The Clinical Obesity Maintenance Model: A Structural Equation Model

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Abstract

Purpose: Theoretical research on the psychological underpinnings of weight management is limited. Recently, the Clinical Obesity Maintenance Model (COMM) proposed a theoretical conceptualisation of salient psychological and neuropsychological mechanisms maintaining weight management issues. The current study aimed to empirically test the COMM and elucidate the results in the context of recent empirical findings.

Methods: Participants (N = 165) were recruited from university and community settings in Australia. The sample consisted of adults with normal weight (n = 41), overweight (n = 40), and obesity (n = 84). Participants completed self-report questionnaires and a brief neuropsychological test. Structural equation modelling was used to estimate the associations between the hypothesised variables of the COMM and evaluate the model fit.

Results: Findings suggested acceptable to good model fit. Furthermore, several direct effects were found. First, cognitive flexibility directly affected eating habit strength. Second, eating habit strength directly affected eating beliefs. Third, eating beliefs directly affected emotion dysregulation. Fourth, emotion dysregulation directly affected depression and binge eating with depression partially mediating this relationship. Finally, depression directly affected binge eating.

Conclusion: This was the first study to empirically test the COMM. Overall, findings provide preliminary support for the COMM as a psychological model of weight management and highlight the underlying psychological and neuropsychological mechanisms that may contribute to weight management issues. As this study examined a simplified version of the COMM, future research should continue evaluating this model and consider incorporating these components into more holistic weight management models to improve long-term treatment outcomes.

Level of evidence: V, cross-sectional descriptive study

Keywords: obesity, weight management, weight maintenance, psychological factors

Declarations

Funding: This research is supported by an Australian Government Research Training Program Scholarship.

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Ethics approval: This study was approved by the University of Technology Sydney Human Research Ethics Committee (ETH19-4065; ETH19-4404). All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to participate: Informed consent was obtained from all individual participants included in the study.

Consent for publication: Not applicable.

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The Clinical Obesity Maintenance Model: A Structural Equation Model

Obesity is a complex health condition that impacts societies worldwide. It places considerable economic burden on health systems and is a major risk factor for premature death and non-communicable diseases such as cardiovascular disease, hypertension, type-2 diabetes, and psychological disorders [1]. The prevalence of overweight and obesity is increasing and affects over 1.9 billion adults worldwide [2]. In Australia, overweight and obesity is the leading risk factor contributing to non-fatal burden and in 2017-18 affected over two-thirds of Australian adults [3]. With increasing prevalence and significant health, social, and economic implications, there is a need to establish effective weight management programs.

Several weight loss treatments are available; however, long-term weight management has remained the biggest challenge for individuals with obesity [4]. Even with professional support and extended behavioural intervention, weight regain commonly occurs once professional contact discontinues [5]. Unsuccessful weight management is likely the result of a complex interaction of environmental, biological, psychological, and neuropsychological components [4-7]. Understanding the interplay of these components in weight management will contribute to developing treatment models that improve the long-term success of individuals with obesity.

Past research has highlighted the importance of conceptualising weight management as an ongoing process and incorporating cognitive-behavioural models of weight management [8]. Recently, the Clinical Obesity Maintenance Model (COMM) [9] incorporated psychological and neuropsychological aspects of weight management within a cognitive-behavioural model of obesity (see Figure 1). This model was not intended to account for the aetiology of obesity or the medical and socio-cultural aspects of obesity. Rather, this model extends previous cognitive-behavioural conceptualisations by highlighting

the interplay of major psychological and neuropsychological drivers of obesity maintenance, including executive function, habit and cluster strength, health literacy, emotion dysregulation, and depression [9].

Fig. 1

Executive function

Executive function is an interconnected set of higher-order cognitive abilities that are vital for everyday living [10]. Research has found a consistent association between obesity and executive function deficits across the lifespan [6], with specific deficits in decision-making, planning, inhibition, working memory, problem-solving, and cognitive flexibility [11]. Cognitive flexibility is an overarching executive process and involves shifting attention between tasks, simultaneously processing multiple sources of information, and devising strategies to adapt behaviours to the environment [12]. Individuals with obesity have demonstrated poor cognitive flexibility in neuropsychological set-shifting tests [11, 13, 14]. This may contribute to dysfunctional eating patterns, inflexible behavioural responses to environmental variations, and heuristic-based decision-making to consume highly convenient and unhealthy food [13, 15]. Therefore, executive function has an important role in the self-regulation of eating behaviours [16] and subsequent weight management.

Habit and cluster strength

Eating is a habitual behaviour that occurs multiple times throughout the day [15]. Habitual behaviours are automatic learned associations that are elicited by internal or external cues [17,18]. Habitual behaviours persist due to the mental efficiency and automaticity of performing the behaviour, vulnerabilities to contextual cues, and accessibility to immediate goals or rewards [17]. Strongly developed unhealthy eating habits are difficult to cease

especially when they co-occur or “cluster” with other unhealthy lifestyle patterns such as smoking, drinking, and physical inactivity [19]. Furthermore, failure to modify unhealthy eating habits may increase depressive thinking processes (e.g., rumination) and further reinforce unhealthy eating patterns that contribute to weight gain [9]. Over time, these habitual eating behaviours may contribute to increased caloric consumption, disordered and rigid views of eating, and low mood.

Health literacy

Health literacy refers to the ability to understand and appraise health information and make appropriate decisions regarding disease prevention and health care [20]. Many decisions that individuals make regarding their lifestyle behaviours are guided by their health literacy. Poor health literacy has been linked to less healthy decisions, higher body mass index (BMI), and poorer health [20]. It also contributes to information-processing biases about obesity that increase the risk of depression and emotion dysregulation [9]. In contrast, high health literacy has been associated with lower BMI, less metabolic syndrome, and less fatty liver disease [21]. The COMM proposes that health literacy is an important and modifiable contributing factor to weight management difficulties [9]. Thus, addressing health literacy deficits in weight loss programs could improve the long-term success of weight management.

Emotion dysregulation

Emotion regulation refers to an individual’s ability to recognise, understand, and accept their emotions, and respond in adaptive ways [22]. Some individuals, however, regulate emotions using unhelpful eating behaviours such as binge eating [23-25]. Binge eating refers to consuming a relatively larger quantity of food than most others in similar circumstances, accompanied by a feeling of loss of control [26]. In addition, binge eating disorder (BED) is characterised by recurrent binge eating episodes along with associated

symptoms and distress [26]. Research has suggested that emotion regulation difficulties are central to BED [24, 25] and may also contribute to the onset of depression [27]. Furthermore, depression has been associated with increased use of unhelpful emotion regulation strategies (e.g., rumination) and decreased use of adaptive emotion regulation strategies (e.g., reappraisal) [27]. Thus, emotion regulation is integral to weight management as it is implicated in unhelpful self-regulatory eating behaviours and depression.

Depression

Depression is the most prevalent psychological disorder diagnosed in individuals with obesity [28]. Evidence suggests that depression and obesity share a reciprocal link [29], with obesity increasing the risk of depression and depression predicting the development of obesity [30]. Individuals with co-occurring depression and obesity demonstrate significantly greater executive function deficits than individuals with obesity that do not have depression and normal weight controls [31]. Similarly, individuals with depression have shown significantly greater impairments in set-shifting, inhibition, memory, and attention compared to matched controls [32, 33]. Poor mood and negative emotion have also been found to precede binge eating in adults with BED [24, 34], suggesting a possible relationship between mood and unhealthy eating behaviour. Overall, depression may potentiate executive function deficits in individuals with obesity and may trigger unhealthy binge eating patterns.

The current study

The current study aimed to empirically test the COMM and elucidate the psychological and neuropsychological mechanisms of weight management. In this study, eating beliefs were used as a subset of health literacy, eating habit strength was used as a subset of habit and cluster strength, and cognitive flexibility was used as a subset of executive function. In light of the existing literature and theoretical underpinnings of the COMM, we hypothesised the following: First, depression would have a direct effect on cognitive

flexibility and binge eating. Second, eating habit strength would have a direct effect on depression. Third, eating beliefs would have a direct effect on depression and emotion dysregulation. Fourth, cognitive flexibility would have a direct effect on eating habit strength. Finally, emotion dysregulation would have a direct effect on depression and binge eating.

Method

Participants

Participants were 185 adults from Australia, recruited via advertisements on social media and university and community noticeboards. The sample consisted of individuals with normal weight (n = 44), overweight (n = 41), and obesity (n = 100). Participants with normal weight and obesity were recruited at one time point (study one), while overweight were recruited at another (study two). Recruitment occurred over a 4-year period. Both studies investigated the relationship between psychological factors and weight. All participants were informed about the research aims prior to consenting. Participant data was collated from both time points for the current study, which was approved by the University of Technology Sydney (ETH19-4065; ETH19-4404). In study one, participants were eligible if aged 18 to 55 years and BMI was between 18.5 to 24.9 kg/m^2 (normal weight) or $\geq$ 30 kg/m^2 (obesity). In study two, participants were eligible if aged 18 to 55 years and BMI was between 25 and 29.9 kg/m^2 (overweight). In both studies, participants were excluded if they had a history of psychosis, neurological disorder, head injury, developmental or intellectual disability, substance use/abuse, or hearing, vision, or language impairment that precluded the completion of neuropsychological testing. Participants in both studies completed online questionnaires and a face-to-face neuropsychological test. Participants in study two were reimbursed with a 10-dollar voucher.

Of the 185 participants, 20 were excluded due to incomplete data. The final sample (N = 165) consisted of males (30.3%) and females (69.7%) who ranged in age from 18 to 55

years (*M* = 38.4, *SD* = 10.2) and ranged in BMI from 18.5 to 60.2 kg/m^2 (*M* = 31.9, *SD* = 9.2). Of these 165, 41 participants were in the normal weight class (24.8%), 40 were in the overweight class (24.2%), and 84 were in the obesity class (50.9%). Table 1 presents descriptive statistics of the final sample.

Table 1 Descriptive statistics by weight class

Measures

Eating Disorder Examination-Questionnaire (EDE-Q). The EDE-Q is a 36-item self-report measure of eating disorder psychopathology [35]. The EDE-Q yields a global score and four subscale scores: Restraint, Eating Concern, Shape Concern, and Weight Concern. Higher scores indicate greater eating disorder psychopathology. The EDE-Q also measures eating disorder features. Item 14 of the EDE-Q was used in this study to measure binge eating frequency. The reliability and validity of the EDE-Q has been well-supported [36].

Eating Beliefs Questionnaire (EBQ). The EBQ is a 32-item self-report measure of positive and negative beliefs about food and eating. Higher scores indicate greater eating disorder cognitions [37]. The EBQ has demonstrated excellent internal consistency, good test-retest reliability, and sensitivity to treatment [38]. The EBQ was used in this study to measure eating beliefs.

Depression, Anxiety, and Stress Scale-21 (DASS-21). The DASS-21 is a 21-item self-report measure of negative emotional states within the past week [39]. Items can be classified into three scales: Depression, Anxiety, and Stress. Higher scores indicate greater severity. The DASS-21 has demonstrated excellent reliability and has been validated in clinical and non-clinical samples [40, 41]. The DASS-21 was used in this study to measure depression.

Difficulties in Emotion Regulation Scale (DERS). The DERS is a 36-item self-report measure of emotion regulation [22]. The DERS comprises six subscales: Non-Acceptance of Emotional Responses, Difficulties Engaging in Goal-Directed Behaviour, Impulse-Control Difficulties, Lack of Emotional Awareness, Limited Access to Emotion Regulation Strategies, and Lack of Emotional Clarity. Higher scores suggest greater emotion regulation problems. The DERS has demonstrated high internal consistency, good test-retest reliability, and adequate validity [22]. The DERS was used in this study to measure emotion dysregulation.

Self-Report Habit Index (SRHI). The SRHI is a 12-item self-report measure of the habit strength of behaviours [42]. The SRHI measures features of habit including automaticity, behavioural frequency, and identity expression. The habit strength of unhealthy eating behaviour was measured in this study with higher scores indicating greater habit strength. The SRHI has demonstrated high internal and test-retest reliability and is a valid measure of habit [42].

Trail Making Test (TMT). The TMT is a paper and pencil-based neuropsychological test consisting of two trials. Trial A requires the individual to draw lines to numbers in ascending order and predominantly measures visuo-perceptual abilities [43]. Trial B requires the individual to alternate drawing lines to numbers and letters in ascending and alphabetical order (e.g., 1-A-2-B), and primarily measures task-switching and working memory [43]. Obtaining a difference score (i.e., Trial B minus Trial A) controls for visuo-perceptual and working memory demands and provides a more reliable indicator of executive control abilities [43]. In this study, the difference score was used to measure cognitive flexibility, with higher scores indicating a greater difference between trials and greater cognitive impairment. The TMT has demonstrated good psychometric properties [44].

Anthropometric measures. Participant height and weight was measured using calibrated scales. Participant BMI was calculated by dividing weight by height (kg/m^2).

Data analyses

Descriptive statistics of the sample and zero-order correlations among the COMM variables were calculated using SPSS Version 26.0. Listwise deletion was utilised to manage missing data. Structural equation modelling was used to estimate the associations between the hypothesised variables of the COMM. As all variables in the model were observed, path analysis was conducted using Stata Version 16.0. Maximum likelihood estimation was used to estimate the parameters in the model. The model chi-square statistic (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the Standardised Root Mean Square Residual (SRMR) were used to estimate model fit. Non-significant ($p > .05$) model chi-square values indicate good fit [45, 46]. RMSEA values < .08 indicate acceptable fit while values < .05 indicate good fit [45, 46]. CFI values ≥ .90, TLI values ≥ .95, and SRMR values < .08 indicate good fit [45, 46].

Results

The final model χ^2 (6, N = 165) = 11.04, p = .087, RMSEA = .072, CFI = .98, TLI = .95, SRMR = .04, produced RMSEA, CFI, TLI, and SRMR values that indicated acceptable to good model fit (see Figure 2). As expected, cognitive flexibilty had a direct effect on eating habit strength (β = .16, p = .035). Cognitive flexibility also had an indirect effect on eating beliefs (β = .08, p = .046), emotion dysregulation (β = .08, p = .047), depression (β = .07, p = .048), and binge eating (β = .08, p = .047). Unexpectedly, eating habit strength had a direct effect on eating beliefs (β = .52, $p < .001$) and an indirect effect on emotion dysregulation (β = .48, $p < .001$), depression (β = .43, $p < .001$), and binge eating (β = .47, $p < .001$). Contrary to our predictions, eating beliefs and eating habit strength did not have a direct effect on depression and depression did not have a direct effect on cognitive flexibility.

As hypothesised, eating beliefs had a direct effect on emotion dysregulation (β = .92, p < .001). Eating beliefs also had an indirect effect on depression (β = .83, p < .001) and binge eating (β = .91, p < .001). As predicted, emotion dysregulation had a direct effect on depression (β = .90, p < .001) and binge eating (β = .53, p = .001). Unexpectedly, emotion dysregulation also had an indirect effect on binge eating (β = .45, p = .019) with depression partially mediating this relationship. The total effect of emotion dysregulation on binge eating was significant (β = .98, p < .001). Finally, as predicted, depression had a direct effect on binge eating (β = .50, p = .001). Table 2 presents the model coefficients and Table 3 presents the indirect effects.

Furthermore, emotion dysregulation was significantly and positively correlated with depression, binge eating, eating beliefs, and eating habit strength. Depression was significantly and positively correlated with binge eating, eating beliefs, and eating habit strength. Binge eating was significantly and positively correlated with eating beliefs and eating habit strength. Finally, eating beliefs and cognitive flexibility were significantly and positively correlated with eating habit strength. Apart from eating habit strength, cognitive flexibility was not significantly associated with any other COMM variables. Table 4 presents the zero-order correlations.

Fig. 2

Table 2 Standardised model coefficients

Table 3 Indirect effects

Table 4 Zero-order correlations among weight management variables

Discussion

This study was the first to empirically test the Clinical Obesity Maintenance Model (COMM) and contributes to elucidating the psychological and neuropsychological mechanisms of weight management. In light of the existing literature and theoretical underpinnings of the COMM, we hypothesised the following: First, depression would have a direct effect on cognitive flexibility and binge eating. Second, eating habit strength would have a direct effect on depression. Third, eating beliefs would have a direct effect on depression and emotion dysregulation. Fourth, cognitive flexibility would have a direct effect on eating habit strength. Finally, emotion dysregulation would have a direct effect on depression and binge eating. Our first and third hypotheses were partially supported, our second hypothesis was not supported, and our fourth and fifth hypotheses were supported. Overall, our findings indicated acceptable to good model fit and provide preliminary support for the COMM as a psychological model of weight management.

First, contrary to our prediction, depression did not have a direct effect on cognitive flexibility. This inconsistency with previous research [32] may be due to how cognitive flexibility was measured. Harvey et al. [32] operationalised cognitive flexibility using trial B of the TMT. In contrast, we operationalised cognitive flexibility using the difference score, which is a more sensitive measure of cognitive flexibility as it controls for processing speed [47], a construct generally reduced in individuals with depression. Furthermore, as hypothesised, depression had a direct effect on binge eating. This result supports previous findings that poor mood and negative emotion precedes binge eating in adults with BED [24, 34]. It is also consistent with cognitive-behavioural models of binge eating [25] which have proposed that individuals respond to negative affect in ways that precipitate binge eating. Overall, our results strengthen the notion of binge eating as a self-regulatory response to

negative mood and highlight the importance of managing depressive symptoms to improve long-term weight management.

Second, eating habit strength had an indirect rather than direct effect on depression. Although contrary to our expectation, there has been limited research examining this relationship. Previous research has focused predominantly on diet type (e.g., high fat versus high vegetables and fruit) rather than the strength of unhealthy eating habits. While most studies agree that healthier diets are associated with reduced risk of depression [48-50], it remains unclear whether unhealthy diets increase the risk of depression [49] or have no association [48, 50]. Furthermore, eating habit strength had a direct effect on eating beliefs and indirect effect on emotion dysregulation and binge eating. These unexpected findings suggest that unhealthy eating habits directly contribute to unhelpful beliefs about food and eating, and indirectly influence emotion regulation and eating behaviours. For individuals striving to lose weight, this may contribute to unhelpful attitudes regarding weight loss and may impact successful weight management. Hence, we encourage researchers to consider the strength of unhealthy eating habits in future research on weight management.

Third, as predicted, eating beliefs had a direct effect on emotion dysregulation. This finding is theoretically consistent with the COMM, which asserts that poor healthy literacy (e.g., unhelpful eating beliefs) contributes to information-processing biases that increase the risk of emotion dysregulation [9]. Interestingly, however, previous research has also found the opposite effect, with emotion regulation difficulties directly affecting eating beliefs [25]. Taken together, these findings may reflect a bidirectional relationship among eating beliefs and emotion dysregulation, but this could not be concluded by either study due to the research design. Furthermore, contrary to our hypothesis, eating beliefs had an indirect rather than direct effect on depression, and indirect effect on binge eating. These findings indicate that unhelpful beliefs about food and eating may indirectly affect mood and eating

behaviours. Overall, our results emphasise the importance of improving health education to guide individuals to make informed decisions about their weight management.

Fourth, as expected, cognitive flexibility had a direct effect on eating habit strength. This finding can be explained within a framework of dual process theory. According to dual process theory, people make decisions using one of two systems of thinking [51]. The first is effortless and involves fast, automatic, and unconscious decision-making that utilises heuristics [51]. This type of processing reduces the cognitive effort required to make decisions and allows individuals to devote their cognitive capacity to other demands [15]. The second system of processing is more effortful and involves slow, deliberate, and conscious decision-making [51]. Individuals with cognitive flexibility deficits may be more likely to rely on the first system of decision-making to preserve their cognitive capacity. Although this may reduce cognitive overload, utilising heuristic-based decision-making to guide food choices may lead to less healthy decisions and favour foods higher in fat, sugar, and calories [15]. It may also indirectly affect other areas of weight management (i.e., eating beliefs, emotion dysregulation, depression, binge eating) as our results suggested. Over time, this may lead to the formation of unhealthy eating habits that are difficult to discontinue due to the mental efficiency, automaticity, and reduced cognitive load associated with this decision-making pattern [17].

Finally, consistent with our hypotheses and previous research [23, 27], emotion dysregulation had a direct effect on depression and binge eating. Unexpectedly, however, depression partially mediated the relationship between emotion dysregulation and binge eating. Similarly, Kenny et al. [52] found that emotion regulation difficulties and binge frequency were positively associated with high but not low levels of depression. Unlike Kenny et al. [52], however, we found a partial mediation effect rather than moderation. Furthermore, our results are consistent with several emotion regulation models of binge

eating [24, 25] that conceptualise negative affect, emotion regulation difficulties, and self-regulatory binge eating as fundamental components. Overall, our findings contribute to understanding the relationship between emotion regulation, mood, and binge eating. They also emphasise the importance of considering depression and emotion dysregulation in the treatment of binge eating and weight management.

Implications and future directions

This study provides preliminary support for the COMM as a psychological model of weight management. Our findings (see Figure 2) suggest that (a) cognitive flexibility directly affects eating habit strength, (b) eating habit strength directly affects eating beliefs, (c) eating beliefs directly affect emotion dysregulation, (d) emotion dysregulation directly affects depression and binge eating, (e) depression partially mediates the relationship between emotion dysregulation and binge eating, and (f) depression directly affects binge eating. These findings have several implications for clinical practice. First, they highlight the importance of addressing executive function deficits in weight management programs. Pre-treatment assessments of executive function may identify individuals vulnerable to adverse outcomes [53]. Similarly, interventions targeting executive function deficits such as cognitive remediation therapy, have found improved cognitive flexibility and significant reductions in weight and binge eating among adults with obesity [54]. Second, they emphasise the importance of integrating health education in weight management programs. Previous research has shown that education interventions significantly reduce weight, and when combined with low-calorie and low-carbohydrate diet, significantly reduce BMI as well [55]. Third, they reinforce the importance of comprehensively assessing and treating psychological difficulties (e.g., depression) in weight management programs. If untreated, depression may increase the risk of obesity and contribute to disordered eating behaviours such as binge eating [24, 30]. Similarly, emotion regulation difficulties may contribute to binge eating and

weight regain [23, 56]. Integrating these components into future weight management models may begin addressing some of the underlying barriers of weight management and thus improve long-term outcomes.

Fig. 2

Interestingly, this model applies to individuals with normal weight, overweight, and obesity, suggesting that anyone could experience weight management difficulties if affected by these factors. Future obesity prevention models should consider these psychological and neuropsychological factors in addition to pre-existing medical and socio-cultural factors. Moreover, future research could consider developing latent constructs within the COMM. For example, a latent construct that subsumes binge eating and other disordered eating (e.g., grazing) or one that includes additional executive skills (e.g., inhibition, decision-making). This will be more representative of everyday circumstances where several executive processes may be implicated in eating behaviour, rather than exclusively relying on cognitive flexibility.

Finally, future research could focus on emerging neuropsychological factors that may contribute to weight management issues such as impulsivity. Higher impulsivity, as operationalised by faster reaction times on a response-inhibition test, has been associated with less weight loss [53]. Future research could also explore more complex and pervasive psychological factors such as schema style, traumatic experiences, and coping methods. Understanding entrenched psychological issues and unhelpful core beliefs, such as those developed following traumatic experiences, may provide insight on ways to minimise their negative impact on weight management and may contribute to developing a more comprehensive conceptualisation of barriers to weight loss.

Limitations

Our conclusions should be interpreted considering several limitations. First, this study provided a preliminary analysis of the COMM and was not intended to be an account for other psychological, neuropsychological, or eating disorder models. Although the results are promising, further analysis is required to comprehensively evaluate the COMM and to distinguish it from other models. Furthermore, since all the COMM variables were observed, we were unable to hypothesise bidirectional associations and develop a non-recursive model, which may be more representative of real-life conditions.

Second, we used a subset of several constructs from the COMM, which limits our ability to draw conclusions about the overarching constructs in the model. For example, our findings on cognitive flexibility are not representative of all executive processes and should be treated independently to other executive abilities. Similarly, health literacy consists of more than unhelpful beliefs about food and eating, while habit and cluster strength contain factors beyond the strength of unhealthy eating habits. Future research could explore the impact of including other factors of executive function (e.g., working memory), health literacy (e.g., obesity knowledge and stigma), and habit and cluster behaviours (e.g., physical inactivity) on the COMM.

Third, apart from cognitive flexibility, all constructs were operationalised using self-report questionnaires. Previous studies have shown that self-report questionnaires have a higher potential to misclassify binge eating and depression compared to clinical interviews, especially among individuals with obesity [28]. Similarly, certain constructs are difficult to measure using self-report questionnaires. For example, most individuals have limited capacity to report on their eating habits due to difficulties consciously accessing this information, which may contribute to recall inaccuracies and biased reports of habit [57]. While the SRHI remains a widely used measure of habit, inferences should be considered

carefully. Furthermore, as each construct was operationalised using a single questionnaire or measurement method, our results are vulnerable to mono-method bias. Despite researchers asserting that self-report methods are not inferior to other assessments methods and that limitations are overemphasised [58], it will be important to replicate our findings using a multi-method assessment (e.g., clinical interview, self-report), which may minimise potential self-report bias.

Finally, our sample was relatively small and heterogeneous with a disproportionately greater number of female participants. Future research could replicate these findings in a larger and more homogenous sample, which may improve the external validity of these results.

Conclusion

This was the first study to empirically test the COMM. Overall, the findings from this study provide preliminary support for the COMM and highlight the underlying psychological and neuropsychological mechanisms that may contribute to weight management issues. Integrating these components into future weight management models may contribute to developing a more comprehensive conceptualisation of the barriers to weight management, and thus provide important clinical information for obesity treatment. Furthermore, addressing these underlying weight management issues through evidence-based psychological interventions may contribute to a more integrated and holistic approach to weight management and improve the long-term success of individuals with obesity.

What is already known on this subject?

Unsuccessful weight management is due to environmental, biological, psychological, and neuropsychological components but there is limited research on the psychological and neuropsychological factors.

What your study adds?

This study was the first to provide empirical support for the COMM and highlights the underlying psychological and neuropsychological factors that may contribute to weight management issues.

Compliance with Ethical Standards

Conflicts of interest: The authors declare that they have no conflict of interest.

Ethics approval: This study was approved by the University of Technology Sydney Human Research Ethics Committee (ETH19-4065; ETH19-4404). All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Table 1 Descriptive statistics by weight class

	Normal weight (n = 41)	Overweight (n = 40)	Obesity (n = 84)	Total sample (N = 165)
Age[a]	34.7 (11.4)	37.5 (12.0)	40.7 (7.9)	38.4 (10.2)
BMI[a]	21.5 (1.6)	27.7 (2.0)	39.4 (6.8)	31.9 (9.2)
Sex[b]				
Female	26 (63.4)	18 (45.7)	70 (83.5)	114 (69.7)
Male	15 (36.6)	22 (54.3)	14 (16.5)	51 (30.3)

Note. [a] = *M* (*SD*); [b] = *n* (*%*). Missing values are not included.

Table 2 Standardised model coefficients

Variable	*β*	SE	*z*	*p*	95% CI
Cognitive flexibility					
Eating habit strength	.16	0.08	2.11	.035	0.01 – 0.31
Eating habit strength					
Eating beliefs	.52	0.06	9.14	< .001	0.41 – 0.63
Eating beliefs					
Emotion dysregulation	.92	0.12	7.42	< .001	0.68 – 1.17
Emotion dysregulation					
Depression	.90	0.11	8.14	< .001	0.69 – 1.12
Binge eating	.53	0.16	3.40	.001	0.22 – 0.84
Depression					
Binge eating	.50	0.15	3.28	.001	0.20 – 0.80

Note. *β* = standardised coefficient; SE = standard error; *z* = standard score; CI = confidence interval.

Table 3 Indirect effects

Variable	*β*	SE	*z*	*p*
Cognitive flexibility				
Eating beliefs	.08	0.04	2.00	.046
Emotion dysregulation	.08	0.04	1.99	.047
Depression	.07	0.01	1.98	.048
Binge eating	.08	0.01	1.99	.047
Eating habit strength				
Emotion dysregulation	.48	1.35	7.11	< .001
Depression	.43	0.50	6.71	< .001
Binge eating	.47	0.38	7.31	< .001
Eating beliefs				
Depression	.83	0.06	5.85	< .001
Binge eating	.91	0.05	6.23	< .001
Emotion dysregulation				
Binge eating	.45	0.06	2.35	.019

Note. *β* = standardised coefficient; SE = standard error; *z* = standard score.

Table 4 Zero-order correlations among weight management variables

Variable	1	2	3	4	5	6
1. Emotion dysregulation	-					
2. Depression	.582**	-				
3. Binge eating	.241*	.284**	-			
4. Eating beliefs	.398**	.453**	.450**	-		
5. Cognitive flexibility	.153	.064	-.031	.121	-	
6. Eating habit strength	.513**	.392**	.463**	.520**	.159*	-

* $p < .05$; ** $p < .001$

Fig. 1 The Clinical Obesity Maintenance Model (COMM) proposed by Ramen et al. [9]

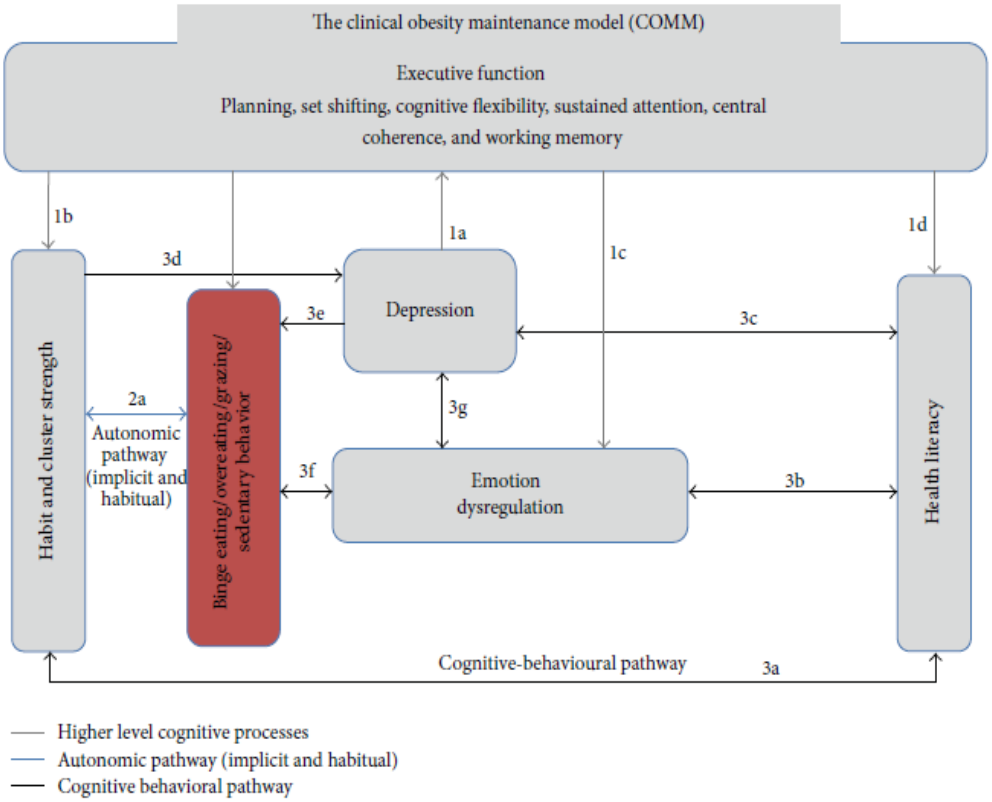
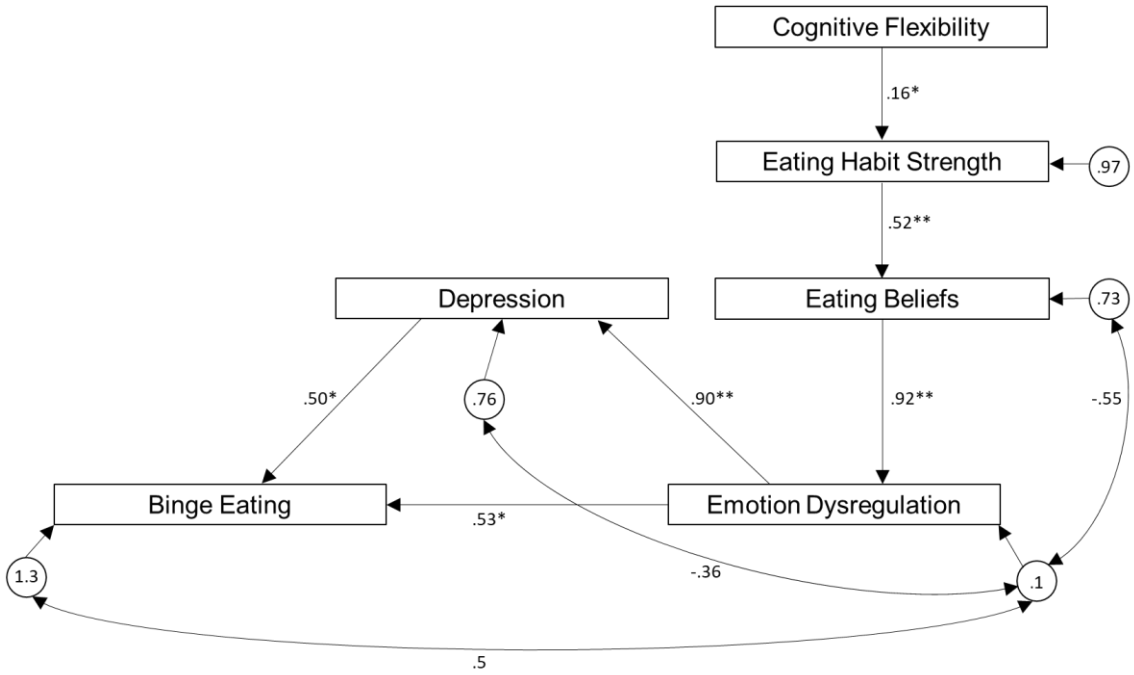


Fig. 2 The best-fitting Clinical Obesity Maintenance Model (COMM)



All values are standardised coefficients.

*p < .05; **p < .001.