

## GLYCEMIC AND ATHEROGENIC STATUS AMONG DUHOK UNIVERSITY STAFF RECOVERED FROM COVID-19 WITH NO COMORBIDITIES

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### ABSTRACT

**Background:** While most infected people recovered completely from COVID-19 within a few weeks, a considerable proportion continues to experience symptoms after their initial recovery similar to SARS survivors. Intensive ongoing research has shed light on the pathogenesis of COVID-19 and the extent of damages caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) but the intermediate and long-term complications remain unclear. The objective of this study is to evaluate the glyceimic and atherogenic status in non-hospitalized and recovered covid-19 individuals without underlying diseases prior to the infection.

**Methods:** A total of 200 apparently healthy subjects from all the staff of Duhok University were enrolled in this case-control study. The subjects were divided into two groups. Group 1 included 107 subjects non-hospitalized recovered from covid-19 at more than 3 months after infection which was proved by RT-PCR and Group 2 included 93 healthy subjects who have not been infected with covid-19 as control group. Venous blood samples were collected and analyzed for glyceimic and atherogenic related parameters.

**Results:** There was no significant differences in blood pressure, glyceimic and atherogenic status between previously infected and not infected subjects. However triglycerides (TG) and cardio-protective index (CPI) were slightly and non-significantly higher and low density lipoprotein (LDL), total cholesterol (TC) and atherogenic index of plasma (AIP) lower in previously infected subjects. Also, fasting plasma insulin (FPI), Homeostasis model assessment-insulin resistance (HOMA-IR) and risk of atherogenicity were slightly higher in the infected males, younger ages, older ages and obese subjects.

**Conclusions:** There are no long-term effects of COVID-19 on the glyceimic and atherogenic status of the recovered not hospitalized patients.

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**Keywords:** Atherogenic status, Covid-19, Glyceimic status, Long term complications.

**C** OVID-19 is an infectious, contagious disease of the respiratory system brought on by the Severe Acute Respiratory Syndrome-Coronavirus 2 (SARSCoV-2), a novel and variable strain of the SARS-CoV (Severe Acute Respiratory Syndrome-related

coronavirus)<sup>1</sup>. The pathogenesis of COVID-19 requires the entrance of SARSCoV-2 through the respiratory system and lodgement in the lung parenchyma.

Then, it interacts with the angiotensin-converting enzyme 2(ACE2) receptors and

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enters host pneumocytes. Apart from pneumocytes, the presence of viral RNA (ribonucleic acid) in the plasma or serum indicates that the virus is freely available to interact with ACE2 expressed in other tissues<sup>2</sup> such as pancreatic beta cells, adipose tissue, the kidneys and the small intestine<sup>3</sup>.

1-2% of patients with mild and 17% with severe COVID-19, have increased blood amylase and/or lipase as a sign of exocrine pancreatic damage<sup>4</sup>. Although any major illness can be associated with stress-related hyperglycemia, Yang and his colleagues found that patients with SARS (caused by SARS-CoV, the "cousin" of SARS-CoV-2) who had never taken glucocorticoids had significantly higher fasting plasma glucose levels than patients with non-SARS pneumonia<sup>5</sup>.

Another study suggested that the development of "acute diabetes" in SARS patients was likely caused by SARS-CoV-mediated damage to the pancreatic beta-cells<sup>6</sup>.

It was also reported that 35% of patients experienced new-onset hyperglycemia after hospital admission for covid-19 and that hyperglycemia persisted over the course of the next six months in these patients<sup>7</sup>.

These findings lead to the hypothesis that COVID-19 positive patients may experience virus-mediated pancreatic damage, leading to the development of diabetes<sup>8</sup>.

Furthermore, the adipose tissue could be a major target tissue affected by COVID-19 due to the higher levels of ACE2 expression in adipose tissue than that in lung tissue<sup>9</sup>.

According to Kassir (2020), the adipose tissue inflammation causes metabolic dysfunction that may result in dyslipidemia, insulin resistance, type 2 diabetes, hypertension, and cardiovascular disease<sup>10</sup>.

Similarly, it has been reported that dyslipidemia occurs in the acute phase of covid-19<sup>11</sup>, also a Follow-up study on serum cholesterol profiles and potential sequelae in recovered hospitalized COVID-19 patients has been performed<sup>12</sup>. Therefore, it is important to conduct extensive metabolic and clinical follow-up investigations in affected groups as well as long-term observation to determine whether these issues will be permanent or will go away once the infection has been treated and to study who is most likely to be affected by these complications.

As no published information was found in the long term follow up of infected patients but non-hospitalized without underlying diseases prior to the infection, therefore this study was planned.

## **SUBJECTS AND METHODS**

This case control study was carried out from November 2021 to April 2022 among staff of University of Duhok. A total of 200 subjects were selected from 600 sampling frame using a systematic random sampling method. From every three individuals one was selected for blood sampling.

A pre-tested questionnaire was designed to obtain information on age, gender, height, weight, smoking habit, past medical history such as heart diseases, liver diseases, renal diseases, thyroid disorders and other diseases, history of infection with Covid-19, systemic hypertension,

diabetes mellitus, dyslipidemia, family history of chronic diseases and history of drugs or supplements taken by the participants.

All respondents who fulfilled the inclusion criteria of no current presence of acute illness, diabetes mellitus, hypertension, dyslipidemia, heart diseases, liver diseases, thyroid disorders and renal diseases, were selected. Those who were taking lipid-lowering drugs, with acute infection or had infection within previous three months were excluded from the study.

The study was approved by the postgraduate committee of the College of health Science (number5, 1/9/2021) and the Medical Ethical Committee of Directorate of Health in Duhok governorate (Reference number: 15092021-9-15R1, 6/11/2022). An informed written consent was obtained from each subject enrolled in this study after explaining its nature.

### **Experimental Design**

The study included 200 apparently healthy individuals (103 males and 97 females). The subjects were divided into two groups: Based on a previous positive test for covid-19 (RT-PCR) or who had developed symptoms after a close contact with a covid-19 patient with a positive test, group 1 was selected. It comprised 107(51 males and 56 females) who had been recovered from covid-19 for > 3 months before obtaining their blood samples and who had not been hospitalized at time of infection. Their mean ages ranged between (22-69) years.

Group 2 included individuals who never developed symptoms of covid-19 or those who had flu like illnesses with negative tests for covid-19, they served as a control

group. It included 93 (52 males and 41 females) with ages ranged from (20-58) years.

### **Blood sampling**

Five ml of venous blood samples were obtained in the morning after 12 hours over night fasting from each participant. Two ml was placed into EDTA containing tube and used for assessment of HbA1c percentage, the remainder 3 ml was placed into a gel separator tube to prepare serum used for all other parameters.

The biochemical analysis has been carried out in General Azadi Teaching Hospital/ Duhok governorate.

### **Methods**

The systolic and diastolic blood pressure (SBP and DBP) and Waist circumference (WC) were measured, Body mass index (BMI) was calculated.

The glycemic status has been assessed by measuring the fasting blood sugar (FBS), fasting plasma insulin (FPI), and glycated hemoglobin (HbA1C). FBS, FPI, and HbA1C have been analyzed by using a commercial kit supplied by (Roche/Hitachi cobas systems, Germany).

Insulin resistance (IR) has been calculated by using the HOMA-IR formula<sup>13</sup>:

Fasting Insulin (mU/ml) x Fasting glucose (mg/dl) /405

Atherogenic status has been investigated by measuring the lipid profile parameters (total cholesterol TC, triglycerides TG, high density lipoprotein HDL, and low density lipoprotein LDL). TC, TG and HDL were analyzed by using a commercial kit supplied by (Roche/Hitachi cobas systems, Germany).

The LDL-c concentration was calculated according to Friedewald formula<sup>14</sup>:

$[LDL-c] = [TC] - [HDL-c] - [TG/5]$

The atherogenic indices [Atherogenic index of plasma AIP, Cardiac risk ratio CRR, Atherogenic coefficient AC, and cardio protective index CPI] were calculated as follows:

$$AIP = \text{Log [TG/HDL-c]}^{15}.$$

$$AC = [TC - HDL-c/HDL-c]^{16}.$$

$$CRR = [TC/HDL-c]^{17}.$$

$$CPI = [HDL-c/LDL-c]^{17}.$$

**STATISTICAL ANALYSES**

Statistical Package for Social Science version 22 (IBM, SPSS Statistics 22, USA) was used for data analysis. All the data were presented as mean (standard deviation).

An independent t-test and Mann-Whitney U test were used to compare the mean values between the infected and control

groups. A two-way ANOVA was used to study the interaction between infection with covid-19 and other categorical variables. *P* values of <0.05 were considered as statistically significant.

**RESULTS**

A total of 200 respondents participated in the study with an average age of (38.4 ±7.93) years old. 107 of them had been previously infected with covid-19 (83% mild infection & 17% moderate which were classified according to WHO classification of severity<sup>18</sup>) and 93 of them had never been infected with covid-19. The details of the respondents are presented in

Table 1

**Table 1: Details of the respondents (N=200)**

		n (%)	Mean( SD)
Age(years)			38.4(7.93)
			39.23(8.04)(previously infected)
			37.52+_7.74)(control group)
Gender	Females	97(48.5)	
	Males	103(51.5)	
BMI	Normal weight	78(39)	26.4(4.06)
	Over weight	84(42)	
	Obese	38(19)	
vaccination	Vaccinated	151(75.5)	
	Not vaccinated	49(24.5)	
Time of infection	Less than 1 year	48(44.8)	
	More than 1 year	59(55.2)	
Physical activity	Yes	42(21)	
	No	158(79)	

By comparing previously infected with not infected subjects, there were no statistically significant differences in mean levels of systolic blood pressure (SBP), diastolic blood pressure (DBP), FBS, FPI, HOMA-IR and HbA1c. Furthermore, no significant variations have been observed

in lipid profile parameters & atherogenic indices between the two groups. On the other hand, a non-significant increase in the levels of TG and CPI in previously infected respondents and a decrease in the levels of LDL, TC & AIP has been noticed (

Table 2).

Variables	Group 1(Infected with covid-19) Mean(SD) N=107	Group 2(control) Mean(SD) N=93	P value
SBP (mmHg)	112.48 (14.64)	112.51(12.99)	0.78
DBP (mmHg)	70.93(10.58)	71.18(9.45)	0.69
FBS (mg/dl)	88.15(7.82)	88.01(7.16)	0.89
FPI (mU/ml)	10.48(6.43)	10.76(5.12)	0.73
HOMA-IR	2.33(1.54)	2.39(1.27)	0.78
HbA1C (%)	5.19(0.39)	5.15(0.43)	0.54
TC (mg/dl)	173.8(30.62)	176.17(28.16)	0.57
TG (mg/dl)	115.44(58.68)	109.32(40.67)	0.40
HDL-c (mg/dl)	48.76(12.05)	46.74(10.79)	0.21
LDL-c (mg/dl)	101.06(27.21)	108.33( 25.74)	0.055
AIP	-0.026(0.28)	-0.01(0.22)	0.66
CRR	3.78(1.16)	3.93(0.97)	0.32
CPI	0.53(0.23)	0.46(0.17)	0.057
AC	2.78(1.16)	2.93(0.97)	0.32

The two groups have been compared in terms of gender as described in (**Error! Reference source not found.**) and it has been noticed that most of the parameters were higher in males than females in both groups except HDL and CPI were higher in females of both groups and FPI and HOMA-IR were higher in not infected females than males. Also the data revealed that there were no significant differences in the mean levels of all parameters between the infected and not infected subjects in terms of gender. Although the variations were non-significant in all the variables, but it was noticed that FPI and

HOMA-IR were higher in infected males and lower in infected females when compared with the control group. Additionally, TG was increased whereas LDL decreased in previously infected males and females. The HDL in infected females was higher than the control females group. Furthermore slightly higher values of AIP, CRR, and AC in the infected group were noticed in males and lower values in females. CPI was higher in infected females than females in control group.

**Table 3 (Difference between infected subjects and not infected according to gender)**

variables	P value for infection* gender	Group 1(Infected with covid-19)		Group 2(control)	
		Male(N=51) Mean(SD)	Female(N=56) Mean(SD)	Male(N=52) Mean(SD)	Female(N=41) Mean(SD)
SBP(mmHg)	.51	116.96 (12.61)	108.39 (15.26)	117.37 (10.83)	106.34 (12.99)
DBP(mmHg)	.41	74.31 (8.95)	67.86 (11.07)	75.00 (7.60)	66.34 (9.42)

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variables	P value for infection* gender	Group 1(Infected with covid-19)		Group 2(control)	
		Male(N=51) Mean(SD)	Female(N=56) Mean(SD)	Male(N=52) Mean(SD)	Female(N=41) Mean(SD)
FBS (mg/dl)	.08	89.96 (8.04)	86.50 (7.18)	88.35 (7.29)	87.59 (7.06)
FPI (mU/ml)	.06	11.73 (7.24)	9.34 (5.41)	10.54 (5.02)	11.04 (5.29)
HOMA-IR	.82	2.67 (1.76)	2.03 (1.25)	2.33 (1.21)	2.45 (1.35)
HbA1C (%)	.54	5.29 (0.38)	5.09 (0.37)	5.23 (0.47)	5.05 (0.37)
TC (mg/dl)	.79	181.47 (28.77)	166.8 (30.83)	180.38 (27.94)	170.83 (27.87)
TG (mg/dl)	.24	131.92 (55.22)	100.4 (58.16)	121.56 (42.81)	93.80 (32.04)
HDL-c (mg/dl)	.31	43.80 (9.51)	53.27 (12.41)	44.17 (9.11)	50.00 (11.94)
LDL-c (mg/dl)	.39	109.37 (25.16)	93.48 (27.00)	112.02 (26.32)	103.66 (24.51)
AIP	.27	0.09 (0.23)	-0.13 (0.28)	0.06 (0.20)	-0.10 (0.22)
CRR	.35	4.31 (1.06)	3.30 (1.03)	4.24 (1.02)	3.55 (0.75)
CPI	.27	0.42 (0.14)	0.63 (0.26)	0.42 (0.16)	0.51 (0.17)
AC	.51	3.31 (1.06)	2.30 (1.02)	3.24 (1.02)	2.55 (0.75)

Furthermore, a non-significant difference has been observed between the infected and not infected groups according to their ages (**Error! Reference source not found.**). SBP, DBP and TC were increased with increasing ages in both groups. In addition, FPI and HOMA-IR were lower in infected subjects in all age groups except the younger ages had higher levels.

The TG levels were apparently higher in previously infected subjects who aged <30 & > 50 years old and no obvious change has been noticed in the middle age groups in comparison with the control group. In

contrast, the HDL levels were lower in infected group who aged <30 & > 50 years and were higher in the middle ages when compared with the same age group in the control group. In addition, the infected group shows lower values of LDL than not infected in all age groups.

Regarding the atherogenic indices, the AIP, CRR, and AC were increased and CPI was decreased proportionally to ages. The AIP, CRR, AC increased in younger and older subjects and decreased in other age groups. While CPI was increased in all age groups.

**Table 4 (Variation between infected and not infected subjects according to their ages)**

Variables	P value for infectio* age groups	Group 1(Infected with covid-19)				Group 2(control)			
		Means(SD)				Means(SD)			
		18-29 N=12	30-39 N=48	40-49 N=38	>=50 N=9	18-29 N=14	30-39 N=48	40-49 N=22	>=50 N=9
SBP (mmHg)	.40	107.5 (16.03)	109.1 (12.70)	117.1 (15.27)	117.8 (14.81)	102.9 (9.95)	112.3 (12.59)	115.0 (10.12)	122.6 (16.92)
DBP (mmHg)	.80	68.33 (12.67)	69.38 (10.75)	72.63 (9.50)	75.56 (10.14)	66.43 (10.08)	71.25 (10.24)	72.05 (6.66)	76.11 (7.82)
FBS (mg/dl)	.51	89.00 (4.95)	86.85 (7.31)	88.47 (8.64)	92.56 (9.15)	86.29 (5.94)	86.79 (7.77)	90.86 (7.04)	90.22 (2.39)

Variables	P value for infectio* age groups	Group 1(infected with covid-19)				Group 2(control)			
		Means(SD)				Means(SD)			
		18-29 N=12	30-39 N=48	40-49 N=38	>=50 N=9	18-29 N=14	30-39 N=48	40-49 N=22	>=50 N=9
FPI (mU/ml)	.54	12.38 (8.80)	9.64 (6.36)	10.92 (5.40)	10.58 (7.67)	9.48 (6.48)	10.46 (5.29)	11.78 (3.66)	11.86 (5.08)
HOMA-IR	.28	2.77 (2.08)	2.11 (1.46)	2.46 (1.42)	2.44 (1.76)	2.08 (1.59)	2.30 (1.31)	2.67 (0.92)	2.66 (1.19)
HbA1C (%)	.65	5.17 (0.34)	5.08 (0.39)	5.26 (0.39)	5.47 (0.23)	4.95 (0.38)	5.09 (0.42)	5.36 (0.36)	5.29 (0.55)
TC (mg/dl)	.38	156.3 (23.08)	167.7 (31.26)	184.2 (28.89)	185.9 (26.88)	152.9 (22.67)	177.1 (27.29)	184.6 (26.99)	186.8 (26.97)
TG (mg/dl)	.53	112.3 (58.75)	117.0 (63.49)	110.7 (52.63)	131.4 (62.88)	78.3 (24.73)	118.5 (46.03)	109.3 (27.96)	108.9 (36.70)
HDL-c (mg/dl)	.89	52.17 (12.82)	47.42 (11.27)	49.92 (12.84)	46.44 (12.22)	53.79 (13.99)	45.38 (9.81)	44.68 (8.77)	48.11 (11.89)
LDL-c (mg/dl)	.24	81.8 (20.39)	96.6 (26.86)	111.0 (25.26)	108.6 (28.99)	84.6 (16.59)	108.0 (24.32)	120.6 (25.60)	116.8 (22.17)
AIP	.61	-0.06 (0.27)	-0.02 (0.31)	-0.04 (0.26)	0.06 (0.24)	-0.20 (0.19)	0.03 (0.23)	0.02 (0.17)	-0.02 (0.21)
CRR	.78	3.11 (0.66)	3.77 (1.27)	3.90 (1.08)	4.24 (1.10)	2.97 (0.65)	4.06 (0.95)	4.25 (0.90)	4.04 (0.87)
CPI	.61	0.67 (0.21)	0.54 (0.24)	0.48 (0.19)	0.49 (0.34)	0.65 (0.19)	0.44 (0.15)	0.39 (0.10)	0.43 (0.15)
AC	.40	2.11 (0.66)	2.77 (1.27)	2.90 (1.08)	3.24 (1.10)	1.97 (0.65)	3.06 (0.95)	3.25 (0.90)	3.04 (0.87)

**Table 5** shows the comparison between previously infected & control groups according to their BMI. The data revealed non-significant differences in all parameters between the two groups whether being normal weight, overweight or obese. An increase in all the tested parameters was detected except HDL and CPI which were decreased with increasing

BMI in both groups. SBP, DBP, FBS, FPI, HOMA-IR and HbA1c were lower in the infected normal weight subjects. Regarding the lipid profile parameters, triglyceride levels were found to be non-significantly lower in previously infected normal weight subjects but higher in previously infected over weight and obese subjects, while LDL levels were found to be non-significantly lower in previously infected subjects regardless of their BMI relative to the control group. HDL increased in the infected normal weight

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and overweight and decreased in obese subjects. AIP, CRR and AC decreased in infected normal weight and increased in obese, while CPI was increased in infected

normal BMI subjects in comparison to the control group.

**Table 5: (Difference between infected subjects and not infected subjects according to BMI)**

	P value for infection*	Group 1(Infected with covid-19)			Group 2 (control)		
		Means(SD)			Means (SD)		
		Normal weight N=41	Over weight N=46	Obese N=20	Normal weight N=37	Over weight N=38	Obese N=18
SBP(mmHg)	0.33	107.07 (14.14)	115.11 (14.85)	117.50 (12.09)	110.54 (12.90)	112.18 (12.76)	117.22 (13.20)
DBP(mmHg)	0.24	67.32 (11.41)	72.07 (9.92)	75.75 (7.83)	70.41 (9.89)	71.18 (9.40)	72.78 (8.95)
FBS(mg/dl)	0.50	84.66 (5.71)	89.54 (8.08)	92.10 (8.39)	85.81 (7.46)	88.08 (6.31)	92.39 (6.47)
FPI (mU/ml)	0.26	6.34 (2.54)	11.75 (5.90)	16.05 (7.84)	8.08 (4.91)	11.10 (3.53)	15.55 (4.85)
HOMA-IR	0.23	1.33 (0.56)	2.64 (1.42)	3.68 (1.87)	1.75 (1.19)	2.43 (0.86)	3.58 (1.29)
HbA1C (%)	0.27	5.04 (0.35)	5.26 (0.42)	5.32 (0.26)	5.09 (0.46)	5.12 (0.40)	5.35 (0.43)
TC (mg/dl)	0.80	164.61 (29.22)	180.67 (28.55)	176.85 (34.57)	170.57 (27.37)	180.66 (29.17)	178.22 (27.12)
TG (mg/dl)	0.14	83.78 (37.56)	131.37 (63.06)	143.70 (56.59)	94.43 (37.88)	117.34 (40.08)	123.00 (39.93)
HDL-c (mg/dl)	0.49	53.24 (12.06)	46.89 (11.81)	43.85 (9.83)	49.76 (11.13)	44.37 (10.91)	45.56 (8.65)
LDL-c (mg/dl)	0.84	94.37 (26.94)	106.83 (27.02)	101.50 (26.41)	101.89 (24.00)	112.34 (25.04)	113.11 (29.17)
AIP	0.22	-0.19 (0.23)	0.05 (0.28)	0.13 (0.22)	-0.10 (0.23)	0.05 (0.22)	0.06 (0.15)
CRR	0.47	3.27 (1.05)	4.07 (1.14)	4.18 (1.06)	3.59 (0.99)	4.24 (0.95)	4.01 (0.80)



	P value for infection*	Group 1 (infected with covid-19)			Group 2 (control)		
		Means(SD)			Means (SD)		
BMI		Normal weight N=41	Over weight N=46	Obese N=20	Normal weight N=37	Over weight N=38	Obese N=18
CPI	0.64	0.62 (0.25)	0.48 (0.23)	0.46 (0.18)	0.52 (0.17)	0.42 (0.16)	0.43 (0.17)
AC	0.47	2.27 (1.05)	3.07 (1.14)	3.18 (1.06)	2.59 (0.99)	3.24 (0.95)	3.01 (0.89)

## DISCUSSION

The present study was designed to identify the long-term effects of covid-19 on the demographic variables, glycometabolic control, lipid profile parameters and atherogenic indices in subjects previously infected with mild or moderate covid-19 who did not need hospital care and had no comorbidities. Hypertension, diabetes, and cardiovascular diseases were identified as common comorbidities in COVID-19 patients<sup>19</sup>.

Endothelial cell injury plays a vital role in the pathogenesis of multi-organ failure in COVID-19. The endothelial cells express ACE2 receptors, and the viral entry causes major clinical conditions such as high blood pressure<sup>20</sup>. The loss of ACE2 promotes vasoconstriction, sodium retention, oxidative stress and inflammation, among other consequences<sup>21</sup>.

It was suggested that (16.08%) out of 199 subjects had either new onset arterial hypertension or a worsening of an existing hypertensive condition related to COVID-19<sup>22</sup>. SBP and DBP were significantly higher in the post COVID-19 after about one month than on admission and new

onset hypertension was observed in 12% of patients<sup>23</sup>.

However, our study showed a non-significant decrease in SBP and DBP in infected normal weight subjects and a slight increase in overweight and obese subjects as compared to the not infected subjects.

It has been shown that DM is associated with COVID-19 pandemic<sup>24</sup>. More interestingly, recent studies have also indicated that COVID-19 patients without a history of DM could experience a new onset of diabetes<sup>25, 26, 27, 28</sup>.

On the other hand, deterioration of glycemic control, including episodes of ketosis, ketoacidosis, or hyperosmolar hyperglycemic state were detected in type 2 diabetes patients with COVID-19, requiring exceptionally high doses of insulin. Further, recent reports showed an increase in new-onset type 1 diabetes, possibly linked to COVID-19<sup>29</sup>.

However, the glucose distribution in recovered covid-19 non-hospitalized patients was similar to that of the control patients as it was proved in a 3 month follow-up study<sup>30</sup>. This is consistent with present study that showed a non-significant variation in mean levels of the glycemic related parameters between the two groups in general. Although, in some

of them minor changes occurred when studied in terms of gender, ages and BMI. FPI and HOMA-IR were non-significantly higher in infected males and younger ages whereas it is lower in infected with ages >30 years old and in females compared to the control group. High levels of glyceemic related parameters were seen in the overweight and obese infected patients relative to the control group.

Our data suggest that diabetes appear to be a non-persistent effect of covid-19 infection in this non-hospitalized patient cohort.

However, this suggestion could not be taken for granted, as the patients were not hospitalized, to include other severity classes of COVID 19.

As observed with other infections, numerous studies have reported that covid-19 patients may show a decrease in total cholesterol, LDL-C, and HDL-C levels and variable changes in triglycerides in patients with COVID-19 infections. With recovery from COVID-19 infection, the lipid levels return toward levels present before infection. As expected, the greater the severity of the illness, the greater the reduction in LDL-C and/or HDL-C levels<sup>31</sup>.

Another study showed that the alterations of lipid metabolism were much more dramatic in fatal COVID-19 cases than in mild and severe cases (survivors). For survivors, many of their lipids had not returned to normal before discharge from hospital, even though SARS-CoV-2 could not be detected and the major clinical signs had disappeared in these patients based on official discharge criteria<sup>32</sup>.

Previous follow up studies on recovered covid-19 patients 3 and 6 months after

discharge revealed that various lipid related parameters were down regulated whereas TG remained significantly high in especially in severe and critical cases versus the control group. A small number of patients showed a decline in LDL-c or HDL-c levels of 15% as compared to the time of admission<sup>33, 34, 35</sup>.

These results came in line with the present study's observations that TC, LDL and HDL were slightly and non-significantly lower and TG was higher in recovered subjects when compared with control group.

Furthermore, it is noteworthy to mention that this study showed a non-significant decrease in FPI and IR in infected females. They also showed an increase in HDL and CPI and a decrease in LDL, AIP, CRR and AC. Though, infected males showed a slight increase in FPI, IR, AIP, CRR and AC. This suggests that females are at lower risk when getting infection than males.

In addition, it is observed that the lipid profile is mostly affected in the infected younger and older age groups than in other age groups. Moreover the obese subjects were the most adversely affected group by the infection. These results are consistent with the finding that males, older ages and obesity are some of the factors that increase the risk of severe infection and death from covid-19<sup>31</sup>.

Further studies on COVID19 patients follow-up are required to evaluate the persistence of diabetes and lipid disturbances in patients who were more severely affected during the acute stage of the disease.

In conclusion, there was no significant variation in the glyceemic and atherogenic

status between the previously infected and not infected individuals except for non-significant variations in some parameters mostly some lipid profile parameters and atherogenic indices. Also, slight changes when studied in terms of gender, age and BMI. The recovered covid-19 patients not hospitalized are not at risk in the future for developing diabetes and/or atherosclerosis.

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### CONFLICT OF INTEREST

The authors declared that they have no conflict of interest.

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## پوخته

### ره وشا گلاسیمیک و خوینبهرا ل نیف کارمه‌ندین زانکویا دوهوک نهوین ش covid-19 چاکبووین بیی کو چ نهخوشیین دی هه‌بن

باکراوند و نارمانج: ل وخته‌کی کو زوربه‌یا تووشبووین کوفید-19 ل ماوی چهند ههفتیه‌کادا ب تمامی چاک دبن، ریژمییکا بهرچاف دبه‌دهوام بوون له نه‌زمونکرنا هنده‌ک نیشانان پشتی چاکبوونا وان هترومکی رزگار بووین سارس ی. فهکولینین بهردهوام روناهی دایه‌سه‌رچهوانیا دروستبوونا نهخوشیا کوفید-19 و ئاستی زیانان پشتی تووشبوونی ب فی نهخوشی بیلی ئالوزییت ناقه‌ند و دومدریژ هه‌تا نووکه دروون نینن. نارمانجا فی فهکولینی ئه‌وه هه‌لسه‌نگاندنا دۆخی گلاسیمیک و خوینبه‌رایه‌ل کهسیت ش covid-19 چاکبووین و ل نهخوشخانی نه‌هاتینه‌نقاندن بی چ نهخوشییت بنه‌رهت هه‌بن به‌ری تووشبوونی.

ریکین کاری: ب گشتی 200 کهسیت ساخه‌م ل ستافی زانکویا دهوکی ل فی فهکولینی هاتنه‌تومارکرن. بابته‌بسه‌ر دوو گروپادا هاته‌دابه‌شکرن. گروپی ئیکی 107 کهس بوون کو ل نهخوشخانی نه‌هاتبوونه‌نقاندن کو پتری 3 مه‌هایه ش covid-19 چاکبووین و گروپی دووی 97 کهسین ته‌ندروست کو تووشی covid-19 نه‌بووین. نمونیت خوینی هاتنه‌ومرگرتن و شروفه‌کرن بۆ پیفه‌ریت په‌یوه‌ندیار ب گلاسیمیک و خوینبه‌را.

نه‌نجام: چ جیاوازیییکا بهرچاف ل په‌ستانا خوینی، ره وشا گلاسیمیک و خوینبه‌را ل ناقه‌را کهسین به‌ری فه‌گرتی و نه فه‌گرتی دا نه‌بوو. به‌لی، TG و CPI هنده‌ک پتر بوون و LDL، TC و AIP له کهسین به‌ری فه‌گرتی دا کیمتر بوون. هه‌روه‌سا نه‌نجاما دیارکر کو FPI و IR و مه‌ترسی ل سترخوینبه‌را هنده‌ک زیده‌تره‌ل نیریت فه‌گرتی و ته‌مه‌نی بچیکتر و ته‌مه‌نی مه‌زنتر و کهسین قه‌له‌ودا.

دهره نجام: ل دوماهیدا چ جوداهیییت بهرچاف ل لئاڤهرا کهسین بهری تووشبووی ونه تووشبووی دا نهبوو ژبلی هندهک  
جیاوازییت کیم ل هندهک پارامیترا دا.

## الخلاصة

حالة نسبة السكر في الدم وتصلب الشرايين بين موظفي جامعة دهوك الذين تعافوا من كوفيد-19 مع عدم وجود أمراض مصاحبة

**الخلفية والأهداف:** بينما تعافى معظم المصابين تماما من COVID-19 في غضون أسابيع قليلة، استمرت نسبة كبيرة منهم في الشعور بالأعراض بعد تعافيتهم الأولى على غرار الناجين من السارس. سلط البحث المكثف المستمر الضوء على التسبب في الإصابة بـ COVID-19 ومدى الأضرار الناجمة عن متلازمة الالتهاب التنفسي الحاد الوخيم التاجي 2 (SARS-CoV-2) ولكن المضاعفات المتوسطة والطويلة الأجل لاتزال غير واضحة. الهدف من هذه الدراسة هو تقييم حالة نسبة السكر في الدم وتصلب الشرايين لدى الأفراد الذين لم يخضعوا للعلاج بالمستشفى والمتعافين من مرض كوفيد-19 بدون أمراض كامنة قبل الإصابة.

**طرق العمل:** تم تسجيل ما مجموعه 200 من الأفراد الذين يبدو أنهم يتمتعون بصحة جيدة من موظفي جامعة دهوك في هذه الدراسة المقطعية. تم تقسيم الموضوعات إلى مجموعتين. تضمنت المجموعة الأولى 107 فردا لم يدخلوا المستشفى و تعافوا من كوفيد-19 بعد أكثر من 3 أشهر من الإصابة ، بينما تضمنت المجموعة الثانية 97 فردا سليما لم يصابوا بفيروس كوفيد-19. تم جمع عينات الدم الوريدي وتحليلها من أجل قياس نسبة السكر ونسبة الدهون في الدم.

**النتائج:** لم يكن هناك فرق معنوي في ضغط الدم وحالة السكر في الدم وحالة تصلب الشرايين بين الأشخاص المصابين سابقا وغير المصابين. ومع ذلك، كان TG وCPI أعلى بشكل طفيف وغير ملحوظ بينما كان LDL وTC وAIP أقل في الأفراد المصابين سابقا. أظهرت النتائج أيضا أن FPI وIR وخطر الإصابة بتصلب الشرايين أعلى قليلا لدى الذكور المصابين والأعمار الأصغر والأعمار الأكبر والأشخاص الذين يعانون من السمنة المفرطة.

**الاستنتاجات:** في الختام لم يكن هناك فروق ذات دلالة إحصائية بين المصابين سابقا وغير المصابين باستثناء بعض الاختلافات الطفيفة في بعض المتغيرات.