissemination. It can be used to improve CERS in a wide variety of populations, including clinical and at-risk groups (Schweizer et al., 2013).

The efficacy of eWMT in reducing MCERS can be attributed to the relationship between working memory and emotion. Improved eWM performance increases capacity for CERS (Pan et al., 2022; Pe et al., 2013; Schmeichel et al., 2008;). Disruptions in the networks mediating emotional regulation are related to deficits in cognitive control and working memory (Aupperle et al., 2012). As working memory capacity increases, CERS also undergo changes. This is because both eWM and CER share common neural substrates (Schmeichel et al., 2008). Therefore, training in one domain can improve performance in the other by enhancing the efficiency of this shared neural network. CERS relies on neural regions, including the prefrontal, posterior, and lateral prefrontal cortex, inferior parietal, and prefrontal cortex (Banich et al., 2009). These regions play a key role in good performance in working memory tasks (Brass et al., 2005; Owen et al., 2005; Samimi et al., 2017). Disorders such as GD are associated with poor cognitive emotion regulation and are caused by the malfunction of these areas (Marchica et al., 2019).

The present study found that eWMT did not improve ACERS. The training period of approximately one month may have been insufficient to transfer the effects of brain flexibility to real-life situations and bring about fundamental changes in the improvement of ACERS. Longer-term training may be necessary to improve these strategies.

Practical implications

According to the present study, 20 training sessions focused on emotional stimuli provided participants with ample opportunity to internalize cognitive emotion regulation strategies through practice, repetition, and feedback. These findings highlight the possibility of implementing remote interventions such as eWMT for GD. Unlike traditional methods, eWMT requires minimal financial resources and is potentially easily accessible. In addition, eWMT does not rely on trained therapists and has a shorter treatment duration than many interventions.

Based on Schweizer et al.'s findings, eWMT could be useful for students and professionals in academic settings. Because online gambling is on the rise compared to other types of gambling due to easy access to the internet, especially among educated young adults (Lelonek-Kuleta & Bartczuk, 2021), it is expected that this group are more likely to engage in problematic gambling behaviours. Healthcare professionals can consider using eWMT to support students with GD. Further studies are needed to explore the effectiveness of eWMT for other disorders. Future studies should investigate eWMT's efficacy in different gambling types and age groups. While present study focused on cognitive control, attention, working memory and CERS, future research could explore other domains such as ambiguity tolerance.

Limitations

Considering the focus in the present study was on individuals with GD who gambled on online sports betting sites, various limitations should be considered. The present study faced challenges in collecting a larger sample due to illegality of gambling in Iran. This limitation made it very difficult to access a sample of disordered gamblers. Moreover, conducting the entire training offline and through participants' personal computers posed a challenge in standardising the training environment. The eWMT programme itself had limitations. The emotional stimuli used in the programme included words such as 'execution' and 'death', which caused a few participants to feel stressed and decreased their desire to continue with their treatment. Additionally, the study lacked access to brain imaging tools, limiting investigation into associated brain changes.

Homogeneity of the participant group (18-23 years and from Iran) was another limitation, suggesting the need for diversity in future studies. The use of self-report measures for CER and impulsivity assessment may have been susceptible to demand effects and biases (e.g., memory recall). The dropout rate was also arguably high in proportion to the number of participants in the study.

To address the aforementioned limitations, future studies should focus on developing and simplifying the eWMT software that was specifically designed for GD. In addition, although the chosen dependent variables, namely cognitive control, attention, working memory capacity, and cognitive emotion regulation strategies, play an important role in the context of GD, they are not the sole criteria for evaluating the effectiveness of an intervention.

Time should also be taken into account. It is usual for short-term therapy sessions to last for a minimum of 20 to 25 hours. In the present study, the intervention only lasted approximately 13 hours. Additionally, as the present study did not consider the long-term effects of the training, it is unclear how long this improvement will last. Finally, a significant limitation of the present study was the lack of measurement of changes in GD symptoms after the completion of the training sessions. Future research should include such measurement.

Conclusion

The primary aim of the present study was to investigate the effectiveness of eWMT as a low-cost and accessible intervention for young adults with GD. The results showed that compared to the placebo group, participants trained with eWMT showed significant improvements in cognitive control, working memory capacity, attention and maladaptive cognitive emotion regulation strategies. By improving cognitive-emotional control among individuals with GD, EWMT appears to be a promising method for reducing GD symptoms.

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