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Investigating the effects of fatigue on blood glucose levels – Implications for diabetes

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ABSTRACT

The purpose of the current study was to investigate the differences and correlations between fatigue levels and blood glucose in individuals with and without diabetes, using psychometric and metabolic assessment of participants. The findings of the present study were that individuals with diabetes are susceptible to fatigue as measured by the Fatigue Severity Scale and the Checklist Individual Scale. Additionally, individuals with fatigue were found to be more susceptible to sleepiness and had overall lower poor sleep quality than those without diabetes as measured by the Karolinska Sleepiness Scale, the Epworth Sleepiness Scale and the Pittsburgh Sleep Quality index (<0.05).

1. Introduction

Non-communicable diseases such as obesity, diabetes mellitus and cardiovascular disease have exponentially increased in prevalence due to the high-fat, high-sodium diet popularised in recent times.[1–3] Diabetes mellitus (DM) currently affects 1.2 million Australians, with two-thirds of Australians considered overweight and 31% classified as obese.[4] By 2040, it is estimated that the global populations of individuals with DM will reach 642 million people.[5] Additionally, DM continues to be the leading cause of mortality globally, contributing to 5 million deaths worldwide in 2015 alone.[6] With DM continuing to rise, both in prevalence and health cost, it is important that more research is conducted to better understand the disease.

DM retains a heavy impact on the global population, and an association has been established between DM and fatigue.[7] The severity of fatigue is apparent, with 1.5 million Australians visiting a doctor each year for fatigue symptoms related to both acute and chronic fatigue.[8] Acute fatigue is a reversible condition; however, if a sufferer of fatigue sustains the condition for longer than 6 months, it is considered chronic fatigue. Both fatigue and DM have been shown to adversely affect the quality of life of affected individuals,[8,9] however, the relationship between diabetes mellitus and fatigue is not yet fully understood.

The psychological component of fatigue affects the ability of an individual with DM to be self-sufficient in treating and managing their blood glucose level (BGL), thus leading to a sense of fatigability, and in turn, hindering strategies to counter their DM symptoms. Fatigue significantly impacts the quality of life of an individual and, besides reducing their ability to manage daily activities, individuals experience physical problems such as body pains, muscle weakness, slowed reflexes, and weight gain.[10] The relationship between fatigue and type 1 diabetes (T1D) has been made evident in some of the literature, with fatigue being found to be more common in individuals with T1D as compared to a comparative (non-diabetes) group. Additionally, it has been established that in individuals with type 2 diabetes (T2D), fatigue was found to be significantly related to metabolic symptoms, higher body mass index (BMI), emotional distress, sleep apnoea, depressive symptoms, inflammation, and lack of physical activity.

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Fatigue is a common symptom of diabetes mellitus, impacting individuals on a daily basis, and particularly hindering self-management of symptoms.[9] The increased likelihood of individuals with DM experiencing fatigue is believed to be related to fluctuations in blood glucose levels, especially hyperglycaemia, due to impaired glucose metabolism.[11,12] There is currently a lack of, or incomplete understanding of the factors contributing to fatigue in T1D and T2D and this study therefore aimed to investigate the differences and correlations between fatigue and BGLs in DM relative to a comparative group.

2. Materials and methods

The recruitment stage of this study was conducted through the use of advertisement on social media and word of mouth communications. All willing participants were provided with given detailed information about the study protocol and inclusion and exclusion criteria.

To be included in the study, participants needed to be aged between 18 and 69 years. Participants for the comparative sample were individuals who did not suffer from a chronic disease (n = 41), and participants in the test sample were individuals with no other chronic disease than diabetes mellitus (n = 16). Other exclusion criteria included excessive alcohol intake, history of drug abuse, psychological or intellectual problems likely to limit compliance, non-fluency in the English language, and regular medication use (with the exception of medications for the management of diabetes mellitus, or antihypertensives in the instance of the test group).

Additionally, any participants with a systolic blood pressure (BP) reading of ≥160 mmHg or a diastolic BP reading of ≥100 mmHg were also excluded from the study. All exclusion criteria were accounted for in an in-house designed questionnaire modified from the Lifestyle Appraisal Questionnaire,[13] which collected information regarding demographics and lifestyle data. All subjects that were eligible to participate were required to refrain from consuming any food or drinks (water excepted), alcohol, medication, or nicotine for at least 8 hours prior to the commencement of the study. This fasting period was included to ensure the BGL and Haemoglobin A1c (HbA1c) were unaffected to ensure a true reading.[14] The importance of fasting from food and drinks, particularly alcohol consumption, is widely stated in the literature, as they may lead to an increase in BGLs, thereby affecting the reliability of the present study.[14,15]

Three blood pressure measurements were taken before and after the study. The participants were then required to complete a series of questionnaires. A modified version of the Lifestyle Appraisal Questionnaire[13] was administered to collect demographic data, the General Health Questionnaire[16] assessed overall psychological wellbeing and signs of psychiatric disorders in participants, the assessment of fatigue was carried out through the use of both the fatigue Severity Scale[17] and the Checklist Individual Scale,[18] and the assessment of sleepiness was carried out through use of the Karolinska Sleepiness Scale,[19] the Epworth Sleepiness Scale[20] and the Pittsburgh Sleep Quality Index.[21] Blood glucose measurements and Haemoglobin A1c assessments were then obtained by a finger prick blood spot test.

Statistical analyses were performed through the use of an independent sample t-test to compare the means of the group of individuals in the comparative group (without DM) with that of the individuals in the sample (with DM) group. Correlations in the data were analysed using a partial correlation test. The data from the comparative group was analysed using a Pearson's partial correlation, and the data from the DM group data was analysed using a Spearman's partial correlation, which is a non-parametric alternative, due to the lower sample size (n < 30).[22] The effect size was calculated as 0.6 using Cohen's power tables.[22]

Table 1
Presents the Mean questionnaire scores for all psychometric measures administered in this study.

Questionnaire	Mean ± Standard Deviation		p-value
	Comparative (n = 41)	Diabetes (n = 16)	
GHQ	6.66 ± 6.71	10.19 ± 11.21	0.15
CIS-20	61.05 ± 17.20	68.50 ± 19.63	0.16
FSS	31.73 ± 8.79	36.25 ± 12.07	0.12
KSS	3.95 ± 1.58	4.19 ± 2.29	0.66
ESS	6.98 ± 3.77	7.94 ± 3.64	0.39
PSQI	5.22 ± 2.54	7.19 ± 4.58	0.04[a]

Table 1 presents the data, using an independent sample t-test, to compare the mean and standard deviation of data derived from each questionnaire sourced from participants with and without diabetes.
Key: n = sample size, GHQ = General Health Questionnaire, CIS-20 = Checklist Individual Strength FSS = Fatigue Severity Scale, KSS = Karolinska Sleepiness Scale, ESS = Epworth Sleepiness Scale, PSQI = Pittsburgh Sleep Quality Index.
[a] Any significant values reported (p < 0.05), are indicated in red.

3. Results and discussion

The present study recruited a total of 57 participants (33 males, 24 females). The test group consisted of individuals with DM (7 males, 9 females) aged between 19–69 (mean age 40.06 ± 14.7). The comparative group consisted of 41 individuals aged between 20–54 (mean age 22.8 ± 6.9), consisting of individuals from the non-diabetes group who did not have any chronic illness (26 males, 15 females). Blood glucose levels (BGLs) and HbA1c levels were significantly higher in the DM sample (n = 16) compared to the comparative group (n = 41) (p < 0.0001). When assessing fatigue of the two sample groups, there were no statistically significant differences found in the scores of the fatigue questionnaires between the two groups. However, it should be noted that the DM sample group, in comparison to the comparative group recorded higher scores in all fatigue questionnaires in comparison to the sample group. The Pittsburgh Sleep Quality Index reported a significantly higher score for the DM group when compared to the comparative group (p = 0.043). However, the Fatigue Severity Scale reported a mean score within the threshold for fatigue (36.3 ± 12.1). Additionally, no significant associations were observed between fatigue and blood glucose or HbA1c levels in the DM group, however, the Pittsburgh Sleep Quality Index displayed a trend towards a positive correlation (p = 0.089, r = 0.269).

As expected, the DM group had significantly higher blood glucose and HbA1c values than the comparative group, indicating that the sample groups were reflective of their respective populations. Furthermore, the BMI of the DM group was significantly higher than that of the comparative sample. As for the associations between fatigue and BGLs, the present study established no significant correlation in the fatigue or sleepiness questionnaires in either the DM group or the comparative group.

Neither the comparative nor the test group showed a significant correlation between fatigue and metabolic variables. The inability to confirm associations between the variables may be attributed to the small sample size in the DM group, which was below the recommended sample size of n = 30 for sufficient sample power.[22] Due to the exploratory nature of the current study design, future studies should utilise a larger sample size, as well as separating the DM samples into T1D and T2D in order to establish associations between fatigue and blood glucose levels in both types of DM. Additionally, future research may benefit from distinguishing between acute and chronic fatigue, as well as incorporating a follow-

up period in order to establish whether fatigue may be a risk factor for the development of DM.

When measuring BGL, many variables must be considered in addition to the fasting period. All measurement systems for BGL have an inaccuracy of less than 5%,[23] however, variables such as uncalibrated glucometers, glucose strip variation, physical factors such as temperature, contamination, and medication may affect the data collected.[24] HbA1c measurement differs from a standard glucometer test as it does not require patient fasting and is a long-term measure of blood glucose management. However, the use of HbA1c also comes with its limitations as the measurement may be affected by haematological illness-related and genetic factors.[25] This cross-sectional and exploratory study therefore only provides an overview of associations between fatigue and BGLs and is unable to provide long-term information on the impact of this relationship. Subsequent studies taking all possible variables, and accounting for them in the analyses would allow for improved accuracy and validity of BGL measurements and provide potential advancements upon the current research. Furthermore, future studies should employ several BGL measurements in order to ensure maximum reliability of results.

The exclusion criteria of the present study excluded individuals affected by medication use, other chronic illnesses, excessive alcohol consumption, history of drug abuse, psychological or intellectual problems likely to limit compliance, and non-fluency in the English language. Furthermore, any participant whose blood pressure (BP) exceeded either 160 mmHg systolic or 100 mmHg diastolic was also excluded from the study. Individuals living with DM are more susceptible to higher blood pressure measurements,[26] and thus, a study with a higher threshold of BP could be a more accurate representation of the Australian population living with DM. The same exclusion criteria applied to the DM group, with the exception that participants who regularly used insulin or antihypertensive medication were allowed to participate, as these were taken to treat diabetes complications. We believe the strict exclusion criteria considerably decreased the size of both sample groups, thereby influencing the strength results. Future studies may better represent the non-diabetes group by permitting participation of individuals living with certain chronic illnesses and taking a particular range of medications to enable additional assessable variables to be introduced for study.

While the term ‘sleepiness’ is sometimes used interchangeably with ‘fatigue’, it is important that the two terms be differentiated into two separate definitions. The use of the sleepiness questionnaires in the present study ensured that any fatigue present was not attributed to sleepiness. This is particularly relevant, as the DM group showed a level of fatigue higher than the threshold for the condition. Although the DM group displayed significantly higher scores in the PSQI than the comparative group, no significant difference was reported between the two groups in the remaining two sleepiness questionnaire scores. This finding is consistent with the literature, as it has been established that people with DM are highly susceptible to sleepiness.[9] The sleepiness questionnaires were administered as a control measure to eliminate the possibility that a high result in one of the two fatigue questionnaires was due to the presence of sleepiness or poor sleep quality.

To ensure reliability of the psychometric measures used in the study, the reliability coefficient or Cronbach alpha score[27] was examined. The General Health Questionnaire (GHQ)[28] targeted the mental and physical health of an individual, reporting an alpha score of 0.86.[29] The measurement of lifestyle risk factors was measured by the modified Lifestyle Appraisal Questionnaire (LAQ),[13] which reported a Cronbach alpha score of 0.89.[30] Fatigue symptoms were measured using two questionnaires, the Checklist Individual Strength questionnaire (CIS-20)[18] and the Fatigue Severity Scale (FSS) 17], with the questionnaires reporting alpha scores of 0.96 and 0.93, respectively.[31,32] The sleepiness questionnaires reported alpha scores ranging from 0.81 to 0.88.[33,34] An alpha score of >0.7 represented an acceptable value of reliability and internal consistency, indicating that the questionnaires administered in the study were all suitable for use in a research setting.[35]

4. Conclusion

The present study established that individuals with diabetes are susceptible to fatigue, as well as being more susceptible to poor sleep quality when compared to the non-diabetes group. Future research is required in order to understand the relationship between fatigue and blood glucose levels, and its implications for diabetes.

Credit author statement

Curtis Beehan-Quirk: Conceptualization, Methodology, Formal Analysis, Investigation, Writing – Original Draft, Visualisation.

Luke Jarman: Validation, Formal analysis, Writing – Review & Editing.

Shamona Maharaj: Validation, Formal analysis, Writing – Review & Editing, Supervision.

A/Prof Sara Lal: Resources, Writing – Review & Editing, Project administration, Funding acquisition, Supervision.

Prof Ann Simpson: Writing – Review & Editing, Supervision.

Dr Najah Nassif: Writing – Review & Editing, Supervision.

Declaration of Competing Interest

All authors have none to declare.

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