Research Article

Physical Activity Behavior During the COVID-19 Outbreak in Individuals with Type 2 Diabetes: Role of Social Support and Other Covariates

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Abstract

Objectives: This study was performed to investigate whether social support and other psychological predictors were associated with physical activity during the prolonged social isolation due to the coronavirus disease 2019 outbreak in Iran.

Methods: This cross-sectional study was performed on 494 individuals with type 2 diabetes (T2D) in a diabetes specialty clinic. The questionnaire package comprised five parts, including sociodemographic and clinical characteristics, physical activity level, diabetes-specific social support, feelings of isolation, and diabetes-related distress. Clinical and hemoglobin A1c data were obtained from electronic medical records. Descriptive statistics, Pearson's chi-square test, and multivariable logistic regressions were conducted to analyze the data.

Results: Approximately 71% of the participants participated in low/insufficient levels of physical activity. The participants who received support from family/friends (odds ratio [OR] = 1.77; 95% confidence interval [CI]: 1.47 - 2.74), diabetes care team (OR = 1.42; 95% CI: 1.15 - 1.77), and neighbors (OR = 1.53; 95% CI: 1.20 - 2.08) were more likely to have sufficient physical activity than those who did not receive these supports. There was also an association between physical activity behavior with feelings of isolation and diabetes distress.

Conclusions: This study points to the importance of social support as an amplifier mechanism for the maintenance of physical activity behavior in individuals with T2D during critical times.

Keywords: COVID-19 Pandemic, Type 2 Diabetes, Physical Activity, Social Support, Diabetes Distress, Social Isolation

1. Background

The prolonged closures and distancing measures practiced during the coronavirus disease 2019 (COVID-19) pandemic have vastly altered the way of individuals' lifestyles and imposed restrictions on physical activity behavior (1). As the pandemic sweeps worldwide, various populations encounter new challenges, particularly individuals with chronic diseases, such as type 2 diabetes (T2D). There is high-quality evidence indicating the importance of physical activity and exercise in diabetes management (2, 3). Moderate to high levels of physical activity are associated with substantially lower morbidity and mortality in patients with diabetes (4, 5). Regular activity and exercise improve glycemic control, contribute to weight loss, reduce cardiovascular risk factors, and enhance well-being and mental health in T2D (2).

It has previously been shown that a majority of diabetic patients do not meet the suggested guidelines for being physically active (6, 7). Currently, social distancing measures implemented due to the pandemic have made matters even worse (4). In a cross-sectional study on 1,396 patients with diabetes in Denmark, 40% reported exercising less than usual in comparison to that before the pandemic (8). Another electronic questionnaire-based study on 928 diabetic patients in Bangladesh showed that about 60% did not undertake regular physical exercise during the pandemic (9). Studies revealed that reducing daily physical activity and regular exercise for even a few days might deteriorate glycemic control in patients with T2D and increase the risk of diabetes complications (10). Moreover, lack of physical activity can suppress the immune system and make an individual with diabetes more vulnera-

ble to COVID-19 infection ([11]). In this regard, the determination of factors associated with successfully maintaining sufficient levels of activity despite this critical situation is important.

Factors affecting the physical activity level in individuals with T2D include individual, psychosocial, and environmental factors. Among these factors, psychosocial factors were considered particularly important to explain the changes in physical activity behavior ([12], [13]). However, to date, there is a lack of evidence to explore how individual psychosocial factors could have influenced changes in physical activity among patients with T2D during the pandemic. Social support is one of those psychosocial factors that has been shown to be associated with a positive effect on physical activity participation before the COVID-19 pandemic ([13]). Social support is a firm predictor of resilience following a crisis; therefore, social factors might be able to play a key role in psychosocial health in individuals with T2D during the pandemic ([14]). Moreover, social support has been shown to decrease the negative effects of psychological distress on self-care behaviors before the pandemic ([15]).

Social distancing measures during the pandemic have led to elevated levels of psychological distress and feelings of loneliness and isolation among diabetic patients ([8]). The results obtained from a cross-national comparative study in the United States, Brazil, and Iran showed that regardless of significant differences among countries, patients with diabetes are experiencing suboptimal psychosocial well-being during the pandemic ([16]). However, whether changes in personal experiences of these psychosocial factors have affected physical activity behavior in patients with T2D remains unclear.

2. Objectives

This study aimed to identify the proportion of patients with T2D who were sufficiently physically active during the prolonged social isolation and investigate whether social support and other psychological covariates were related to physical activity behavior during this critical time in Iran.

3. Methods

3.1. Study Design and Setting

This descriptive-analytical cross-sectional study was conducted in a diabetes specialty clinic affiliated with Tehran University of Medical Sciences, Tehran, Iran. The study data were gathered within 22 June and 23 July 2021, in the middle of the fifth peak of the pandemic in Iran. The study adhered to the principles of the Declaration of Helsinki. Ethical permission for the research was granted by the Research Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.EMRI.REC.1399.052).

3.2. Study Participants

All the patients with T2D routinely visiting the clinic constituted the target population and were screened for eligibility. Eligible patients should be diagnosed with T2D, aged over 18 years, have been registered and treated at this clinic before the start of the pandemic, and provide informed consent to participate in the study. Patients below 18 years, diagnosed with type 1 or gestational diabetes, unable to complete questionnaires, and not providing their consent were excluded from the study. The convenience sampling technique was utilized in the study. The participants were informed of the study goals, and the anonymity of responses was guaranteed. All interviews were conducted in a quiet room alone in the clinic.

3.3. Sociodemographic and Clinical Characteristics

The respondents provided information, including age (i.e., < 55, 55 - 65, and > 65 years), gender (i.e., male/female), body mass index (BMI) (i.e., < 25, 25 - 30, and $\geq$ 30 kg/m^2), educational level (i.e., primary school, high school, diploma, and college), marital status (i.e., married, widowed, and divorced), employment status (i.e., employed, retired, and homemaker), and smoking status (i.e., a current smoker and nonsmoker/quitted). The data related to T2D clinical history, including diagnosis, diabetes duration (i.e., < 5, 6 - 10, and $\geq$ 11 years), treatment regimen type (i.e., only oral medications, insulin plus oral medications, and only insulin), the presence of diabetes-related complications (i.e., no complication, 1 complication, and $\geq$ 2 complications), and the value of hemoglobin A1c (HbA1c), were collected from electronic medical records.

3.4. Study Instrument

The questionnaire package comprised (1) sociodemographic and clinical characteristics, (2) physical activity level, (3) diabetes-specific social support, (4) feelings of isolation and loneliness, and (5) diabetes-related distress. The data were collected through face-to-face interviewer-administered tools.

The International Physical Activity Questionnaires (IPAQ) were utilized to measure self-reported physical activity levels. The IPAQ is a scale comprising items related to free time activities, yard work, housework, transportation, and job-related activities ([17]). The researchers asked the participants to answer items on their physical activity from the previous week. The researchers asked the subjects the number of days that they did moderate-intensity

activity, vigorous-intensity activity, and walking, and the number of minutes they did each of those activities. For the calculation of metabolic equivalent (MET-minute) for each activity first, the number of minutes was multiplied by the number of days of the week the activity was done during the week. Then, each of the activities of similar intensity together was summed. A higher MET-minute score shows that the individual has been more active in that week.

The participants were categorized into low, moderate, and high levels of participation in physical activity ([17]). A moderate level was characterized as at least 5 days a week in the form of walking and moderate- and vigorous-intensity activities equaling 600 MET-minute/week. A high level was characterized as 7 days in the form of walking and moderate- and vigorous-intensity activities equaling 3,000 MET-minute/week. A low level was characterized as not having the criteria of the previous two categories. Additionally, all the participants were divided into groups of sufficiently and insufficiently active. The sufficiently active group included those meeting the criteria for moderate and high activities. The insufficiently active comprised those in the low category. This tool has been previously validated in Persian ([18]).

Diabetes-related social support was measured by 5 items with three-choice answers (from do not support to fully support) (Table 1). The data related to support from family members and friends, individuals at the workplace, other patients with diabetes, other individuals in the community (neighbors), and the diabetes care team were obtained ([8]).

Diabetes-related distress was measured by the 17-Item Diabetes Distress Scale, a scale in which patients rate the extent to which potential diabetes-related problems have hassled them in the previous month ([19]). This scale has four subscales, namely emotional burden, physician distress, regimen distress, and interpersonal distress, and it is possible to calculate a total score for the scale. Scores range from 1 (not at all a problem) to 6 (a very serious problem). A mean score > 2 shows a moderate level of distress, and a score $\geq$ 3 represents a high level of distress.

A 10-point scale from 1 (low) to 10 (high) was used to assess the degree of feeling socially isolated ([20]). The patients with T2D were asked to rate their feelings of isolation during the pandemic on the scale.

3.5. Statistical Analysis

Continuous variables are shown as mean $\pm$ standard deviation, and categorical variables are shown as numbers (%). Pearson's chi-square test was used to test whether physical activity was associated with sociodemographic and diabetes status variables. Physical activity-related factors were determined by multivariable binary logistic regression. The odds ratios (ORs) with a 95% confidence interval (CI) were acquired with "sufficient activity" as a dependent variable to recognize potential determinants when "insufficient activity" was regarded as a category for reference purposes. Two models were utilized in this regard; model 1 included all significant sociodemographic and diabetes status variables; model 2 included model 1 plus social support, diabetes distress, and feelings of isolation. The level of significance was assumed to be less than 0.05.

4. Results

More than half of the participants (n = 494) were female, with a mean age of 60.88 $\pm$ 9.52 years. The mean BMI was 28.31 $\pm$ 4.87 kg/m^2. In this study, 83.6% of the subjects were married, and 37% of the participants were educated to a diploma level. Moreover, 36.6% of the subjects were retired, and 12.6% of the participants smoked. The mean duration of diabetes was 12.86 $\pm$ 7.97 years. Furthermore, 55.9% of the subjects used only oral medication for their diabetes, and the mean value of HbA1c was 8.01% $\pm$ 1.42. The participants reported diabetes-related complications as without complications (44.1%), one complication (39.7%), and $\geq$ 2 complications (16.2%) (Table 2).

Table 1 shows the patients' IPAQ scores and descriptive analysis of items regarding social support, diabetes-related distress, and feelings of isolation. The mean value of feeling socially isolated was 5.48. The mean value of diabetes-related distress was 2.49, and 76% of the subjects had moderate to high distress (Diabetes Distress Scale score > 2). The majority of the participants reported moderate to high social support from their family, friends, and close individuals. About 53%, 41%, 32%, and 20% of the patients received moderate to high support from the diabetes care team, neighbors, other individuals with diabetes, and individuals at work, respectively.

The results of physical activity participation showed that 71% of the patients participated in low levels of physical activity (Table 1). Significant factors affecting the level of physical activity were age, BMI, gender, educational level, and the presence of diabetes complications (Table 2).

Table 3 shows the findings of the multivariable binary logistic regression analysis predicting physical activity behavior (sufficient activity). In multivariable models, model 1 included all significant sociodemographic and diabetes status variables. In model 2, social support, diabetes distress, and feelings of isolation were added to model 1. The ultimate model showed that the respondents aged 55 - 65 and > 65 years were less likely to have sufficient physical activity than those under 55 years; however, a significant finding was only observed for the group older than

Table 1. Descriptive Analysis of Items Regarding International Physical Activity Questionnaires, Social Support, Diabetes-Related Distress, and Feelings of Isolation (n = 494) [a]

Variables	Values
IPAQ	
IPAQ-walking MET (minute/week)	363.49 ± 460.99
IPAQ-moderate MET (minute/week)	450.92 ± 633.90
IPAQ-vigorous MET (minute/week)	185.72 ± 226.31
Total physical activity MET (minute/week)	1000.13 ± 1247.2
Participation in physical activity; moderate/high vs. low activity	
Sufficiently active	144 (29.15)
Insufficiently active	350 (70.85)
Social support: Moderate and high	
Family members, friends, and close individuals	398 (80.5)
Diabetes care team	262 (53.1)
Individuals at work	101 (20.4)
Other individuals with diabetes	156 (31.6)
Other individuals in the community (neighbors)	204 (41.2)
Feelings of isolation and loneliness	
Scale from 1 (low) to 10 (high)	5.48 ± 3.11
DDS score (range: 1 - 6)	2.49 ± 1.03
Moderate and high diabetes distress (DDS > 2)	376 (76.2)
None/low diabetes distress (DDS ≤ 2)	118 (23.8)

Abbreviations: IPAQ, International Physical Activity Questionnaires; MET, metabolic equivalent; DDS, Diabetes Distress Scale.

[a] Values are expressed as Mean ± Standard Deviation or No. (%).

65 years (OR = 0.75; 95% CI: 0.21 - 0.88 and OR = 0.88; 95% CI: 0.59 - 1.45, respectively). Furthermore, the subjects in the obese group seem to be less likely to have sufficient physical activity (OR = 0.70; 95% CI: 0.35 - 0.79) than those in the normal - weight group. Being female (OR = 0.73; 95% CI: 0.19 - 0.81) and presence of multiple diabetes complications (OR = 0.43; 95% CI: 0.31 - 0.55) correlated with lower odds of sufficient activity. Those participants with a college education were more likely to be sufficiently active than those with lower educational levels (OR = 2.11; 95% CI: 1.14 - 3.47).

The individuals who had moderate to high levels of distress were less likely to have sufficient physical activity (OR = 0.60; 95% CI: 0.19 - 0.79) than the individuals with low/no diabetes-related distress. The participants who felt a stronger sense of isolation (OR = 0.77; 95% CI: 0.67 - 0.90) were less likely to be sufficiently active. The participants who had moderate to high support from their family and friends (OR = 1.77; 95% CI: 1.47 - 2.74), care team (OR = 1.42; 95% CI: 1.15 - 1.77), and neighbors (OR = 1.53; 95% CI: 1.20 - 2.08) were more likely to have sufficient physical activity than those who did not have these supports.

5. Discussion

This study showed that the low and insufficient levels of physical activity were highly prevalent among individuals with T2D during the COVID-19 pandemic (71%). The level of physical activity obtained in this study is similar to those from other Iran sources during this crisis. For example, a study conducted during COVID-19 in Iran showed that 78% of the sample participants did not have sufficient physical activity as recommended by the physical activity guidelines (21). Pre-COVID-19 research (22) has reported that the prevalence of meeting recommendations for total physical activity (either moderate- or vigorous-intensity physical activity) in older adults with diabetes was 42%; however, our study reported 29% sufficiently active, indicating a considerable reduction in the physical activity level in comparison to that of before the pandemic. Such levels are concerning in themselves, as reducing physical activity for just a few weeks results in detrimental impacts on glycemic control (23, 24). For example, substantial worsening of glycemic control was observed in individuals with diabetes who were previously active but reduced their activity levels for 2 weeks (25, 26), which can easily happen

Table 2. General Characteristics of Participants (n = 494) [a]

Characteristics	Total (n = 494)	Insufficiently Active (n = 350)	Sufficiently Active (n = 144)	P-Value [b]
Age (y)				0.00
< 55	87 (17.6)	37 (42.53)	50 (57.47)	
55 - 65	247 (50)	188 (76.11)	59 (23.89)	
> 65	160 (32.4)	125 (78.12)	35 (21.88)	
Body mass index (kg/m²)				0.00
< 25 (normal)	110 (22.27)	41 (37.27)	69 (62.73)	
25 - 30 (overweight)	247 (50)	192 (77.73)	55 (22.27)	
≥ 30 (obese)	137 (27.73)	117 (85.40)	20 (14.60)	
Gender				0.003
Male	233 (47.17)	134 (57.51)	99 (42.49)	
Female	261 (52.83)	216 (82.76)	45 (17.24)	
Educational level				0.01
Primary school	148 (30)	130 (87.84)	18 (12.16)	
7th to 11th grade	68 (13.77)	58 (85.29)	10 (14.71)	
12th grade	183 (37)	127 (69.40)	56 (30.60)	
College	95 (19.23)	35 (36.84)	60 (63.16)	
Employment status				0.34
Employed	100 (20.24)	73 (73)	27 (27)	
Retired	181 (36.64)	111 (61.33)	70 (38.67)	
Homemaker	213 (43.12)	166 (77.90)	47 (22.10)	
Smoking				0.89
Current smoker	62 (12.55)	50 (80.65)	12 (19.35)	
Nonsmoker/quitted	432 (87.45)	300 (69.44)	132 (30.56)	
Diabetes duration (y)				0.25
< 5	108 (21.86)	59 (54.63)	49 (45.37)	
6 - 10	147 (29.76)	102 (69.39)	45 (30.61)	
≥ 11	239 (48.38)	189 (79.08)	50 (20.92)	
Diabetes complications				0.01
No complication	218 (44.13)	139 (63.76)	79 (36.24)	
1 complication	196 (39.68)	151 (77.04)	45 (22.96)	
≥ 2 complications	80 (16.19)	61 (76.25)	19 (23.75)	
Diabetes medication				
Only oral medications	276 (55.87)	176 (63.77)	100 (36.23)	
Insulin plus oral medications	149 (30.16)	115 (77.18)	34 (22.82)	0.32
Only insulin	69 (13.97)	59 (85.51)	10 (14.49)	

[a] Values are expressed as No. (%).
[b] P: Pearson's chi-square test.

during home confinement. Therefore, this finding alone proposes that more effort is necessary to be made to support individuals with T2D during the COVID-19 pandemic and other pandemics, to meet the guidelines for regular physical activity to gain maximum advantage from the activity.

Table 3. Multivariable Logistic Regressions to Determine Factors Predicting Physical Activity Behavior (n = 494)

Predictors	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Age group (y) (reference: < 55)		
55 - 65	0.85 (0.55 - 1.40)	0.88 (0.59 - 1.45)
> 65	0.71 (0.11 - 0.91) [b]	0.75 (0.21 - 0.88) [b]
Body mass index (kg/m²) (reference: < 25 [normal])		
25 - 30 (overweight)	0.75 (0.41 - 0.98) [a]	0.85 (0.46 - 1.32)
≥ 30 (obese)	0.61 (0.46 - 0.81) [c]	0.70 (0.35 - 0.79) [b]
Gender; female vs. male	0.67 (0.22 - 0.99) [b]	0.73 (0.19 - 0.81) [a]
Educational level (reference: Primary school)		
7th to 11th grade	1.13 (0.67 - 1.90)	1.10 (0.44 - 2.11)
12th grade	1.71 (1.09 - 2.70) [a]	1.64 (1.06 - 2.65) [a]
College	2.25 (1.24 - 3.36) [c]	2.11 (1.14 - 3.47) [c]
Diabetes complications (reference: No complication)		
1 complication	0.69 (0.41 - 0.97) [a]	0.76 (0.41 - 1.17)
≥ 2 complications	0.40 (0.31 - 0.52) [c]	0.43 (0.31 - 0.55) [b]
Social support: Moderate and high vs. none		
Family members, friends, and close individuals		1.77 (1.47 - 2.74) [c]
Diabetes care team		1.42 (1.15 - 1.77) [b]
Individuals at work		1.21 (0.98 - 1.50)
Other individuals with diabetes		1.18 (0.79 - 1.77)
Other individuals in the community (neighbors)		1.53 (1.20 - 2.08) [c]
Isolation: Scale from 1 (low) to 10 (high)		0.77 (0.67 - 0.90) [b]
Moderate/high vs. none/low diabetes distress		0.60 (0.19 - 0.79) [c]

Abbreviations: OR, odds ratio; CI, confidence interval.
[a] $P < 0.05$
[b] $P < 0.01$
[c] $P < 0.001$

This study also explored the potential factors associated with physical activity during this critical time. Logistic regression analysis showed that insufficient physical activity was significantly associated with being female, higher age, obesity, presence of diabetes-related complications, feelings of isolation, and higher levels of distress related to diabetes. Furthermore, physical activity was associated with a higher educational level and having social support from family/friends, neighbors, and the diabetes care team. The sociodemographic predictors of insufficient levels of physical activity in this study are broadly in line with those before and during COVID-19 research (6, 27-29). The aforementioned findings might be beneficial for healthcare providers to identify patients who are at risk of insufficient activity, especially during this time, and educate them about different exercise interventions and programs (e.g., a home-based exercise program).

The results of this study showed that experiencing higher levels of diabetes distress was related to a less likelihood of being sufficiently physically active. A large-scale cohort study on 2,040 participants (30) showed that higher diabetes distress was associated with worse self-management behaviors, including physical activity behavior. Another large national study in Australia on 2,552 adults with T2D also demonstrated that patients with diabetes distress were more likely not to follow the recommendations for physical activity (31). In the current study, feelings of isolation were a significant predictor of less sufficient physical activity. This finding is in line with those of a systematic review in older adults, where more consistent negative associations were observed between feelings of loneliness and physical activity level (13). The aforementioned findings support that poor psychosocial health is associated with poor self-management behaviors, including lower physical activity engagement (32, 33). Recent evidence has shown that psychosocial health was adversely

affected by the pandemic (34) and might even be more severe and long-lasting for patients with T2D than in the general population (35). Therefore, online psychoeducation programs and mindfulness-based interventions are essential to mitigate the psychological effects and worries associated with diabetes and the pandemic and increase mental health (36).

The present study also revealed that patients with social support (i.e., from family/friends/close individuals, neighbors, and diabetes care team) were more likely to be sufficiently physically active than those without support. This result is confirmed by a prior systematic review indicating an overall positive association between physical activity and social support, especially from family (13). The aforementioned results suggest that high support from family and friends can assist and motivate diabetic patients to keep being active and preserve their physical and mental health, especially in the extended periods of pandemic-related lockdowns.

This study is subject to several limitations. Firstly, physical activity levels were not measured directly, for example, using a pedometer. Secondly, the data on the physical activity levels of the studied patients corresponding to before the COVID-19 era were not collected; therefore, there was no information on the exact level of patients' activity before this crisis. Thirdly, this was a cross-sectional study, which makes it difficult to conclude causation. Finally, self-reported data were used to assess physical activity; as a result, this study was subject to reporting bias. However, the authors attempted to minimize this issue by giving examples of usual types of physical activity with corresponding intensities.

5.1. Conclusions

Based on the results of this study, about 70% of patients with diabetes were insufficiently active. Since physical activity is a crucial element in the management of T2D, more effort needs to be made to support patients with T2D to meet guidelines for sufficient physical activity during the COVID-19 pandemic and potential future crises.

The present study also explored that insufficient physical activity was significantly associated with being female, higher age, obesity, presence of diabetes-related complications, feelings of isolation, and higher levels of distress related to diabetes. Sufficient physical activity was significantly associated with a higher educational level and having social support from family/friends, neighbors, and the diabetes care team. The obtained results point to the importance of social support as an amplifier mechanism for the maintenance of physical activity behavior.

References

1. Pecanha T, Goessler KF, Roschel H, Gualano B. Social isolation during the COVID-19 pandemic can increase physical inactivity and the global burden of cardiovascular disease. *Am J Physiol Heart Circ Physiol.* 2020;**318**(6):H1441–6. doi: 10.1152/ajpheart.00268.2020. [PubMed: 32412779]. [PubMed Central: PMC7303725].

2. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, et al. Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. *Diabetes Care.* 2016;**39**(11):2065–79. doi: 10.2337/dc16-1728. [PubMed: 27926890]. [PubMed Central: PMC6908414].

3. Sigal RJ, Armstrong MJ, Bacon SL, Boule NG, Dasgupta K; Diabetes Canada Clinical Practice Guidelines Expert Committee, et al. Physical Activity and Diabetes. *Can J Diabetes.* 2018;**42 Suppl 1**:S54–63. doi: 10.1016/j.jcjd.2017.10.008. [PubMed: 29650112].

4. Marcal IR, Fernandes B, Viana AA, Ciolac EG. The Urgent Need for Recommending Physical Activity for the Management of Diabetes During and Beyond COVID-19 Outbreak. *Front Endocrinol (Lausanne)*. 2020;**11**:584642. doi: 10.3389/fendo.2020.584642. [PubMed: 33250859]. [PubMed Central: PMC7673403].

5. Silva DAS, Naghavi M, Duncan BB, Schmidt MI, de Souza MFM, Malta DC. Physical inactivity as risk factor for mortality by diabetes mellitus in Brazil in 1990, 2006, and 2016. *Diabetol Metab Syndr*. 2019;**11**:23. doi: 10.1186/s13098-019-0419-9. [PubMed: 30867683]. [PubMed Central: PMC6396532].

6. Linder S, Abu-Omar K, Geidl W, Messing S, Sarshar M, Reimers AK, et al. Physical inactivity in healthy, obese, and diabetic adults in Germany: An analysis of related socio-demographic variables. *PLoS One*. 2021;**16**(2). e0246634. doi: 10.1371/journal.pone.0246634. [PubMed: 33561175]. [PubMed Central: PMC7872299].

7. Abubakari AR, Lauder W, Jones MC, Kirk A, Agyemang C, Bhopal RS. Prevalence and time trends in diabetes and physical inactivity among adult West African populations: the epidemic has arrived. *Public Health*. 2009;**123**(9):602–14. doi: 10.1016/j.puhe.2009.07.009. [PubMed: 19748643].

8. Joensen LE, Madsen KP, Holm L, Nielsen KA, Rod MH, Petersen AA, et al. Diabetes and COVID-19: psychosocial consequences of the COVID-19 pandemic in people with diabetes in Denmark-what characterizes people with high levels of COVID-19-related worries? *Diabet Med*. 2020;**37**(7):1146–54. doi: 10.1111/dme.14319. [PubMed: 32392380]. [PubMed Central: PMC7273071].

9. Sujan MSH, Tasnim R, Islam MS, Ferdous MZ, Apu MAR, Musfique MM, et al. COVID-19-specific diabetes worries amongst diabetic patients: The role of social support and other co-variates. *Prim Care Diabetes*. 2021;**15**(5):778–85. doi: 10.1016/j.pcd.2021.06.009. [PubMed: 34210639]. [PubMed Central: PMC8226038].

10. Koliaki C, Tentolouris A, Eleftheriadou I, Melidonis A, Dimitriadis G, Tentolouris N. Clinical Management of Diabetes Mellitus in the Era of COVID-19: Practical Issues, Peculiarities and Concerns. *J Clin Med*. 2020;**9**(7). doi: 10.3390/jcm9072288. [PubMed: 32708504]. [PubMed Central: PMC7408673].

11. Woods JA, Hutchinson NT, Powers SK, Roberts WO, Gomez-Cabrera MC, Radak Z, et al. The COVID-19 pandemic and physical activity. *Sports Med Health Sci*. 2020;**2**(2):55–64. doi: 10.1016/j.smhs.2020.05.006. [PubMed: 34189484]. [PubMed Central: PMC7261095].

12. Murano I, Asakawa Y, Mizukami M, Takihara J, Shimizu K, Imai T. Factors increasing physical activity levels in diabetes mellitus: a survey of patients after an inpatient diabetes education program. *J Phys Ther Sci*. 2014;**26**(5):695–9. doi: 10.1589/jpts.26.695. [PubMed: 24926134]. [PubMed Central: PMC4047234].

13. Lindsay Smith G, Banting L, Eime R, O'Sullivan G, van Uffelen JGZ. The association between social support and physical activity in older adults: a systematic review. *Int J Behav Nutr Phys Act*. 2017;**14**(1):56. doi: 10.1186/s12966-017-0509-8. [PubMed: 28449673]. [PubMed Central: PMC5408452].

14. Veer IM, Riepenhausen A, Zerban M, Wackerhagen C, Puhlmann LMC, Engen H, et al. Psycho-social factors associated with mental resilience in the Corona lockdown. *Transl Psychiatry*. 2021;**11**(1):67. doi: 10.1038/s41398-020-01150-4. [PubMed: 33479211]. [PubMed Central: PMC7817958].

15. Beverly EA, Ritholz MD, Dhanyamraju K. The buffering effect of social support on diabetes distress and depressive symptoms in adults with Type 1 and Type 2 diabetes. *Diabet Med*. 2021;**38**(4). e14472. doi: 10.1111/dme.14472. [PubMed: 33258148].

16. Abdoli S, Silveira M, Doosti-Irani M, Fanti P, Miller-Bains K, Pavin EJ, et al. Cross-national comparison of psychosocial well-being and diabetes outcomes in adults with type 1 diabetes during the COVID-19 pandemic in US, Brazil, and Iran. *Diabetol Metab Syndr*. 2021;**13**(1):63. doi: 10.1186/s13098-021-00681-0. [PubMed: 34116721]. [PubMed Central: PMC8193175].

17. de Moraes AC, Guerra PH, Menezes PR. The worldwide prevalence of insufficient physical activity in adolescents; a systematic review. *Nutr Hosp*. 2013;**28**(3):575–84. doi: 10.3305/nh.2013.28.3.6398. [PubMed: 23848074].

18. Baghiani Moghaddam MH, Bakhtari Aghdam F, Asghari Jafarabadi M, Allahverdipour H, Dabagh Nikookheslat S, Safarpour S. The Iranian Version of International Physical Activity Questionnaire (IPAQ) in Iran: Content and Construct Validity, Factor Structure, Internal Consistency and Stability. *World Applied Sciences Journal*. 2012;**18**(8):1073–80.

19. Tol A, Baghbanian A, Sharifirad G, Shojaeizadeh D, Eslami A, Alhani F, et al. Assessment of diabetic distress and disease related factors in patients with type 2 diabetes in Isfahan: A way to tailor an effective intervention planning in Isfahan-Iran. *J Diabetes Metab Disord*. 2012;**11**(1):20. doi: 10.1186/2251-6581-11-20. [PubMed: 23497508]. [PubMed Central: PMC3598171].

20. Ray ME, Coon JM, Al-Jumaili AA, Fullerton M. Quantitative and Qualitative Factors Associated with Social Isolation Among Graduate and Professional Health Science Students. *Am J Pharm Educ*. 2019;**83**(7):6983. doi: 10.5688/ajpe6983. [PubMed: 31619819]. [PubMed Central: PMC6788151].

21. Amini H, Isanejad A, Chamani N, Movahedi-Fard F, Salimi F, Moezi M, et al. Physical activity during COVID-19 pandemic in the Iranian population: A brief report. *Heliyon*. 2020;**6**(11). e05411. doi: 10.1016/j.heliyon.2020.e05411. [PubMed: 33163638]. [PubMed Central: PMC7605807].

22. Zhao G, Ford ES, Li C, Balluz LS. Physical activity in U.S. older adults with diabetes mellitus: prevalence and correlates of meeting physical activity recommendations. *J Am Geriatr Soc*. 2011;**59**(1):132–7. doi: 10.1111/j.1532-5415.2010.03236.x. [PubMed: 21226683].

23. Martinez-Ferran M, de la Guia-Galipienso F, Sanchis-Gomar F, Pareja-Galeano H. Metabolic Impacts of Confinement during the COVID-19 Pandemic Due to Modified Diet and Physical Activity Habits. *Nutrients*. 2020;**12**(6). doi: 10.3390/nu12061549. [PubMed: 32466598]. [PubMed Central: PMC7352228].

24. Laddu DR, Lavie CJ, Phillips SA, Arena R. Physical activity for immunity protection: Inoculating populations with healthy living medicine in preparation for the next pandemic. *Prog Cardiovasc Dis*. 2021;**64**:102–4. doi: 10.1016/j.pcad.2020.04.006. [PubMed: 32278694]. [PubMed Central: PMC7195025].

25. McGlory C, von Allmen MT, Stokes T, Morton RW, Hector AJ, Lago BA, et al. Failed Recovery of Glycemic Control and Myofibrillar Protein Synthesis With 2 wk of Physical Inactivity in Overweight, Prediabetic Older Adults. *J Gerontol A Biol Sci Med Sci*. 2018;**73**(8):1070–7. doi: 10.1093/gerona/glx203. [PubMed: 29095970]. [PubMed Central: PMC6037059].

26. Liu JX, Zhu L, Li PJ, Li N, Xu YB. Effectiveness of high-intensity interval training on glycemic control and cardiorespiratory fitness in patients with type 2 diabetes: a systematic review and meta-analysis. *Aging Clin Exp Res*. 2019;**31**(5):575–93. doi: 10.1007/s40520-018-1012-z. [PubMed: 30097811]. [PubMed Central: PMC6491404].

27. Fernández-Rio J, Cecchini JA, Méndez-Giménez A, Carriedo A. COVID-19 and home confinement: data on physical activity. *Arch Med Deporte*. 2021;**38**(1):36–40. doi: 10.18176/archmeddeporte.00024.

28. Hassabi M, Esteghamati A, Halabchi F, Abedi-Yekta AH, Mahdaviani B, Hassanmirzaie B, et al. Iranian National Clinical Practice Guideline for Exercise in Patients with Diabetes. *Int J Endocrinol Metab*. 2021;**19**(3). e109021. doi: 10.5812/ijem.109021. [PubMed: 34567134]. [PubMed Central: PMC8453655].

29. Smith L, Gardner B, Fisher A, Hamer M. Patterns and correlates of physical activity behaviour over 10 years in older adults: prospective analyses from the English Longitudinal Study of Ageing. *BMJ Open*. 2015;**5**(4). e007423. doi: 10.1136/bmjopen-2014-007423. [PubMed: 25877281]. [PubMed Central: PMC4401868].

30. Johnson ST, Al Sayah F, Mathe N, Johnson JA. The relationship of diabetes-related distress and depressive symptoms with physical

activity and dietary behaviors in adults with type 2 diabetes: A cross-sectional study. *J Diabetes Complications*. 2016;**30**(5):967–70. doi: 10.1016/j.jdiacomp.2016.02.019. [PubMed: 27083444].

31. Nanayakkara N, Pease A, Ranasinha S, Wischer N, Andrikopoulos S, Speight J, et al. Depression and diabetes distress in adults with type 2 diabetes: results from the Australian National Diabetes Audit (ANDA) 2016. *Sci Rep*. 2018;**8**(1):7846. doi: 10.1038/s41598-018-26138-5. [PubMed: 29777153]. [PubMed Central: PMC5959930].

32. Shor R, Shalev A. Barriers to involvement in physical activities of persons with mental illness. *Health Promot Int*. 2016;**31**(1):116–23. doi: 10.1093/heapro/dau078. [PubMed: 25204451].

33. Peterson JA, Chesbro G, Larson R, Larson D, Black CD. Short-Term Analysis (8 Weeks) of Social Distancing and Isolation on Mental Health and Physical Activity Behavior During COVID-19. *Front Psychol*. 2021;**12**:652086. doi: 10.3389/fpsyg.2021.652086. [PubMed: 33815233]. [PubMed Central: PMC8012844].

34. Fancourt D, Steptoe A, Bu F. Trajectories of anxiety and depressive symptoms during enforced isolation due to COVID-19 in England: a longitudinal observational study. *Lancet Psychiatry*. 2021;**8**(2):141–9. doi: 10.1016/S2215-0366(20)30482-X. [PubMed: 33308420]. [PubMed Central: PMC7820109].

35. Madsen KP, Willaing I, Rod NH, Varga TV, Joensen LE. Psychosocial health in people with diabetes during the first three months of the COVID-19 pandemic in Denmark. *J Diabetes Complications*. 2021;**35**(4):107858. doi: 10.1016/j.jdiacomp.2021.107858. [PubMed: 33573890]. [PubMed Central: PMC7816585].

36. Peimani M, Bandarian F, Namazi N, Nasli-Esfahani E. COVID-19-specific worries among people with type 2 diabetes following the continuation of the pandemic and occurrence of multiple waves of COVID-19 in Iran. *J Diabetes Metab Disord*. 2022;**21**(1):61–8. doi: 10.1007/s40200-021-00935-8. [PubMed: 35036383]. [PubMed Central: PMC8753953].