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Severely obese people with type 2 diabetes experience impaired emotional well-being associated with socioeconomic disadvantage: Results from Diabetes MILES – Australia

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Objective: To examine the emotional well-being of severely obese Australians with type 2 diabetes, along with markers of social and economic disadvantage, using the Diabetes MILES-Australia dataset.

Research Design & Methods: Diabetes MILES – Australia was a national survey of 3,338 adults with diabetes that focused on psychosocial issues; 1795 had type 2 diabetes and reported BMI. We extracted data regarding depression (PHQ-9), anxiety (GAD-7), obesity- and diabetes-related comorbidities, and demographics. The severely obese group (SOG) (BMI≥35; median BMI=41.6) constituted 530 (30%) of the type 2 diabetes respondents and were matched with 530 controls (CG) (BMI<35; median BMI=28.2). Within- and between-group trends were examined.

Results: The SOG had higher depression scores (median (IQR) 6.0 (3-12)) than CG (5.0 (2-10)); $p<0.001$, and were more likely to report moderate-severe depressive symptoms (37% versus 27%; $p<0.001$). The groups did not differ on anxiety. The SOG, compared with the CG, were more likely to live alone (21% versus 17%), receive a disability pension (21% versus 15%), earn ≤$40,000/year (51% versus 41%; all $p<0.05$), and were less likely to be employed (46% versus 53%), tertiary educated (17% versus 26%), or have health insurance (50% versus 60%; all $p\leq0.01$). Moderate-severe depression was positively associated with cumulative stressors of severe obesity, socioeconomic disadvantage, and obesity- and diabetes-related comorbidity.

Conclusions: People with type 2 diabetes and severe obesity are more likely to report depressive symptoms and markers of social/economic disadvantage than those with diabetes alone. Increased awareness of these issues may assist in developing appropriate healthcare goals.

The determinants of the global obesity and type 2 diabetes epidemics are highly complex, arising from interactions between genes and a broad range of aspects of the modern post-industrial environment (1; 2). The issues are well beyond the simplistic lay view of "energy in, energy out coupled with a dose of willpower"(3). There has also been a disproportionately large rise in the more severe forms of obesity, that is Class II (BMI 35-40 kg/m^2) and III (BMI >40 kg/m^2) (4). Obesity, type 2 diabetes, negative affect, and cardiovascular disease are all common conditions that generate enormous morbidity, mortality and costs to both the individual and society. These conditions all appear to be inter-related in a series of causal and counter-causal pathways, in which the strength and the direction of relationships vary in clarity (5-11).

Severe obesity (a chronic relapsing condition), and type 2 diabetes (a chronic progressive condition), require a chronic disease model of care to optimize health outcomes. In a healthcare setting, detailed knowledge of the patient's physical condition, socioeconomic situation and emotional well-being are all required to effectively engage the patient in optimal self-care strategies (12).

The associations between diabetes and obesity with impaired emotional well-being are established. The link between a range of mental health disorders and increasing BMI is influenced by age and gender, with younger women at greatest risk (13; 14). Depression is more common in adults with diabetes, than in the general population, and is associated with poor health status (11; 15; 16). Diabetes and obesity also have a major impact on employment and productivity. Higher medical costs and reduced productivity through disability, absenteeism and presenteeism are associated with obesity, especially in those with a BMI >35 kg/m^2 (17). Association between work-related disability, depression, and socio-demographic factors in those with diabetes has also been described (18), but limited quality evidence is available (19). This emphasizes a knowledge gap and potential missed opportunities in addressing physical, emotional and socio-demographic factors when developing person-centered management plans.

There is poor understanding of the compounding issues of disease, socio-demographic factors, and mental health and emotional well-being (19), and surprisingly little is written about morbidly or severely obese people with type 2 diabetes. The literature in this area is dominated by bariatric surgery, with articles usually describing weight loss and glycemic outcomes (20). Much of what is known about psychological comorbidity comes from bariatric surgical cohorts (21) and these

represent a highly selected subgroup, as less than 2% of those eligible (BMI >35 kg/m^2) are treated surgically (20; 22). Successful management of type 2 diabetes and severe obesity requires attention to the behavioral, psychological and social aspects of these serious comorbid conditions (23). A systematic review of socio-demographic factors, diabetes-related complications/comorbidity, and the risk of incident depression included only eight eligible studies, of which, only three examined interactions between these factors. In that review, comorbidity broadly appeared to be related to depression, but there was no interaction with socio-demographic factors. The authors argued for more research concerning the mediating and modifying factors, in order to identify groups at risk or to identify treatment strategies (19).

Diabetes MILES - Australia (Management and Impact for Long-term Empowerment and Success) was a national survey of adults with type 1 and type 2 diabetes, that is focused on the psychosocial impact and behavioral aspects of living with the condition (23). The current case-controlled analysis focuses on a subset of participants of Diabetes MILES – Australia and describes the combined emotional, socioeconomic and disease burden of severely obese Australians living with type 2 diabetes. Our aim was to provide insights into the overall condition of people with co-morbid type 2 diabetes and severe obesity, help identify those at greatest risk of emotional problems, and provide evidence to inform more focused, realistic and appropriate chronic disease management plans, with the ultimate goal of improving health and well-being in this group.

Based on findings in the literature, we hypothesized that those with comorbid severe obesity and type 2 diabetes, compared with respondents who were not severely obese, would:

1) report greater depression and anxiety symptoms;
2) experience greater socio-economic hardship, greater likelihood of living alone and not having a partner; and that these factors would be associated with an increased risk of symptoms of depression and anxiety; and
3) experience obesity- and diabetes-related physical comorbidities that would in turn be associated with an increase in symptoms of anxiety and depression.

Research Design and Methods

A detailed description of the study design and methods, including a full index of validated scales and study-specific items and detailed sample characteristics, has been published elsewhere (23). A brief summary is provided here.

Survey Design and Content

The survey focused on the topics of emotional well-being, self-management, healthcare and support in relation to diabetes. In order to maximize the relevance of questions for particular subgroups and minimize respondent burden, multiple versions of the survey were used in the study. However, all responses used in this analysis were common to all versions.

Data Collection

The survey was made available in hard copy and online. Survey booklets were posted to 15,000 randomly selected National Diabetes Services Scheme (NDSS) registrants with type 1 or 2 diabetes, aged 18-70 years. Completed postal surveys and online surveys (advertised nationally through diabetes-specific media) were accepted for inclusion if returned within eight weeks of 1st July 2011. Those who received the postal survey were invited to complete the survey online if they preferred. Diabetes MILES – Australia received ethical approval from the Deakin University Human Research Ethics Committee (reference number 2011-046).

Participants

In total, 3,338 eligible respondents took part in the Diabetes MILES – Australia 2011 survey, the majority (70%; n=2,351) completing the postal survey. All states and territories of Australia were represented. Respondent characteristics are reported elsewhere (23). Fifty-nine percent of the sample (n=1,941) had type 2 diabetes (49% women; age 59±9 years, 37% insulin-treated). The current paper focuses on a subset of participants with type 2 diabetes and severe obesity, defined as a body mass index (BMI) of $\geq$35g/m^2. A total of 1,795 participants with type 2 diabetes had valid data for age, gender, diabetes duration, height, and weight (for calculation of BMI). For this case-controlled analysis, each severely obese participant was carefully matched to one control participant with type 2 diabetes and BMI <35 kg/m^2 on the basis of age, gender, duration of diabetes and use of insulin (Table 1). Each control was used once only. This matching allowed for confounding differences between the groups to be minimized.

***Data extracted for this analysis**:* The major variables of interest in this analysis were symptoms of depression and anxiety, as measured by the Patient Health Questionnaire (PHQ-9) (24) and the Generalized Anxiety Disorder (GAD-7) questionnaire (25) respectively.

The PHQ-9 comprises nine items, each addressing a symptom of depression and scored on a four-point Likert scale. The total score is computed by summing item scores (possible total score range 0-27, where higher scores indicate more depressive symptoms). Scores of 5, 10, 15, and 20 represent cut-points for mild, moderate, moderately severe and severe depression respectively. A binary score representing the presence/absence of moderate-severe symptoms (cut-off score of ≥10) was also used.

The GAD-7 is a seven-item scale assessing symptoms of anxiety; each item is scored on a four-point Likert scale and the total score is computed by summing item scores (possible total score range 0-21, where higher scores indicate more anxiety symptoms). Scores of 5, 10, and 15 represent cut-points for mild, moderate, and severe anxiety respectively. A binary score for presence/absence of moderate-severe symptoms (score of ≥10) was also used (25; 26).

The following data were also extracted from the MILES database:

- *To further characterize mental health problems:* self-reported history of depression and/or anxiety, and any professional help received for these emotional problems.
- *To characterize socioeconomic disadvantage:* marital-relationship status, housing status, living alone, education, household income, private health insurance (a personal choice influenced by the ability to pay), unemployment, and level of employment.
- *To characterize demographics and clinical characteristics of type 2 diabetes:* age, gender, diabetes duration, insulin use, microvascular disease (renal, retinal, neuropathy), and macrovascular/cardiovascular disease (heart attack, stroke, or vascular disease)
- *To characterize medical comorbidity associated with obesity or type 2 diabetes;* self-reported history of fatty liver disease, hypertension, lipid disorder, polycystic ovary syndrome, proteinuria, sexual dysfunction, sleep apnea, and poor sleep quality.

Statistical Methods

The analysis involved comparing cases with controls, and an examination of increasingly severe obesity by stratifying the severely obese group into Class II (BMI 35-40 kg/m^2), Class IIIa (BMI

40-45 kg/m^2), and Class IIIb (BMI >45 kg/m^2) to assess relative associations with increasing BMI.

Cases and controls were compared using Chi-square tests for proportions, student t-tests for normally distributed outcomes (mean±SD) or Mann -Whitney U tests otherwise (median±IQR). Controls and the three levels of severe obesity were compared using one way analysis of variance ($\log_e$ transformation if required), Kruskal-Wallis Test for non-parametric continuous variables, and linear association for proportions.

Binary logistic regression analysis was used to identify factors independently associated with moderate to severe depressive symptoms. A logical clinically relevant hierarchical model was built using 5 blocks with all variables in each block included. Finally, independence confirmed after placing all independent associations together in one block. SPSS statistical software 18 (SPSS Inc, Chicago,Il) was used for all analysis and two-sided p-value of ≤ 0.05 was considered to be statistically significant.

Results

Sample Characteristics

The characteristics of the 1,795 participants who reported having type 2 diabetes and reported their height and weight (enabling BMI to be calculated) are shown in Table 1. The mean BMI for this cohort was 32.5 SD ±7.9 kg/m^2, and the median was 31.2 (IQR 27.4 – 36.2). Increasing BMI was associated with being female, younger, and a considerably greater likelihood of using oral hypoglycemic agents (OHAs) and insulin (all $p<0.001$). Of these 1,795 respondents, 530 (29.5%) were severely obese (BMI ≥35) and the proportion of Class III obese (BMI ≥40) was greater than the proportion of those in the healthy weight range (BMI ≤25). Men were more highly represented in the overweight category but women comprised the majority in the BMI ≥ 35 and, in particular, BMI ≥ 40, categories.

After carefully matching the 530 participants with a BMI≥35 (cases) with 530 with a BMI <35 (controls), there was no statistical difference between the groups on any of the matching variables, i.e. gender, age, duration of diabetes and use of insulin therapy (Table 2).

Table 2 details the demographic, socioeconomic, clinical characteristics, and comorbidities of the controls and cases (including stratification by BMI). Many indicators of socioeconomic disadvantage were more common in cases than controls, and for some there was increasing disadvantage with increasing BMI. Women predominated in the BMI >45 kg/m^2 category where there were low levels of paid work and household income, and high levels of unemployment and dependence on disability pensions. The severely obese group was more likely to be single, living alone and less likely to have had formal education after leaving school.

The severely obese group was not more likely than the control group to report specific serious micro- and macrovascular complications, but was more likely to report "vascular disease" generally. Respondents who responded positively to the presence of "vascular disease" in general were more likely to respond positively to any specific form of vascular disease (micro- or macrovascular), so providing internal consistency. With increasing levels of obesity, a predictable increase was observed in those reporting hypertension, obstructive sleep apnea and (for women only) polycystic ovary syndrome (PCOS). Sexual dysfunction was not influenced by BMI in either gender, but dysfunction was reported in 34% of men and 10% of women overall.

Depression and Anxiety

There was a clear increase in the median PHQ-9 score and the prevalence of moderate-severe depressive symptoms with increasing BMI (Table 3); 43% of participants with Class III obesity (BMI ≥ 40 kg/m^2) reported moderate-severe depressive symptoms. Overall, 36% of the cases and controls combined reported a history of depression and of the total, 19% reported seeking help for depression. Increasing levels of obesity were associated with a greater discrepancy between numbers reporting a history of depression and those reporting a history of seeking help for depression (p=0.002; Table 3).

Across the entire cohort (cases and controls combined), eight independent factors were associated with a higher PHQ-9 score: younger age (β=-0.16, p<0.001); receiving a disability pension (β=-0.14, p<0.001); no formal education qualification after leaving school (β=0.11, p<0.001); being unemployed (β=0.09, p=0.004); having a history of sexual dysfunction (β=0.12,

p<0.001), sleep apnea (β=0.13, *p*<0.001), PCOS (β=0.13, *p*<0.001), or vascular disease (β=0.14, *p*<0.001). β values represent standardized coefficients, with all variables included in the model explaining 21% of the variance. Gender and BMI were not predictors in this overall general linear regression model; however, the identified socioeconomic and comorbidity issues that were identified had already emerged as being significantly associated with increasing obesity.

In the severely obese group, moderate-severe depressive symptoms were associated with four independent factors: receiving a disability pension; current unemployment; history of albuminuria and/or vascular disease. The details of the hierarchical build of the binary logistic regression model are shown in Table 4. Eight independent factors were associated with moderate-severe depressive symptoms in the full cohort of 1,060 matched cases and controls (Table 5). Five of the eight factors were independent predictors of the total PHQ-9 score and moderate-severe depressive symptoms. Additional factors included BMI, a history of fatty liver disease, and using insulin therapy. Thus, BMI was associated with an increase in moderate-severe depressive symptoms when modeled with and controlled for socioeconomic factors, and obesity- / diabetes-related comorbidity. Table 5 also shows the hierarchical binary logistic regression model identifying independent predictors of moderate-severe depressive symptoms stratified by gender. Important gender differences emerged, with sexual dysfunction independently associated with depressive symptoms in women but not men. Moderate-severe depressive symptoms were associated with unemployment and sleep apnea in men, and receipt of a disability pension and a history of albuminuria in women. When a PHQ-9 cutoff value of 12 was examined, the same predictors emerged with one addition – that of a history of PCOS in women (OR 1.9 (1.0 3.5) *p*=0.047(27)).

In contrast to the findings for depressive symptoms, there was no evidence of increasing levels of anxiety symptoms with increasing BMI. Similar factors were associated with increasing GAD-7 scores as had been associated with increasing PHQ-9 scores. Nine independent factors were associated with a higher GAD-7 score when combining both cases and controls into a single cohort: younger age (β = -0.17, p<0.001); receiving a disability pension (β=0.11, p<0.001); no formal education qualification after school (β=0.11, p<0.001); unemployment (β=0.09, p=0.004); history of sexual dysfunction (β=0.12, p<0.001), sleep apnea (β=0.10, p=0.002), PCOS (β=-0.14, p<0.001), vascular disease (β=0.11, p=0.001), and retinopathy (β=0.11, p=0.006). These β values represent standardized coefficients with all variables included in the model explaining 17% of

variance. While the factors associated with GAD-7 total scores were essentially the same as for PHQ-9 scores, there was no association with increasing BMI. There was also no evidence at any stage during the linear regression model build that increasing BMI protected against anxiety symptoms (details not shown).

A total of 160 participants in the two groups combined reported the combination of moderate-severe symptoms of depression *and* anxiety, and in this group there was a weak but significant association with increasing BMI (r=0.08, p=0.009).

Discussion

The self-reported height and weight of Diabetes MILES – Australia respondents with type 2 diabetes indicated an average BMI in the class I obese range, with 30% having a BMI in the severely obese range. These figures, while alarming, may underestimate the actual numbers of people in the severely obese range, as there is a tendency to self-report being taller and weighing less than one really does (28). In a very confronting way, the figures demonstrate the significant numbers of those with more severe forms of obesity among the type 2 diabetes population, as would be expected, given the overall growth in population waistlines and mean community BMI (4). Our results demonstrate that general emotional well-being is severely compromised, represented by the high prevalence of moderate-severe symptoms of depression, but not anxiety, in those who are severely obese, compared with a carefully matched control group. A similar pattern of increase in symptoms of depression, but not anxiety, was found in the Edinburgh Study in those with abdominal obesity, cardiovascular disease and type 2 diabetes (29). The association between obesity and major depressive disorder, but not anxiety, is also supported from cross-sectional general practice data from the Netherlands study of Depression and Anxiety (30). Perhaps somatic symptoms of sleepiness, poor energy and breathlessness may contribute to reducing anxiety symptoms and increasing those of depression.

Severely obese respondents clearly had higher levels of demographic and socioeconomic disadvantage. Compared with controls, those who were severely obese were less likely to have a current partner, paid employment, health insurance, and university or higher educational qualifications. Living alone, lower income, unemployment, and receiving a disability pension were all more commonly reported. While these factors are inter-related, unemployment and

receiving a disability pension were most strongly associated with poor emotional well-being, demonstrated by increased symptoms of depression and/or anxiety. Obesity has previously been shown to be the single most important factor associated with poor productivity, work disability and impaired daily activities among US workers with diabetes (31). Finkelstein and colleagues have also demonstrated the health and productivity costs associated with increasing obesity, especially in those with a BMI >35 kg/m^2 (18). The current study clearly demonstrates the presence of socio-demographic and economic disadvantage in the severely obese respondents and an association with symptoms of depression. The association between work and work-related disability and depression in those with diabetes highlights the need to adequately assess and address both physical and psychological conditions (18).

We confirm previously reported associations between symptoms of depression and obesity- and diabetes-related comorbidity in those with vascular disease, obstructive sleep apnea, microalbuminuria, fatty liver disease and sexual dysfunction (29; 32-34). Independent factors associated with depression identified groups at particular risk, for example younger men who are unemployed, using insulin and have sleep apnea; and women who are on a disability pension and report sexual dysfunction. While this clustering does not imply particular causal or counter-causal relationships, it provides a practical clinical snapshot of those at risk and may allow for a more detailed and focused clinical discussion and evaluation. The interactions between type 2 diabetes, severe obesity, depression, and cardiovascular risk and disease are established, and depressive illness is not an innocent bystander. In major depressive illness, stress pathways are activated, with increased sympathetic activity, reduced heart rate variability, increased cortisol levels, and elevated CRP levels (35; 36).

Diabetes, obesity and depression are associated with great direct and indirect costs to the individual and the community (17; 37; 38). Better understanding of the combined issues experienced by severely obese Australians living with type 2 diabetes provides insights to inform the delivery of more effective chronic disease management plans. This includes the community and healthcare support needed to engage people with type 2 diabetes and obesity in optimal self-care, which is critical to achieving better health outcomes, and more effective use of healthcare resources (39). A cycle of failure and frustration is experienced by those living with severe obesity (and their therapists alike), as a result of compounding socio-demographic, emotional, and physical health issues, together with the physiologically-driven inability to maintain often

unrealistic weight loss goals. The expected long-term weight loss from behavioral, lifestyle, dietary and pharmaco-therapeutic methods is very modest (3-5% of total body weight) and, while helpful, these methods do not achieve the levels desired by the individual or their therapist (40; 41). Bariatric surgical options are indicated for people with type 2 diabetes and severe obesity (42) and are associated with marked improvement in quality of life and symptoms of depression (43). Procedures, now performed largely by laparoscopy, are highly effective in achieving and sustaining substantial weight loss, providing excellent glycemic benefits, and being cost-neutral if not actually providing a beneficial return on the health investment, due to productivity gains and reduced ongoing medical costs (20; 44). Delivering surgical options within a medical paradigm of chronic disease/diabetes management is challenging and integrated care models are currently unusual, yet this is exactly what is required. In addition, the challenge of equity of access to surgical options must be considered in light of the demographic and socioeconomic characteristics of severely obese individuals with type 2 diabetes identified in the current study.

There are several important limitations to this study, many of which have been outlined elsewhere (23). It is a cross-sectional self-report survey including only those who volunteered to take part. Therefore, results cannot be used to estimate population prevalence of factors involved, including the presence of obesity, depression, anxiety and comorbidity. Additionally, the instruments used to measure symptoms of anxiety and depression, while widely used and well-validated, are not diagnostic of these conditions, so caution must be exercised in the interpretation of emotional and psychological impairment. This study does, however, provide a detailed snapshot of the combined issues of severe obesity, demographic and socioeconomic disadvantage, comorbidity, and emotional well-being, and indicates several avenues that warrant further investigation and targeted intervention. Furthermore, we were conservative in adopting a control group of respondents with a BMI up to 34, rather than including only those in the healthy BMI range. Thus, compared with those in the healthy BMI range, those with severe obesity are likely to be even more disadvantaged in many respects.

In conclusion, this study demonstrates that severely obese people living with type 2 diabetes have cumulative stressors related to health, disability, demographic and socioeconomic factors, and impaired emotional well-being. These cumulative stressors deserve consideration and awareness of these issues may assist in developing realistic and appropriate healthcare goals.

Author Contributions

J.D. designed and performed the analysis and wrote the manuscript. J.S. led the design of the Diabetes MILES – Australia study and J.B. assisted J.S. in the design and conduct of the study. J.B. and J.S. are responsible for data collection and management, and contributed to the design and conduct of the analysis and the writing and critical review of the manuscript. J.D., K.J., P.R. and F.P. were part of the Expert Reference Group for the Diabetes MILES - Australia study. K.J., P.R., F.P. and G.L. provided input into the manuscript and critically reviewed drafts.

Disclosures

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J.B., P.R., F.P., and J.S. have no potential conflicts of interest to declare.

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A/Prof Dixon accepts full responsibility for the design and completion of the analysis presented in this manuscript, and the decision to submit and publish the manuscript. Prof. Speight takes full responsibility for access to the data.

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