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ORIGINAL RESEARCH

Evaluation of Vicarious Somatosensory Experience in Diabetes Mellitus: Bases for Empathy and Social Cognition

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Purpose: Diabetes Mellitus (DM) is a common metabolic disorder with negative impacts on brain functions. Social cognition and vicarious experience impairments are features of DM. This research aimed to estimate the social cognition and vicarious experience among Jordanian people with diabetes.

Patients and Methods: Cognitive abilities were assessed using the Vicarious Pain Questionnaire (VPQ) and the Mirror Touch Questionnaire (MTQ). Data on disease history, medications, routine laboratory measurements, and anthropometric indices.

Results: Patients had lower pain responses and intensity scores, and higher unpleasantness scores than the control group ($p < 0.05$). Most of the VPQ and MTQ measures were mainly impaired among study participants who had higher education, were not practicing exercises, and were not consuming healthy diets ($p < 0.05$). The number of responses to the VPQ and average pain intensity were negatively correlated with age and positively correlated with both the serum aminotransferase (AST) concentration and the serum urea concentration ($p < 0.05$). The average unpleasantness score was positively correlated with the duration of therapy, serum creatinine, and albumin concentrations ($p < 0.05$). The final regression models for the number of pain responses and localized–generalized included group, practicing exercise, and AST, while the model for the average pain intensity included only the grouping variable. The model for average unpleasantness included grouping, AST, Albumin, consuming a healthy diet, and duration of therapy.

Conclusion: The Jordanian diabetic patients who participated in the study had impaired social cognition and vicarious experience. A healthy lifestyle had a significant effect on the scores of the vicarious experience in addition to the level of education. Despite being the first study in Jordan to assess vicarious experience in DM, further studies are needed considering imaging and electrophysiological workup. Besides, further prospective studies are needed to determine the significance of the current study.

Keywords: diabetes mellitus, social cognition, vicarious experience

Introduction

Social cognition is concerned with how individuals communicate with one another in social contexts by recognizing their actions, intentions, and feelings. The mirror mechanism is the specific mechanism that facilitates this capability. The mechanism transforms sensory data about other people's actions into a motor type similar to what observers independently produce when they mimic or carry out those actions. Without requiring any detailed cognitive elaboration, the

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observer can understand other people's behavior due to the resemblance between the motor format produced when one observes others and the one produced inwardly during emotional and motor conduct.[1]

The vicarious experience delivers a feeling or experience from one person to another.[2] As previously believed to be a neurobiological indicator of empathy, the hypothesis posits that activating brain regions associated with one's own experiences upon seeing other people's experiences induces the same response. Certain regions of the brain, particularly the anterior cingulate cortex and anterior insula, are responsive to vicarious experience. These regions contain a network of neurons referred to as the mirror neuron system.[3]

A cluster of neurons becomes active in response to an individual's actions or observations of others' conduct. The premotor area and the inferior parietal lobule (IPL) are the two primary components of the mirror neuron system.[4] Furthermore, the superior temporal sulcus (STS) serves as the primary node of the mirror neuron system.[5]

Diabetes mellitus (DM) is a long-term metabolic disorder characterized by insulin resistance or impaired insulin signaling. DM often leads to problems with small and large blood vessels.[6] DM has been acknowledged to be a significant risk factor for cognitive impairment because it affects brain blood flow and metabolism.[7] Two potential underlying causes of dementia include insulin resistance and deficiency, which may start and advance the illness in conjunction with tau phosphorylation and amyloid protein.[8]

The prevalence of type II diabetes is increasing with the burden disproportionately falling on older adults and racial/ethnic minorities.[9] Older adults with diabetes show greater cognitive decline and there are disparities in cognitive function by race/ethnicity that can be explained by social determinants such as wealth.[9]

Conflicting evidence exists on the relationship between diabetes mellitus (DM) and Alzheimer's disease (AD) biomarkers.[10] DM is associated with biomarkers of tau but not with amyloid-β.[10] This knowledge is valuable for improving dementia and DM diagnostics and treatment.[10]

In Jordan, DM is a significant health problem that burdens the health system, with a prevalence of 15.4% in 2021, and is expected to increase to 17.1% in 2030, according to the 10th edition of the International Diabetes Federation (IDF) Diabetes Atlas.[11] However, the underlying mechanism and effect of these interventions on Jordanians' living standards need to be better investigated. Specifically, the investigation of social cognition and vicarious experience in people with diabetes has not been previously explored in Jordan, which represents the aim of the present study.

The hypothesis tested was that people with diabetes have more impairment in social cognition and vicarious experience than normal control nondiabetic individuals, and the primary goal of the study was to assess the effect of diabetes on social cognition and vicarious experience in Jordanian people with diabetes and compare it to that of healthy people. Secondary goals included determining the relationships and interactions between social cognition and vicarious experience, as well as lifestyle, medication use, body mass index (BMI), waist-to-hip ratio (WHR), glycemic markers, and diabetes duration among people with diabetes in Jordan.

Subjects and Methods

This was a retrospective case-control study, and the protocol complies with the Declaration of Helsinki and was approved by the Hashemite University's Institutional Review Board (No. 10/3/2022/2023).

Site and Participants of the Study

The investigation was carried out in university and governmental hospitals in Jordan (the hospitals where the Hashemite University students have clinical training).

After a detailed explanation of the study's goals and the anonymous data collection procedure, participants were told about the purpose and benefits of the analysis. Participation in the study was voluntary. Eligible participants who met the inclusion criteria and completed the consent form were enrolled in the study.

The sample of the study was divided into two groups according to the age and sex status of the subjects:

Group I included adult people with diabetes aged 30–60 years.

Group II included healthy adults aged 30–60 years.

Calculating the Sample Size

Based on a prior investigation by Ebady et al,[12] cognitive impairments were detected in 35% of the people with diabetes and 18.3% of the non-diabetic group. To achieve 80% power and a 5% significance level for group differences, a minimum sample size of 242 participants was required (121 participants in each group). To account for potential losses, an additional 10% was added, resulting in a sample size of 268 participants overall (134 participants in each group). PS version 3.1.6 was used to calculate the sample size using an uncorrected chi-square test.[13]

The inclusion criteria for patients were as follows: male and female adult patients with diabetes (type I and type II) aged 30–60 years and matched for age and sex.

The exclusion criterion was a history of other neurological conditions, mental illnesses, or metabolic issues that may impact cognitive ability.

Procedure

History taken with emphasis on age, duration of diabetic illness, education level, occupation, current medications, diabetic complications, and lifestyle (smoking, regular exercise, healthy dietary habits).

The following data were collected from participant records: duration of DM (date of DM diagnosis), medication history since diagnosis, and last laboratory measurements [glucose, hemoglobin A1C (HBA1C), liver function tests, kidney function test].

Anthropometric and Functional Measurements

Body Mass Index

The calculation of a person's body mass index (BMI; kg/m2) involves dividing their body weight (in kilograms) by the square of their height (in meters). A digital scale was used to measure the subjects' height and body weight. Before taking their weight and height readings, each participant was requested to take off their hats, shoes, and bulky clothing. They were also instructed to stand straight, place their heels together, and face forward.[14]

Waist-to-Hip Ratio (WHR)

Using a soft cotton tape measure, waist circumferences were taken halfway between the iliac crest and the lower rib border. Using a soft cloth tape measure, hip circumferences were taken at the point where the circumference over the greater trochanter was the widest. The waist-to-hip ratio (WHR) was computed by dividing the individuals' circumference measurements.[15]

Testing Vicarious Experience

The subjects were shown two sets of videos and then assessed by the Vicarious Experiences Questionnaire.[16]

The Vicarious Pain Questionnaire (VPQ)

The 16 video clips in the pain films showed people with mild to moderate pain from injections or sports injuries. Every clip lasted roughly ten seconds and was audio-free. Following each film, participants were first asked to indicate whether they felt pain in their bodies while watching the video and then to score how harsh the experience was ("How unpleasant did you find the experience of watching this video? One is not unpleasant, and ten is quite unpleasant.

Participants were asked three more questions if they selected "yes" to the first question. The first was questioned about the intensity of their pain experience (1 was incredibly light, 10 was intensely agitated, and 0 was not painful at all). (2) to specify where they experienced the pain (ie, "localized to the same point as the observed pain", "localized but not to the same point", or "a general/nonlocalizable pain experience"). (3) The pain adjectives that most accurately depict their situation were chosen (from a set of 20 with multiple selections possible).

These latter ones, which included ten descriptors with sensory properties and 10 with affective qualities, were taken from a standard set used in the literature on pain assessment.

Mirror-Touch Questionnaire (MTQ)

The twenty-four brief video snippets that made up the “touch and itch” videos showed touch and itch. The stimuli that were scored to classify the participants were fourteen movies that showed touch on a human. These consisted of seven sets of stimuli that showed touch on the left or right, namely:

(1) Put a finger on the cheek. (2) Press the tip of a knife against the cheek. (3) Use a finger to touch the hands in an egocentric manner. (4) Use a knife to touch the hands in an egotistical manner. (5) Use a finger to contact the hands in an allocentric manner. (6) Place a finger in an egocentric manner and touch crossed hands. (7) With your face turned back, touch your cheek with a finger.

Six movies of people touching inanimate objects were also included. These included videos of people touching a fan from both the left and right sides, a dummy head, and dummy hands from an egocentric perspective.

Four twenty-second movies featured a person with significant chest or upper arm scratches.

Participants were asked, “Do you feel anything on YOUR body?” following the playback of each video. (apart from discomfort, disgust, or flinching) [Yes/No]. Three further questions were posed to them after they gave an affirmative response: They were initially asked, “How would you describe the sensation?” and were required to select one of the following answers: touch (painless); pain (painful); tingling; itchiness; scratching sensation; or other [asking them to list any additional sensations they experienced].

The second question asked, ”Where was it felt on the YOUR body?” The participants were instructed to select one of the following options: left face, right face, left hand, right hand, left arm, right arm, chest, back, or other [asked to identify what other regions]. Not localizable. They were ultimately questioned, ”How intense was it? (0 is nothing, and ten is truly intense).

Statistical Methods

Appropriate statistical methods were employed to analyze the data using SAS 9.1 software. Categorical variables are presented as numbers and percentages and included smoking status, sex, education, exercise practice, and type of medication. Conversely, continuous variables, eg, MTQ and VPQ scores, are shown as the median and interquartile range (IQR). Normality tests, such as the Kolmogorov–Smirnov test and the Shapiro–Wilk test, showed that the continuous variables were not distributed normally. The chi-square test was used to evaluate the relationships between categorical variables. Nonparametric tests, such as the Kruskal–Wallis and Wilcoxon signed-rank tests, were used to evaluate the group differences in variables that were not normally distributed. As the variables were nonnormally distributed, the correlation was investigated using the Spearman correlation between demographic variables and social cognitive scores. Linear regression models were used to construct regression models to examine the predisposing factors for the MTQ and VPQ score variables. The variables included in the regression models were selected according to various strategies, eg, scientific reasoning, the univariate analysis outcomes, and clinical relevance, until the final models were reached with only significant variables. The regression coefficients and their p-values are reported for the final models for each cognitive measure.

Results

Table 1 shows that males and females were distributed equally between the patient and control groups ($p > 0.05$), while the people with diabetes group (median age = 52.0 (IQR=11.0)) was older than the control group (median age = 42.0 (IQR=16.0), $p < 0.001$). The table also shows that the highest percentage of the people with diabetes group was not working (43.1%), while the highest percentage of the control group had professional jobs (41.3%, $p = 0.02$). In addition, the table shows that half of the people with diabetes had only a high school education. In contrast, the highest percentage of the individuals in the control group (45.3%) had an education level higher than high school ($p = 0.003$). Although neither group showed significant differences in smoking or consuming healthy diets ($p > 0.05$), a greater percentage of the people with diabetes (24.6%) practiced exercise than did the control group (12.0, $p = 0.03$). Interestingly, BMI and the WHR were greater in the people with diabetes group (median BMI = 31 (IQR=9.7) and median WHR = 0.97 (IQR=0.09), respectively) than in the control group (median BMI = 27.7 (IQR=4.0) and WHR = 0.94 (IQR=0.09), respectively; $p < 0.05$). Disease duration and type of medication used are also presented in Table 1. Slightly less than half

Table 1 Demographic Attributes and Biological Parameters of People with Diabetes Patients in the Research Groups

Factor	Control Group No. (%)	Group with diabetes No. (%)	Statisticsvalue	P-value
Sex[a]				
Male	38 (50.7)	68 (52.3)	0.05	0.82
Female	37 (49.3)	62 (47.7)		
Age (Years)[b]	42.0 (16.0)	52.0 (11.0)	31.0	< 0.001
Occupation[a]				
No work	22 (29.3)	56 (43.1)	10.1	0.02
Technical	12 (16.0)	32 (24.6)		
Professional	31 (41.3)	30 (23.1)		
Retired	10 (13.3)	12 (9.2)		
Education[a]				
Less than high school	11 (14.7)	35 (26.9)	11.8	0.003
High School	30 (40.0)	65 (50.0)		
Higher education	34 (45.3)	30 (23.1)		
Smoking	40 (53.3)	60 (46.2)	0.98	0.32
Exercise	9 (12.0)	32 (24.6)	4.7	0.03
Healthy Diets	22 (29.3)	34 (26.2)	0.2	0.62
BMI[b]	27.7 (4.0)	31.0 (9.7)	19.7	< 0.001
WHR[b]	0.94 (0.09)	0.97 (0.09)	9.7	0.002
Disease Duration[b]		5.5 (9.3)		
Medication[a]				
Insulin		47 (36.2)		
Drugs		61 (46.9)		
Insulin and Drugs		18 (13.9)		
No treatment		4 (3.1)		
Duration of treatment (Years)[b]		5.5 (9.3)		
Glucose[b]		10.0 (5.9)		
HBA1C[b]		8.0 (2.9)		
ALT[b]		20.0 (13.3)		
AST[b]		19.4 (13.3)		
Urea[b]		5.2 (3.4)		
Creatinine[b]		68.8 (27.5)		
Albumin[b]		3.9 (0.9)		

Notes: [a]Numbers (%) and chi-square test results were reported; [b]medians (interquartile ranges (IQR)) and Kruskal–Wallis test results were reported.
Abbreviations: BMI, body mass index; WHR, waist-to-hip ratio; HBA1C, hemoglobin A1C; ALT, alanine transaminase; AST, aspartate aminotransferase.

Table 2 Social and Cognitive Outcomes of the Study Groups

	Factor	Control (Median (IQR))	Group with Diabetes (Median (IQR))	Kruskal–Wallis test (Statistic, p value)
VPQ	No. of pain responses	3.0 (2.0)	2.0 (1.0)	37.9, < 0.0001
	Average pain intensity	5.0 (4.8)	1.0 (4.5)	40.7, < 0.0001
	Localized – Generalized	3.0 (2.0)	2.0 (1.0)	37.9, < 0.0001
	Average unpleasantness	5.1 (1.5)	7.5 (8.0)	7.8, 0.005
MTQ	MTS score	0.0 (0.0)	0.0 (1.0)	0.03, 0.9

Abbreviations: VPQ, Vicarious Pain Questionnaire; MTQ, Mirror-touch Questionnaire; IQR, Interquartile range.

of the patients (47%) used only oral drugs to treat diabetes, more than one-third (36.2%) used only insulin, and 14% used both oral drugs and insulin. The median duration of the disease in the people with diabetes group was approximately eight years. Finally, the average values of the biological measures of the people with diabetes group are also presented in the table These included glucose, HBA1C, albumin, aspartate aminotransferase (AST), alanine transaminase (ALT), creatinine, and urea.

Table 2 shows that the 2 people with diabetes group had lower scores on social cognitive measures than did the control group. Regarding the VPQ score, the number of pain responses (median=2, IQR=1.0), average pain intensity (median=1.0, IQR=4.5), and number of localized minus generalized responses (L-G score) (median=2.0, IQR=1.0) were significantly lower in the people with diabetes group than in the control group (number of pain responses (median=3.0, IQR=2.0); average pain intensity (median=5.0, IQR=4.8; and L-G score (median=3.0, IQR=2.0), $p < 0.01$). In contrast, the average unpleasantness score in the people with diabetes group (median=7.5, IQR=8.0) was significantly greater than that in the control group (median=5.1, IQR=1.5). The mirror-touch (MTS) score did not significantly differ between the two groups ($p > 0.05$).

Table 3 shows that the number of pain responses and L-G score differed significantly by education level and the condition of practicing exercise. The results showed that the higher education group reported less pain responses (median=2.0, IQR=2.0) and L-G scores (median=2.0, IQR=2.0) than did the group with less than a high school education (median=2.0, IQR=1.0; median=2.0, IQR=1.0; respectively, $p < 0.05$). The group that practiced exercise reported fewer pain responses (median=2.0, IQR=1.0), and lower L-G scores (median=2.0, IQR=1.0) than did the group that did not practice exercise (median=2.0, IQR=2.0; median=2.0, IQR=2.0; respectively, $p < 0.05$). The average pain intensity score differed significantly according to occupation: the retired group reported the highest pain intensity (median=5.1, IQR=5.8), while the group with no work reported the least pain intensity (median=1.0, IQR=4.5, $p = 0.01$). The average unpleasantness score differed significantly according to education level, practice of exercise, and consumption of a healthy diet. The group with higher levels of education reported the highest level of unpleasantness (median=7.5, IQR=5.0) compared with the group with lower levels of education ($p = 0.001$). The participants who practiced exercise reported higher levels of unpleasantness (median=7.5, IQR=5.0) than did others who did not practice exercise (median=5.1, IQR=4.9, $p = 0.006$). The participants who reported eating a healthy diet reported less levels of unpleasantness (median=5.1, IQR=5.5) than did those who did not eat healthy diets (median=5.8, IQR=5.2, $p = 0.02$). MTS scores differed significantly according to the practice of exercise and the consumption of healthy diets. MTS scores were significantly greater for participants practicing exercise (median=0, IQR=2.0) and eating healthy diets (median=0, IQR=2.0) than those who were not practicing exercise (median=0.0, IQR=0.0) and not eating healthy diets (median=0.0, IQR=0.0, $p = 0.01$).

Table 4 shows that the number of VPQs responded negatively to age ($r= - 0.2$, $p = 0.003$) and positively to both AST ($r = 0.2$, $p = 0.02$) and urea ($r = 0.2$, $p = 0.03$). The average pain intensity was negatively correlated with HBA1C levels ($r= - 0.2$, $p = 0.04$). The L-G score was negatively correlated with age ($r= - 0.2$, $p = 0.004$) and positively correlated with both AST ($r = 0.2$, $p = 0.02$) and urea ($r = 0.2$, $p = 0.03$). The average unpleasantness score was positively correlated with

Table 3 Social Cognitive Functions by Study Characteristics

	VPQ				MTQ
	No. of Pain Responses (Median (IQR))	**Average Pain Intensity (Median (IQR))**	**Localized – Generalized (Median (IQR))**	**Average Unpleasantness (Median (IQR))**	**MTS Score (Median (IQR))**
Sex					
Male	2.0 (2.0)	2.6 (6.0)	2.0 (2.0)	5.6 (6.1)	0.0 (0.0)
Female	2.0 (2.0)	2.3 (4.5)	2.0 (2.0)	5.0 (3.8)	0.0 (1.0)
Sig (Kruskal–Wallis, p value)	0.1, 0.7	1.6, 0.2	0.1, 0.7	1.4, 0.2	0.1, 0.7
Occupation					
No work	2.0 (2.0)	1.0 (4.5)	2.0 (2.0)	5.0 (4.6)	0.0 (0.0)
Technical	2.0 (1.5)	1.5 (5.3)	2.0 (1.5)	5.6 (5.8)	0.0 (1.0)
Professional	2.0 (1.0)	4.3 (7.0)	2.0 (1.0)	5.4 (2.9)	0.0 (0.0)
Retired	2.0 (0.0)	5.1 (5.8)	2.0 (0.0)	5.4 (5.0)	0.0 (0.0)
Sig (Kruskal–Wallis, p value)	4.6, 0.2	10.5, 0.01	4.6, 0.2	0.9, 0.8	2.6, 0.5
Education					
Less than HS	2.0 (1.0)	4.0 (8.5)	2.0 (1.0)	5.3 (2.9)	0.0 (1.0)
Completed HS	2.0 (2.0)	1.0 (4.5)	2.0 (2.0)	5.0 (8.0)	0.0 (0.0)
Higher Education	2.0 (2.0)	4.7 (6.7)	2.0 (2.0)	7.5 (5.0)	0.0 (0.0)
Sig (Kruskal–Wallis, p value)	10.1, 0.006	6.2, 0.05	10.1, 0.006	13.2, 0.001	0.9, 0.6
Smoking					
No	2.0 (2.0)	2.3 (5.0)	2.0 (2.0)	5.4 (4.6)	0.0 (0.0)
Yes	2.0 (2.0)	2.3 (6.0)	2.0 (2.0)	5.4 (6.1)	0.0 (1.0)
Sig (Kruskal–Wallis, p value)	0.02, 0.9	0.6, 0.4	0.02, 0.9	0.07, 0.8	0.6, 0.4
Exercise					
No	2.0 (2.0)	2.3 (6.0)	2.0 (2.0)	5.1 (4.9)	0.0 (0.0)
Yes	2.0 (1.0)	1.6 (5.0)	2.0 (1.0)	7.5 (5.0)	0.0 (2.0)
Sig (Kruskal–Wallis, p value)	5.1, 0.02	0.06, 0.8	5.1, 0.02	7.6, 0.006	6.0, 0.01
Healthy diets					
No	2.0 (2.0)	2.3 (6.0)	2.0 (2.0)	5.8 (5.2)	0.0 (0.0)
Yes	2.0 (1.0)	4.3 (4.5)	2.0 (1.0)	5.1 (5.5)	0.0 (2.0)
Sig (Kruskal–Wallis, p value)	1.1, 0.3	0.001, 1.0	1.1, 0.3	5.7, 0.02	6.2, 0.01

Notes: 1, the higher education group against the other two groups. 2, the professional group against the other three groups.
Abbreviations: VPQ, Vicarious Pain Questionnaire; MTQ, Mirror-touch Questionnaire; MTS, Mirror-touch Score; IQR, Interquartile range.

duration of therapy (r = 0.2, p = 0.01), creatinine level (r = 0.2, p = 0.02), and albumin level (r = 0.3, p = 0.01), while it was negatively correlated with AST (r = −0.2, p = 0.02). The MTS score was not significantly correlated with any of the other biological metrics.

Table 4 Correlations Between Social Cognitive Functions and Demographic Characteristics and Biological Measures

	VPQ								MTQ	
	No. of Pain Responses		Average Pain Intensity		Localized – Generalized		Average Unpleasantness		MTS Score	
	r	p value	r	p value	r	p value	r	p value	r	p value
Age	−0.2	0.003	−0.1	0.08	−0.2	0.004	0.1	0.2	−0.1	0.5
BMI	−0.04	0.6	−0.1	0.1	−0.04	0.6	0.1	0.3	−0.1	0.4
WHR	−0.1	0.1	0.1	0.1	−0.1	0.1	0.1	0.1	−0.1	0.4
Duration of therapy	−0.1	0.4	−0.05	0.6	−0.1	0.4	0.2	0.01	0.1	0.5
Glucose	0.05	0.6	−0.1	0.1	0.1	0.6	−0.002	1.0	0.1	0.5
HBA1C	−0.02	0.8	−0.2	0.04	−0.02	0.8	−0.1	0.3	−0.01	0.9
ALT	0.1	0.5	−0.01	0.9	0.1	0.5	−0.2	0.05	0.1	0.2
AST	0.2	0.02	0.05	0.6	0.2	0.02	−0.2	0.02	0.1	0.3
Urea	0.2	0.03	0.1	0.2	0.2	0.03	−0.1	0.4	0.03	0.7
Creatinine	−0.03	0.8	0.1	0.2	−0.03	0.8	0.2	0.02	−0.01	0.9
Albumin	−0.1	0.3	0.2	0.08	−0.1	0.3	0.3	0.01	−0.01	0.9

Abbreviations: VPQ, Vicarious Pain Questionnaire; MTQ, Mirror-touch Questionnaire; MTS, Mirror-touch Score; BMI, Body mass index; WHR, Waist-to-Hip Ratio; HBA1C, hemoglobin A1C; ALT, alanine transaminase; AST, aspartate aminotransferase.

As demonstrated in Table 5; the final models for the number of pain responses included the study grouping (b = - 1.2, p < 0.001), practicing exercise (- 0.6, p = 0.005), and AST (b = 0.02, p = 0.007), controlling for age, ALT, and education. The model for average pain intensity included only the study grouping (b = - 2.2, p < 0.001), controlling for HBA1C,

Table 5 Factors That Were Significantly Associated with the Final Regression Models of Social Cognitive Measures

		No. of Pain Responses	Average Pain Intensity	Localized – Generalized	Average Unpleasantness
Group	β coefficient	−1.2	−2.2	0.7	1.3
	p value	< 0.001	< 0.001	0.01	0.005
Exercise	β coefficient	−0.6		0.6	
	p value	0.005		0.01	
AST	β coefficient	0.02		002	−0.1
	p value	0.007		0.01	0.0002
Albumin	β coefficient				1.6
	p value				0.002
Healthy diets	β coefficient				−3.0
	p value				0.001
Duration of therapy	β coefficient				0.2
	p value				0.006

Abbreviation: AST, Aspartate aminotransferase.

education, and occupation. The final model for the L-G score included the study group (b = 0.7 p = 0.01), practicing exercise (0.6, p = 0.01), and AST (b = 0.02, p = 0.01), controlling for age, urea, creatinine, and education. The final model for average unpleasantness included group participation (b = 1.3, p = 0.005), AST (b = −0.1, p = 0.0002), albumin (b = 1.6, p = 0.002), eating healthy diets (b = - 3.0, p = 0.001), and the duration of diabetes therapy (b = 0.2, p = 0.006), controlling for creatinine, education, and practicing exercise.

Discussion

Our study aimed to test the hypothesis that Jordanian people with diabetes have greater social cognition and vicarious experience impairment than healthy individuals. We evaluated how various factors, such as lifestyle, sex, BMI, WHR, glycemic marker levels, and duration of DM illness, affect social cognition and vicarious experience. Our data suggest that individuals with diabetes exhibit poorer social cognition and vicarious experience than individuals without diabetes. Lower cognitive function was linked to worse glycemic control (higher HbA1c levels) in an earlier study that examined the relationship between cognitive impairment and glycemic control in older adults with diabetes. Social support for diabetes care helps lower this risk, especially for individuals with lower cognitive function.[17]

Metabolic control and cardiovascular risks have been extensively linked with BMI and the WHR. Several studies have explored the correlation between BMI and WHR and social cognition among people with diabetes and have shown that greater BMI is linked to cognitive disorders and diminished social cognition.[18] Increased BMI and WHR may compromise individuals' ability to empathize via vicarious experiences.[19]

The biological parameters and demographic data of the studied DM patients and a control group showed that the people with diabetes group was older than the control group, consistent with the known link between age and the risk of developing DM. DM, especially type II occurs mainly in older age groups and predominantly among those with an unhealthy lifestyle.[20]

Possible socioeconomic variables impacting diabetes incidence are highlighted by the distribution of professional positions in the control group and the higher rates of unemployment and technical jobs in the people with diabetes group. It was suggested that people associated with professional driving, manufacturing, and cleaning have a threefold greater risk of diabetes than university teachers and physiotherapists.[21] Hence, occupations with more unhealthy lifestyles increase the risk of developing DM. This fact makes it difficult to differentiate between the cause and the effect, DM impaired the skills needed for having professional jobs or technical jobs with unhealthy lifestyles predisposed to DM. The distinction between these two possibilities was out of the design or nature of the observational nature of the current study.

One potential area for improvement is the people with diabetes group's lower reported activity levels. Exercise is a known preventive factor against DM. Regular exercise reduces the body fat percentage, further maintaining stable insulin signaling.[22] The illness's average length and distribution of treatment methods are consistent with trends observed in people with diabetes worldwide. Insulin usage may suggest more advanced instances of DM, whereas most of the medication used alone may represent early-stage cases.

The people with diabetes group's biological measurements were within the predicted ranges. Diabetes-related metabolic abnormalities are associated with higher HbA1c, glucose, ALT, AST, and urea levels.[23] These findings support the validity of the study in identifying the typical physiological changes in people with diabetes.

In our study, the people with diabetes group had lower scores on social cognitive measures than did the control group, as indicated by the increase in both the VPQ and MTQ scores and the increase in the values of the measured laboratory variables. This finding aligns with that of a previous study by Zhang et al,[24] which revealed that participants with untreated DM and higher-than-normal HbA1c levels had worse cognitive functioning. Another study is in agreement with our study, in which higher HbA1c levels were significantly associated with reduced performance across all social cognition domains, with more potent effects on theory of mind and emotion processing than on social perception; moreover, the link between HbA1c and a decrease in social cognition may be explained by several different pathways, including chronically high blood sugar levels. Metabolic disturbances lead to changes in large and small blood vessels, significantly impacting cerebral blood flow and brain structure.[25]

The findings from this study showed that the higher education group reported more pain responses and a greater level of unpleasantness than did the group with less than a high school education. The average pain intensity score differed significantly according to occupation: the retired group reported the highest pain intensity, and the group with no work reported the least pain intensity. These findings agree with a study by Ghoreishi et al,[26] on education intervention based on social cognition; they found that when educational interventions are planned and put into place, they are more effective at promoting emotional adaptation, self-efficacy and self-regulation, and patient self-care increases with educational interventions, improving physical, mental, and blood sugar control in those with DM.

The group that practiced exercise reported fewer pain responses and greater levels of unpleasantness than did the group that did not practice exercise. In agreement with our results, a study investigated physical activity-related social cognition and revealed that individuals who were not diagnosed with diabetes expressed more intentions toward physical activity and a more favorable attitude toward it.[27] Research on exercise barriers and their relationship with self-efficacy in individuals with diabetes mellitus revealed that patients in lifestyle modification programs reported a variety of obstacles to exercising and that a lack of motivation negatively impacted their baseline levels of exercise self-efficacy. Other factors to take into account include depressive symptoms and increased obesity.[28]

The results from our investigation suggested that age is a relatively ineffective descriptor of the number of pain responses and L-G pain according to the VPQ score. This finding fits with what Keightley et al[29] found: a particular age difference in the processing of emotional faces and other social skills does not change much with age.

The study demonstrated that the AST, urea, creatinine, and albumin levels were effective assessment metrics used to test for the number of pain responses and L-G pain, and they were positively correlated with unpleasantness. These findings are in line with the findings of Umegaki et al,[30] who discovered that the connection between blood albumin levels, urea, and creatinine levels, and DM-related cognitive decline may lead to the development of effective prophylactic or treatment strategies for this deterioration.

The HBA1C score was influential in determining average pain intensity according to the VPQ score, and this finding is consistent with the results of Plotnikoff et al.[31]

The information provided in our study explored possible relationships between various factors and different aspects of pain experiences.

For the people with diabetes group, exercise, and AST were included in the final regression model: exercise had negative coefficients, indicating a decrease in pain response. Moreover, AST had a positive correlation, suggesting increased pain responses with higher AST levels.

Study group and exercise had positive coefficients, implying an increase in the L-G score. AST had a positive coefficient, suggesting an increase in the L-G score with increasing AST. These findings may be interpreted as increased cognitive function is correlated with exercise.

This finding aligns with earlier research that established a link between exercise and improved cognitive function. For example, when participants in one study were compared to those without cognitive impairment, it was discovered that those with cognitive impairment were less likely to be physically active. Positive correlations for the serum albumin concentration and group engagement suggested that average discomfort would increase. This finding aligns with that of a prior study that revealed that a decreased risk of cognitive impairment was associated with increased serum albumin levels. Higher albumin levels may be linked to healthier people and improved cognitive function, as lower albumin levels have been associated with poor cognitive performance.[32]

Group participation and the serum albumin concentration had positive coefficients, suggesting an increase in average unpleasantness. This finding is consistent with a previous study that revealed that individuals with higher levels of albumin had a lower risk of cognitive impairment. Lower albumin levels have been linked to poor cognitive performance, suggesting that higher albumin levels may be associated with healthier individuals and better cognitive function.[32,33]

Moreover, AST had a negative coefficient, indicating a decrease in unpleasantness with increasing AST. This finding is consistent with that of another study that investigated the relationships between liver enzymes, specifically AST and ALT, and cognitive function. These findings suggest that elevated AST/ALT levels could be a risk factor for cognitive impairment in the future for older adults whose baseline cognitive function is normal. The study proposed a potential mechanism for cognitive impairment involving the influence of AST/ALT on the volume of the right hippocampus, a brain region crucial for memory.[34]

A negative coefficient was shown for healthy diets, implying a decrease in unpleasantness for those with healthier diets. This finding is in accordance with research indicating that the risk of dementia and age-related cognitive decline are significantly influenced by dietary choices made in adulthood. Although the exact physiological mechanisms underlying these benefits remain unclear, neuroinflammation and brain insulin activity regulation likely play a role. Cognitive difficulties are common in people with DM, particularly in areas involving the medial temporal lobes. The relationship between food consumption and decreased cognitive performance in people with type 2 diabetes is likely explained by this impairment, which is linked to increases in oxidative stress and cytokine release caused by food.[35]

Conclusion

The Jordanian people with diabetes who participated in the study had impaired social cognition and vicarious experience. Lifestyle, including practicing exercise and eating a healthy diet, may have a significant effect on the scores of the vicarious experience questionnaire in addition to the level of education.

Limitations and Recommendations

The current study has financial and logistic limitations that have prevented additional investigations to confirm and support or explain the results of the vicarious experience questionnaire. Mirror neurons were better studied in previous studies using electroencephalography or radiological techniques; however, we could not perform these studies because of a lack of funds for the current project. It is recommended that future studies include additional confirmatory investigations and follow-up prospectively on the effect of manipulating the most significant factors that affected the scores on the vicarious experience questionnaire in our study, such as exercise, healthy diet eating, and other laboratory results, and evaluate the effect of changes in these factors on social cognition and mirror neuron function.

Another limitation was having two separate groups for type 1 and type 2 diabetes, because of the time needed to interview the patients, some of the patients found it boring especially if they had other plans for the day of their hospital visit, so we could not recruit a sufficient number of participants to have separate groups for type 1 and type 2 diabetes.

Abbreviations

ALT, Alanine transaminase; AST, Aspartate aminotransferase; BMI, Body mass index; DM, Diabetes mellitus; HBA1C, hemoglobin A1C; IDF, International Diabetes Federation; IPL, inferior parietal lobule; L-G score, localized minus generalized responses; MTQ, Mirror-touch Questionnaire; MTS, mirror-touch score; STS, superior temporal sulcus; VPQ, Vicarious Pain Questionnaire; WHR, Waist-to-Hip Ratio.

Disclosure

Regarding this paper, the authors disclose no conflicts of interest.

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