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Executive functions and the role of dieting: A comparison between English and Greek females

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Abstract

Introduction: This study investigated and compared the effect of dieting status and culture on executive functions (EFs) between English and Greek females. The moderating role of restrained eating, preoccupying cognitions, depressed affect and IQ was also investigated to provide further evidence of the nature of this effect.

Methods: A between-subjects design was employed, where 192 females were recruited from UK (n =45) and Greek (n =147) Universities; 99 were current dieters and 93 were non-dieters. The Behavior Rating Inventory of Executive Function (BRIEF-A) was used to assess Executive Functions (EFs). Participants also completed the Dutch Eating Behaviour Questionnaire-Restraint (DEBQ-R), Preoccupying cognitions, Centre for Epidemiologic Studies Depression scale (CES-D), Raven's Advanced Progressive Matrices-Set I, and a questionnaire acquiring demographic information. MANOVA and MANCOVA analyses were carried out.

Results: There was a significant multivariate main effect for dieting status ($P < 0.05$) and nationality ($P < 0.001$). Specifically, dieters self-report greater difficulty on inhibit ($P < 0.001$), self- and task-monitor, organisation of materials and working memory ($P < 0.01$), and shift, emotional control, initiate and plan/organise ($P < 0.05$). A significant univariate effect was found for nationality, in terms of emotional control ($P < .0.01$), whereby a higher mean T-score was revealed for Greek ($M = 62.12$; $SD = 11.01$) compared to English females ($M = 59.28$; $SD = 13.95$). With DEBQ-R and preoccupying cognition scores entered as covariates, the effect of nationality, on emotional control, remained significant ($P < 0.001$). However, none of the main effects for dieting status remained significant ($P > 0.05$).

Discussion and Conclusion: Greek females self-report greater difficulty in controlling their emotions. Dieters found to have a poorer ability on the components of EFs; nationality also found to have an effect on EFs. Outcomes of this research provide fruitful implications on the association between dieting, culture and EFs.

KEY WORDS: BRIEF-A; culture; dieting; eating behaviour**;** executive functions.

Riassunto

Introduzione: Questa ricerca ha studiato e confrontato l'effetto della dieta e della cultura sulle funzioni esecutive tra donne inglesi e greche. Il ruolo moderatore delle restrizioni dietetiche, delle preoccupazioni, dell'umore depresso e del quoziente intellettivo è stato anche studiato per fornire ulteriore evidenza sulla natura di tale effetto.

Metodi: Un disegno tra soggetti è stato impiegato, dove 192 donne sono state reclutate nelle università della Gran Bretagna ($n = 45$) e della Grecia ($n = 147$); 99 partecipanti erano a dieta e 93 non. Il Behavior Rating Inventory of Executive Function (BRIEF-A) è stato usato per valutare le funzioni esecutive. I partecipanti hanno anche completato il Dutch Eating Behaviour

Questionnaire-Restraint (DEBQ-R), il Preoccupying cognitions, il Centre for Epidemiologic Studies Depression scale (CES-D), il Raven's Advanced Progressive Matrices-Set I ed un questionario per acquisire informazioni demografiche. Sono state utilizzate come analisi statistiche la MANOVA e la MANCOVA.

Risultati: E' stato evidenziato un significativo effetto principale multivariato sull'essere a dieta ($P < 0.05$) e la nazionalità ($P < 0.001$). Le partecipanti a dieta hanno riportato maggiori difficoltà su inibizione ($P < 0 .001$), auto-monitoraggio, organizzazione dei materiali, memoria ($P < 0.01$), trasformazione, controllo emozionale, capacità di iniziare e di pianificare/organizzare ($P < 0.05$). Un significativo effetto univariato è stato trovato per la nazionalità, in termini di controllo emozionale ($P < 0.01$), laddove un punteggio medio al Test più elevato per le partecipanti greche ($M = 62.12$; $DS = 11.01$) rispetto alle inglesi ($M = 59.28$; $DS = 13.95$) è stato evidenziato. Con il DEBQ-R ed i la conoscenza della preoccupazione come covariate, l'effetto della nazionalità sul controllo emozionale è rimasto significativo ($P < 0.001$). Tuttavia, nessuno dei principali effetti per lo stato di essere a dieta è rimasto significativo ($P > 0.05$).

Discussione e Conclusione: Le donne greche riferiscono maggiore difficoltà nel controllo delle loro emozioni. I risultati di questa ricerca forniscono utili implicazioni sull'associazione tra dieta, cultura e funzioni esecutive. L'utilità del BRIEF-A in questa area di ricerca è stata confermata.

TAKE-HOME MESSAGE: Analysis revealed fruitful findings in the area of dieting, culture and EFs. Dieters found to have a poorer ability on the components of EFs; nationality also found to have an effect on EFs.

Competing interests: none declared

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INTRODUCTION

Executive function (EF) refers to a set of skills necessary for carrying out higher order cognitive processes (i.e., working memory (WM), inhibitory control, the ability to switch attention, regulate emotional responses, initiate activity, plan/organise, and monitor one's performance) [1, 2]. There is a growing body of research investigating the role, nature and organisation of individual differences in EFs [1], reflecting the idea that EFs are the key feature underpinning self-control and self-regulatory ability with broad and important implications for everyday life [2, 3], such as regulating eating habits. The use of Baddeley's model [4, 5] is well-established within research associated with EFs and abnormal feeding [6–11]. Components of this model include a supervisory system, known as the central executive (an attentional control system, responsible for updating information, focusing and switching attention, and the coordination of two tasks carried out simultaneously); and two slave systems (the phonological loop, responsible for maintaining and manipulating auditory and verbal material and the visuospatial sketch pad, that performs a similar function in relation to visual and spatial information). The slave systems have limited storage capacity leading to the conclusion that the concurrent processing of information (verbal or visual) interferes with the content of the slave systems (phonological loop or visuospatial sketch pad) by competing for limited processing resources [12].

There is a consistent evidence for the relationship between EF and the self-regulation of eating behaviour [13]. However, several theorists have reported that central executive dysfunction in dieters is at least partly attributable to preoccupying thoughts about food, weight and body shape [8, 10, 11, 14–16]. Moreover, body mass index (BMI) has been reported to *not* mediate the

observed dieting-related central executive impairment [8, 10]. On a conceptual level EF can therefore be linked to the self-regulation of eating behavior in theoretically meaningful ways; as "dieting" normally requires planning the diet, decision making in avoiding unhealthy foods, and the capability of persisting with long-term goals such as healthy eating [13].

The importance of working memory (WM) capacity on self-regulating feeding behaviour, such as dietary restraint, is well-documented [8, 10, 11, 14, 17–22]. Other investigations present WM capacity as a critical factor in helping people to stick to their long-term dieting goals [20–23]. Whitelock and colleagues (2018) investigated the role of different WM sub-components, including the visuospatial WM on food intake in a non-clinical sample of female dieters and non-dieters. The researchers found that dieters with greater visuospatial WM capacity are more likely to adapt to a successful dieting approach and deal with demands on the WM, such as food cravings, more appropriately. They also found that visuospatial WM capacity mediates the relationship between diet success and low energy dense food intake. There is also evidence that WM deficits exhibited by dieters are not the result of impairments in dieter's general cognitive ability or IQ [16].

Inhibitory control has also been found to play a key role in dieting, as a number of studies have shown that diminished inhibitory performance is associated with overeating [24–33]. Response inhibition has been found to moderate food consumption such that particularly those restrained eaters that exhibited low inhibition ate more in a laboratory setting [34, 35], suggesting that lower behavioral inhibition may be associated with lower eating-related self-regulation, as operationalized by greater food intake in the laboratory setting, higher BMI, or binge eating. Additional support is provided by Nederkoorn et al (2010), as these researchers found that people with low inhibitory control were more likely to gain weight due to strong impulsive tendencies towards unhealthy foods, such as snacks. Task-switching has been reported to also be related to

the self-regulation of feeding behaviour [10, 24, 36–42]. However, the effect of task-switching in non-clinical dieters appears to be a moderating one [43]. According to Allan et al. (2011) the extent of this effect found to be partially determined by the size of the discrepancy between intentions and behaviour. Individuals who performed worst on measures of task-switching and cognitive flexibility were less likely than others to achieve their dietary intentions, such as to eat more 'healthy' (e.g., fruits & vegetables) than 'unhealthy' (eg., snacks) foods [43]. It is also evidenced that dieters with restrained eating demonstrate problems with their shifting [10], self-monitoring [44] and task-monitoring [45] ability.

Most of the research linking dietary behaviour with EF dysfunctions had been within Western settings. However, it is still unclear whether the same relationships exist in other cultural contexts. Determinants of dietary habits and food choices include ethnicity, social and cultural factors, geography, climate, religion and political systems [46–49]. Having undergone significant socioeconomic development, this has led the Mediterranean country of Greece into a period of 'nutritional transition' [50, 51], with a deviation away from a healthy Mediterranean diet towards a unhealthy 'Western' lifestyle, resulting in an increased incidence of obesity, and associated chronic illnesses [52], and a significant rise in the prevalence of eating disorders [53]. In addition, an increase in problematic but non-clinical disordered eating attitudes and behaviours, such as restrained, emotional and external eating styles, and unhealthy dieting behaviours has been in evidence [54–56], and these have been viewed as a precursor to the development of clinical level eating disorders.

The Western media idealizes a thin body shape for women, which has, in part become the 'cultural norm'. As a consequence, females in particular are under pressure to constantly regulate their food consumption, not only for health reasons, but also to comply with the sociocultural 'ideal' of

beauty [57]. In Greece, increases in levels of body dissatisfaction, dieting to lose weight and eating disorders have been reported in both adolescents and adults, particularly in females [58]. To date, to the best of our knowledge, only one cross-cultural comparison study has been undertaken in the domain of dietary restriction and executive functioning [59]. Their comparison of undergraduate students from Greece, Iran, and England revealed that those with high dietary restraint scores demonstrated an attentional bias towards food stimuli, contained within the Stroop task [60], a test of inhibition; however, no significant effect was found for 'Country'. Thus, it remains unclear whether or not dietary behaviours have the same effect on EF dysfunctions cross-culturally. Moreover, it is noteworthy that differences on components of EFs, especially shifting, inhibition, and WM, have been reported as a function of culture [61–63]. A further limitation in this field of research is the extensive use of laboratory-based measures of EFs [64–66]. The challenge here is a lack of ecological validity of executive processes and multi-dimensional decision making that self-report measures can provide in real-world situations [67, 68]. To supplement these insights gained from laboratory-based neuropsychological tests, the Behavior Rating Inventory of Executive Function for Adults (BRIEF-A) [69] is suggested. The BRIEF-A includes questions about everyday activities in familiar contexts that respondents can readily identify themselves with. The nine discrete, theoretically and empirically derived clinical scales capture the behavioural and metacognitive manifestations of executive dysfunctions in the interrelated domains which commonly occur in the everyday environment. Bodnar, Prahme, Cutting, & Mahone (2007) suggest that instruments such as the BRIEF-A possess the capability of measuring subtle individual differences in discrete real world processes, and unlike many laboratory tests are unrelated to and not contaminated by overall differences in general ability, such as IQ. Given that the BRIEF-A is designed to tap component executive processes within an everyday context,

researchers do not always find a significant relationship between the BRIEF-A sub-scales and laboratory-based measures [71–74]. However, relative to laboratory measures, the BRIEF has been useful in predicting the behavioural correlates of clinical conditions, for example, behavioural problems associated with attention deficit hyperactivity disorder (ADHD) [75]. It is clear, therefore, that the BRIEF-A is a reliable self-report measure that can capture behavioural manifestations of EF as effectively as laboratory-based measures.

To address the shortcomings apparent within the existing literature, the current research seeks to examine under whether English and Greek females, classified as current dieters versus non-dieters, differ in terms of components of EF, defined by the BRIEF-A. In accordance with previous literature, it is expected that dieters would show impairments on at least one component of EFs, including deficits on inhibition, shifting, WM, self- and task-monitoring ability. The moderating role of dietary restraint, preoccupying thoughts about food, weight and body shape, as well as emotional and behavioural symptoms of depression and IQ were investigated to provide further insight into the effect that dieting and culture might have on EFs.

METHODS

Study design and procedure

A between-subjects design was employed, with dieting status (dieters *vs.* non-dieters) and nationality (English *vs.* Greek) as the between-subjects factors and the scores of the nine subscales of the BRIEF-A as multiple dependent variables. All participants were tested in accordance with the national and BPS ethical guidelines. To avoid any language barriers, participants were tested in their native language. For Greek translations, questionnaires translated to Greek and back-translation of the questionnaires from Greek to English language confirm the reliability and validity of the questionnaires.

Study participants and sampling

192 female volunteers, who met the inclusion criteria, recruited from UK (n = 45) and Greek (n = 147) Universities via a snowball technique took part. 99 were currently on a diet and 93 where not dieting. The participants' age range was between 18 to 52 years old (Mean = 22.4; SD = 5.09) and they had an average BMI of 23.06.

Study instruments and measures

Demographic questionnaire

Demographic information (age, nationality, ethnicity), together with the number of years of education, current use of alcohol (units per week) and height and weight measures (used to calculate BMI) were assessed. Questions referring to any medical issues, any use of medication, and whether they were currently on a diet were also included to gather participants' characteristics.

Dutch Eating Behaviour Questionnaire-Restraint (DEBQ-R) [55]

DEBQ-R was used to investigate degrees of restrained eating (e.g., "Do you try to eat less at mealtimes than you would like to eat?"). 10 non-reversed items, scored from 1 (never) to 5 (very often) were included in the questionnaire. A higher score on this scale indicates that people intend to limit their food intake, but often indulge in exactly those foods they want to avoid. The DEBQ-R was found to be a reliable instrument among the general population, as Cronbach alpha coefficients were above the recommended cut-off values of 0.80 [81–84]. Internal reliability for this sample reported at 0.95.

Preoccupying cognitions [16]

Preoccupying cognitions were assessed using the measure developed by Vreugdenburg et al. (2003) consisting of 20 statements relating to thoughts about food, weight and body shape (e.g., "I spend a lot of time thinking about my weight"). Participants rated the extent to which they

experienced such diet-related thoughts during the past month on a 6-point Likert scale, ranging from 1 ('never') to 6 ('always'). The total for this scale was used within main analyses. Internal reliability for the present sample was 0.97.

Centre for Epidemiologic Studies Depression scale (CES-D) [76]

Depressed affect was assessed using the CES-D. This scale consists of 20 statements describing emotional and behavioural symptoms of depression (e.g., "I was bothered by things that don't usually bother me"). Participants rated the extent to which they experienced these depressive symptoms over the past month on a 4-point Likert scale, ranging from 1 ('rarely or none of the time') to 4 ('most or all of the time'). Internal reliability for the present sample was 0.92.

Raven's Advanced Progressive Matrices - Set I [77]

Fluid intelligence was measured via the Raven's Advanced Progressive Matrices - Set I. These are 12 non-verbal multiple choice measures of reasoning; often referred to as general intelligence. For each of the 12 test items, the participant is asked to identify the missing element that completes a pattern, with the potential to score 12/12. Items are presented in black ink on a white background, and the problems become increasingly difficult as progress is made through each set.

The Behavior Rating Inventory of Executive Function- Adult Version (BRIEF-A) [69]

The Behavior Rating Inventory of Executive Function-Adult Version was used to capture participants' views of EFs in their everyday environment. The BRIEF-A is composed of 75 items within nine non-overlapping subscales that measure different aspects of EFs. The nine subscales are divided into two broader indexes: Behavioural Regulation (BRI; inhibit, shift, emotional control & self-monitor) and Metacognition (MI; initiate, WM, plan & organise, task monitor & organisation of materials) and the indexes form the overall summary score, the Global Executive Composite (GEC). Each subscale has its own purpose:

- Inhibit (8 items): measures respondent's inhibitory control and the ability to stop one's own behaviour at the appropriate time – e.g., "I am impulsive" (a = .80).
- Shift (6 items): measures respondent's ability to move freely from one situation, activity or aspect of a problem to another, as the circumstances demand. Key aspects of shifting include the ability to make transitions, problem-solve flexibly, switch or alternate attention and change focus from one mind-set or topic to another – e.g., "I have trouble changing from one activity or task to another" (a = .73).
- Emotional Control (10 items): addresses individuals' ability to modulate emotional responses. Poor emotional control can be expressed as emotional under- or over-reaction, with apparently overblown emotional reactions to seemingly minor events – e.g., "My mood changes frequently" (a = .90).
- Self-Monitor (6 items): assesses the extent to which a person keeps track of their own social behaviour and the effect it has on others – e.g., "When people seem upset with me, I don't understand why" (a = .82).
- Initiate (8 items): reflects individual's ability to begin tasks or activities and to generate ideas, responses or problem-solving strategies independently – e.g., "I have trouble getting started on tasks" (a = .79).
- Working Memory (8 items): measures respondent's capacity to actively hold information in mind for the purpose of completing a task or generating a response – e.g., "I have trouble with jobs or tasks that have more than one step". Integral to WM is the ability to sustain attention and performance over time – e.g., "I forget what I am doing in the middle of things" (a = .81).
- Plan/Organize (10 items): measures individuals' ability to manage current and future task

demands within the situational context. Planning often involves envisaging an end point and then selecting the most effective method or steps to attain that goal; and may involve selecting the correct tools or materials necessary to complete the activity – e.g., "I start tasks without the right materials" (a = .84).

- Task Monitor (6 items): measures the extent to which the individual keeps track of his/her own problem solving success or failure. A person with problems of this kind may repeatedly make the same minor error during the completion of a task, thereby preventing successful completion of the task – e.g., "I have trouble finishing tasks" (a = .80).
- Organisation of Materials (8 items): measures organisation in the adult's everyday environment. People who have difficulties in this area often cannot function efficiently as they often misplace items needed to complete projects - e.g., "I am disorganized" (a = .9).

For each item, participants respond on a 3-point scale: 'Never' (1 point), 'Sometimes' (2 points), and 'Often' (3 points). For each of the nine subscales, the scores for the relevant questions are combined to make the total score; the higher score on each subscale indicates a more executive dysfunction. In addition, the BRIEF-A contains, three validity scales as follows: Negativity, Infrequency and Inconsistency. Negativity measures the extent to which the participant responds in an unusually negative manner – a total score of > 6 is problematic. Infrequency (5 items; e.g., "I forgot my name") measures the extent to which adults endorse items that the vast majority of people reject – scores on this scale range from 0-5, where a score of >3 is considered to be problematic. Inconsistency measures the extent to which the respondent answers similar items in an inconsistent manner - scores can range from 0-20, with scores of >8 to be considered as problematic. None of the scales was an issue for the current study. T-scores were used to interpret the individual's level of EFs on the BRIEF-A, where scores at or above 65 are traditionally

considered clinically significant. T-scores for the current sample were within the non-elevated range.

Ethical aspects

The study adhered to the British Psychological Society's ethics guidelines [78] complied with the World Medical Association Declaration of Helsinki [79] and was approved by the ethics committee of the University of Central Lancashire.

Data analysis

Preliminary analyses were performed to ensure no violation of the assumptions of normality and/or any indication of univariate or multivariate outliers. A MANOVA was performed to investigate the effect of dieting status and nationality on the nine aspects of EF, using the BRIEF-A sub-scales. The MANOVA was followed up by a MANCOVA, including a series of covariates. Statistical significance was set at $P < 0.05$. The B-Y method ($\alpha = 0.018$) [80] was used to evaluate the univariate effects for dieting status and nationality on the BRIEF-A components.

RESULTS

Preliminary analysis

Missing data analyses showed that < 5% of data were missing at random. Missing data were replaced using Person Mean Substitution x sub-scale (where applicable) for all variables, with the exception of the BRIEF-A sub-scales. For this scale, no participant had >14 missing responses; more than one item on the Shift, Self-Monitor, or Task Monitor scales, or more than two items on the remaining scales. As recommended within the BRIEF-A manual, a score of 1 was therefore assigned to any unanswered item before a total for the sub-scale was calculated. Thereafter, raw scores were converted to T scores, taking into consideration age norms. There were no univariate outliers (z scores +3.0) and on the basis of Mahalanobis distance there were no multivariate outliers

(< 0.001). Inspection of the validity in relation to the subscales of the BRIEF revealed no cases where the negativity score exceeded > 6. There were no unacceptable inconsistency scores (> 8) and all cases had an acceptable infrequency score of between 0-2.

Participant characteristics

Descriptive statistics for these variables are presented in Table 1.

	English females		**Greek females**	
	Dieters *(n = 26)*	**Non-Dieters *(n = 19)***	**Dieters *(n = 73)***	**Non-Dieters *(n = 74)***
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age	22.16 (4.73)	25.95 (8.76)	21.93 (5.00)	21.97 (3.46)
BMI	22.61 (3.90)	22.87 (4.15)	22.30 (2.82)	21.27 (3.86)
DEBQ-R	39.93 (4.11)	27.91 (5.96)	39.51 (4.45)	27.51 (6.02)
CES-D	17.77 (14.51)	12.98 (10.69)	16.20 (9.60)	13.99 (11.87)
Intelligence	10.08 (1.80)	10.00 (1.41)	10.39 (1.62)	10.52 (1.57)
Alcohol (units p/w)	1.09 (.44)	1.20 (.56)	1.05 (.22)	1.12 (.42)
Preoccupying Cognitions	75.05 (26.25)	52.78 (22.64)	62.75 (21.69)	41.29 (17.43)

Table 1. Demographic statistics for female English and Greek Dieters and Non-Dieters *(n=192)*.

Univariate ANOVAs were undertaken to assess group differences between female Greek and English dieters and non-dieters for age (years), BMI, self-reported level of dietary restraint, depressed affect, fluid intelligence, preoccupying cognitions and alcohol consumption (weekly units).

There were no significant main or interaction effects for age, BMI, depressed affect, weekly units of alcohol consumed or fluid intelligence between the groups. The mean DEBQ-R score for dieters was significantly higher than that of non-dieters: $F(1, 188) = 180.183$, $P < 0.001$, partial $\eta^2 = .489$, observed power = 1.00). Preoccupying cognitions for English females were significantly higher than those for Greek females ($F(1, 188) = 11.006$, $P < 0.001$, partial $\eta^2 = .055$, observed power = 0.910), and for dieters when compared to non-dieters ($F(1, 188) = 37.203$, $P < 0.001$, partial $\eta^2 =$

.165, observed power = 1.000).

Executive functioning

Group differences in executive functioning were then assessed using MANOVA. Table 2 shows Means (SD) T-scores for female English and Greek, dieters and non-dieters, for the nine BRIEF-A sub-scales.

Table 2. Mean T-Scores for the nine BRIEF-A sub-scales for female English and Greek, Dieters and Non-Dieters

T-scores	**English females (n=45)**		**Greek females (n=147)**	
	Dieters *(n = 26)*	**Non-Dieters *(n = 19)***	**Dieters *(n = 73)***	**Non-Dieters *(n = 74)***
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Inhibit	56.72 (12.31)	49.80 (7.45)	54.42 (10.33)	48.08 (7,38)
Shift	55.32 (11.27)	51.90 (10.07)	57.04 (10.19)	53.05 (8.44)
Emotional Control	59.28 (13.95)	51.45 (13.64)	62.12 (11.01)	59.48 (11.50)
Self-Monitor	54.04 (14.03)	48.30 (8.63)	49.40 (12.07)	45.19 (8.25)
Organisation of Materials	56.08 (16.32)	46.50 (10.95)	51.80 (12.65)	48.14 (9.65)
Initiate	55.88 (11.71)	49.70 (10.24)	54.46 (10.87)	51.77 (10.38)
Working Memory	59.96 (15.33)	50.95 (9.77)	54.53 (11.92)	50.93 (9.01)
Plan/Organise	55.24 (13.51)	49.45 (9.65)	53.11 (10.79)	49.42 (9.36)
Task Monitor	58.84 (16.15)	49.35 (10.47)	51.39 (12.53)	48.93 (9.83)

There was a significant multivariate main effect for dieting status ($\Lambda = .908$, $F (9, 180) = 2.032$, $P < 0.05$, partial $\eta^2 = .092$, observed power = .850) and nationality ($\Lambda = .847$, $F (9, 180) = 3.642$, $P < 0.001$, Partial $\eta^2 = .153$, observed power = .989). However, the multivariate test for the interaction effect was non-significant. After adjustment using the B-Y method ($\alpha = 0.018$) [80], significant univariate effects were found for dieting versus non-dieting groups, with significantly higher mean T scores for dieters when compared to non-dieters for all BRIEF-A sub-scales. A significant univariate effect was found for nationality, in terms of Emotional Control ($F = 7.134$, $P < 0.01$, partial $\eta^2 = .037$, observed power = .757), whereby a higher mean T score was revealed

for Greek compared to English females (Table 3).

Table 3. MANOVA results for Dieters and Non-Dieters, for the nine BRIEF-A sub-scales.

	Dieting Status			
df (1,188)	F	*p*	partial η^2	observed power
Inhibit	17.179	.000	.084	.985
Shift	4.663	.032	.024	.575
Emotional Control	6.616	.011	.034	.725
Self-Monitor	7.334	.007	.038	.769
Organisation of Materials	10.393	.001	.052	.894
Initiate	5.830	.017	.030	.671
Working Memory	10.768	.001	.054	.904
Plan/Organise	6.864	.010	.035	.741
Task Monitor	8.558	.004	.044	.829

As Univariate ANOVA analyses revealed significant group differences for DEBQ-R and Preoccupying Cognition scores, and because these two variables correlated significantly with the nine BRIEF-A sub-scales (Table 4), they were entered as covariates within MANCOVA analysis.

Table 4. Correlations between the nine BRIEF-A subscales and DEBQ-R and Preoccupying cognition.

	DEBQ-R	Preoccupying cognitions
Inhibit	.452*	.326*
Shift	.226*	.504*
Emotional Control	.286*	.274*
Self-Monitor	.278*	.317*
Organisation of Materials	.281**	.294*
Initiate	.292*	.413*
Working Memory	.319*	.346*
Plan/Organise	.32*	.372*
Task Monitor	.302*	.504*

*Note: *. Correlation is significant at the 0.001 level (2-tailed). **. Correlation is significant at the 0.05 level (2-tailed).*

With DEBQ-R and preoccupying cognition scores entered as covariates, the univariate effect for

nationality, in terms of Emotional Control, remained statistically significant ($F = 13.436$, $P < 0.001$, partial $\eta^2 = .067$, observed power = .954). However, none of the univariate main effects for dieting status remained statistically significant, suggesting that group differences in restrained eating and preoccupying cognition scores were at least partly responsible for the previously observed main effects of dieting status on the Inhibit, Shift, Self-Monitor, Organisation of Materials, Initiate, WM, Plan/Organise and Task Monitor sub-scales of the BRIEF-A.

DISCUSSION

The impact of abnormal eating on EFs using laboratory measures is well-established [8, 10]. Less well understood is the impact of dieting on a series of EFs using well-validated self-report measures, such as the BRIEF-A, which can capture the multiple interrelated domains of executive dysfunctions as they occur within the everyday environment. It is also important to further investigate the effect that culture might have on EFs within a non-clinical sample. Therefore, the primary aim of this research was to investigate the effect that dieting status and nationality (alternately culture) may have on EFs as defined by the BRIEF-A sub-scales. Furthermore, this research examined the moderating effect of several factors, such as depression, dietary restraint and preoccupying cognitions, on this effect.

Findings provide further evidence for the role of dietary restraint and preoccupying thoughts about food, weight and body shape on dieting status, as dieters demonstrated higher scores in comparison to non-dieters [8, 10, 11, 14–16]. In terms of nationality English females were more likely to demonstrate higher levels of preoccupying cognitions in comparison to Greek females, providing an important indication of the role of nationality in terms of how females experienced such diet-related thoughts; however, culture was found to have no effect on dietary restraint, supporting previous research [59]. The age, BMI, depressed affect, weekly alcohol consumption or fluid

intelligence (IQ) were unrelated to dieting status, indicating no particular effect on whether a dieter, regardless of her nationality, might approach decisions relating to daily eating habits.

Analysis revealed fruitful findings in area of dieting, culture and EFs that support previous research. Trends of mean T-Scores for the nine BRRIEF-A sub-scales demonstrated higher scores for dieters than non-dieters, across all components of EFs, as defined by the BRIEF-A sub-scales [2, 3, 13]. Furthermore, English females found to perform worse on Inhibit, Self-Monitor, Organisation of Materials, Initiate, WM, Plan/Organise and Task Monitor than Greeks; while, Greek females showed poor performance on Shift and Emotional Control. Multivariate analysis supports previous research suggesting that dieting status has an impact on EFs [10, 17–24, 26–29, 39, 44, 45]. This significant effect is accompanied by a medium effect size and power statistic of .85, which indicates that the study has sufficient statistical power. Similarly, culture was found to have a multivariate effect on EFs [61–63]. The medium effect size and the power of .99 provide additional evidence to bolster the limited existing research, as this study has clearly demonstrated that English and Greek females differ in terms of their EF performance. However, there was not an interaction effect of dieting status and nationality on EFs.

Knowing that the ineffective use of inhibitory control can contribute to the unsuccessful self-regulation of eating behaviour, this research provides further evidence that dieters face difficulties in relation to this particular component of EF; namely in the ability to stop impulsive behaviours at an appropriate time [42, 26–29]. The outcome of this study in relation to the EF component of 'shifting' allows the researchers to argue that dieters might be characterised by the dichotomous "all or nothing" approach to feeding, weighing and dieting, due to their difficulties cognitively shifting from one task or activity to another; as dieters in this sample were less able to adapt to a behavioural set of actions in response to environmental or situational change, and to solve

problems in a flexible manner. This finding supports Kemps et al.'s (2005) study that revealed impairments on switching abilities between dieters with unrestrained eating style and controls, as well as the literature on rigid attitudes to dieting [35].

Dieters were also found to have poor ability to keep track of their own social behaviour and the effect it has on others, as well as to prevent successful completion of tasks. These findings are particularly interesting, as self- and task-monitoring, and task-switching have been reported to be related to the lack of self-regulatory behaviour towards eating [24, 39, 44, 45]; a precursor to the development of eating disorders. Therefore, in line with previous research, this study provides further insight relating to the notion that dieters utilise post-hoc rationalisations such as '*I broke my diet, so I will eat as much as I want today, and I will eat less calories tomorrow'*.

This study also adds to the literature pertaining to the relationship between dieting and WM [17-23], as dieters of this cohort demonstrated poorer capacity to retain information that was important for performing everyday tasks even momentarily; and they were less able to sustain attention and performance over time. Although dieting normally requires good skills in planning, decision making and the capability of persisting with long-term goals, the findings suggest that dieters might struggle to initiate a task or to generate problem-solving strategies independently; to plan and organise task demands with the situation context, and to function efficiently, as they often misplace the materials needed to complete a task. Moreover, dieters, more specifically Greek, were found to have weak response to the emotional control compared to the non-dieters. This suggests that dieters might not be able to modulate or regulate their emotions, such as to have frequent mood changes or excessive periods of emotional upset.

The moderating role of dietary restraint and preoccupying cognitions on the effect of dieting status and nationality on EFs was further investigated. Findings suggest that this effect was at least partly

responsible for the previously observed main effects of dieting status on the Inhibit, Shift, Self-Monitor, Organisation of Materials, Initiate, WM, Plan/Organise and Task Monitor, as none of the effects for dieting status remained statistically significant when these factors were inserted as co-variates. The significant effect of nationality in relation to the sub-scales of the BRIEF-A was also erased with the inclusion of scores for restrained eating and preoccupying thoughts about food, weight and body shape with the exception of emotional control.

An important implication of the findings of this research is that improving components of EF, including but not limited to inhibitory control, shifting ability or WM, might be useful for people who are trying to improve their appetite control in order to lose weight or maintain their weight. For instance, improving the cognitive performance of people by asking dieters to track records of their food consumption daily could contribute to better weight outcomes; and one reason why this might be the case is the 'tracking' improves memory for recent eating [18]. Another implication of this research relates to the utility of the BRIEF-A; highlighting its ability to capture the behavioural and metacognitive manifestations of EFs in real world situations; thereby, going beyond laboratory-based tasks that have been extensively used in this field of investigation.

The current study is not without limitations. Although the current area of research is well-documented for female participants, providing homogenous samples, recruiting only females does limit of the generalizability of the findings. Therefore, it is possible that testing for gender differences would provide further evidence for individual differences in the area of dieting and EF. The sample size, particularly of the English females in the present study, is relatively small; thus future studies with larger sample sizes would be helpful to verify the effect that dieting status has on EFs. Given the preliminary evidence on the effect of nationality on EFs, it would also be worth investigating this area cross-culturally.

CONCLUSION

Self-reports of EF as defined by the sub-scales of the BRIEF-A (Inhibit, Shift, Self-Monitor, Organisation of Materials, Initiate, WM, Plan/Organise and Task Monitor) yielded significantly higher mean T scores for female dieters when compared to non-dieters, suggesting that dieters self-report poorer EF than non-dieters. When scores for levels of dietary restraint (DEBQ-R) and preoccupying cognitions relating to thoughts about food, weight and shape were entered as co-variates, the significant effect of dieting status on EF was eradicated, suggesting a moderating role for these variables. With DEBQ-R and preoccupying cognition scores entered as covariates, the univariate effect for nationality for Emotional Control remained statistically significant. Mean T scores suggest that Greek females, compared to English females, self-report greater difficulty in controlling their emotions, and that restrained eating status and preoccupying cognitions have no part to play in this effect. These results might provide the insights for the design and development of interventions which could decrease unhealthy food consumption and might bolster the achievement of dieting goals. This cross-cultural investigation contributes to a better understanding of the development of complex cognitive capacities and their origins.

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