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A low glycaemic load breakfast can attenuate cognitive impairments observed in middle aged obese females with impaired glucose tolerance

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Abstract *Background and aims:* There has been no systematic investigation of the individual and combined effects of impaired glucose tolerance (IGT) and obesity on cognitive function in the absence of ageing. The aims were to examine the effects of IGT and increased waist circumference on cognitive function in ostensibly healthy adults, and to investigate whether a low glycaemic load (GL) breakfast can attenuate cognitive impairments in these populations..
Methods and results: Sixty five females aged 30–50 years were classified into one of four groups following waist circumference (WC) measurements and an oral glucose tolerance test: NGT/low WC (n = 25), NGT/high WC (n = 22), IGT/low WC (n = 9), IGT/high WC (n = 9). Memory, psychomotor and executive functions were examined 30 and 120 min after consuming low GL, high GL and water breakfasts according to a randomised, crossover, counterbalanced design. IGT was associated with impairment of verbal and spatial memory, and psychomotor function relative to females with NGT, independent of waist circumference. Increased waist circumference was associated with impairment of verbal memory and executive function relative to females with low WC, independent of IGT. Consumption of the LGL breakfast attenuated verbal memory impairment in the IGT/high WC group relative to the HGL breakfast and no energy control.
Conclusion: Increased central adiposity and abnormalities in glucose tolerance preceding type 2 diabetes can have demonstrable negative effects on cognitive function, even in ostensibly healthy, middle-aged females. The potential for GL manipulations to modulate glycaemic response and cognitive function in type 2 diabetes and obesity merits further investigation..

Introduction

Type 2 diabetes has been associated with impairments across a wide range of cognitive domains [1,2] and there is increasing evidence that the clinical state of pre-diabetes (impaired glucose tolerance; IGT) is also associated with cognitive impairments [1,3]. However a review of IGT studies highlighted the almost exclusive sampling of older populations (aged 65+ years) indicating that the contribution of IGT rather than ageing associated co-morbidities such as obesity and cardiovascular disease to the observed cognitive deficits is difficult to disentangle [4,5]. As such, there is a need to examine cognitive function in IGT in otherwise healthy populations who have yet to reach old

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age. There is accumulating evidence that obesity and increased central adiposity are associated with cognitive impairment independent of other risk factors for cognitive decline such as hypertension, cardiovascular disease and lower socio economic status [5]. Abnormalities in glucose tolerance often occur with obesity, however, the effects of IGT and increased central adiposity on cognitive outcomes in middle aged adults have not previously been concurrently investigated using sensitive cognitive tests. Given the well established relationship between glucose tolerance and cognitive function [1,4] there has been interest in examining whether foods which improve the postprandial glycaemic response are associated with cognitive benefits. For example, compared to high glycaemic index foods, low glycaemic index foods have been associated with better verbal memory performance in healthy adults [6–8] and children [9–11]. These acute nutritional interventions are of particular relevance to populations with clinically impaired postprandial glycaemic profiles such as type 2 diabetes and IGT. However, to date, only one study has demonstrated that a low GI breakfast is associated with better memory function in adults with type 2 diabetes [12]. Moreover, no studies have examined the effects of acute GI or GL manipulations on cognitive function in adults with IGT or obesity. Given the rapidly increasing prevalence of type 2 diabetes and obesity, there is an urgent need to investigate the potential for lifestyle and dietary interventions to improve glucose tolerance and body weight, and examine effects on cognitive function. Therefore, the aims of this study were two-fold; firstly to investigate the effects of IGT and increased waist circumference on cognitive function in ostensibly healthy middle-aged adults, and secondly, to investigate the acute effects of HGL and LGL breakfasts on cognitive performance over the morning in adults with NGT and IGT and varying in central adiposity. We chose to manipulate glycaemic load rather than glycaemic index since the former considers both quality and quantity of carbohydrate, whereas the latter only considers quality [13]. Glycaemic load is therefore more representative of everyday dietary intake.

Methods

Participants

Sixty five premenopausal, non-smoking females aged 30–50 years of White British ethnicity, with English as their first language, were recruited from the local community via public advertisements (Leeds, UK). The rationale for a female sample was to maximise the hypothesised effect of the breakfast manipulations given that females show greater variation in postprandial glycaemic responses than males [14]. Exclusion criteria were diagnosis of diabetes, neurological disorder, cardiovascular disease, hypertension, depression, and current use of any medication. Based on a medium effect size ($d = .83$) from our previous study in type 2 diabetes with identical cognitive tests and nutritional interventions [2], we calculated a sample size of 65 would provide suitable power (.8) for a mixed ANOVA F test with four independent groups. To our knowledge, no published studies exist which have examined the cognitive effects of acute nutritional interventions in populations with high and low waist circumferences, therefore we were unable to perform a power calculation incorporating an effect size for waist circumference. There were no dropouts, and all sixty five participants completed all visit days.

Design

The study was a counterbalanced, randomised, crossover, $2 \times 2 \times 3$ mixed design with glucose tolerance as a between groups factor with two levels (NGT and IGT), waist circumference as a between groups factor with 2 levels (high waist circumference; HWC, and low waist circumference; LWC), and breakfast type as the within groups factor with 3 levels (water, LGL, and HGL). Therefore, each participant belonged to one of four groups; (i) NGT/LWC ($n = 25$), (ii) NGT/HWC ($n = 22$), (iii) IGT/LWC ($n = 9$), or (iv) IGT/HWC ($n = 9$). The heterogeneous sample size across the experimental groups reflects the relative frequency of these characteristics in the general population given that IGT could only be identified once participants had enrolled in the research and undergone an oral glucose tolerance test (OGTT). Waist circumference has been shown to be a better predictor of all-cause mortality than BMI [15]. LWC was defined as <80 cm and HWC was defined as ≥ 80 cm [16]. IGT and NGT were defined following an OGTT using WHO criteria [17].

Test breakfast composition

All three breakfasts were matched for weight (438 g). The LGL and HGL breakfasts were isocaloric (307 kcal). The LGL breakfast (toasted soya and linseed bread with strawberry yoghurt, fat 9.3 g, protein 20.9, fibre 5 g) contained half the amount of carbohydrate as the HGL breakfast (37.3 g and 75 g respectively). The HGL breakfast was administered in the form of a glucose drink (Lucozade Energy Original). The GL of the LGL and HGL breakfasts was 12 and 71 respectively [18].

Cognitive tests

The 45 min cognitive battery consisted of the following tests administered in respective order: Visual Spatial Learning Test, Visual Verbal Learning Test, Corsi Block Tapping Test, Tower of Hanoi, Grooved Pegboard, Psychomotor Test, and a Word Recognition test. These validated cognitive measures were carefully selected on the basis of previous research and literature reviews [1,2,4,19] indicating that impairments in memory function and psychomotor speed are most consistently reported in IGT populations, whilst obesity has been associated with executive function decrements. Full details of these previously published tests are provided in Supplementary Material 1.