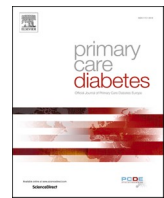




Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



# Physical activity and fruit and vegetable consumption during the COVID-19 pandemic for people with type 2 diabetes mellitus

Jennifer A. Andersen<sup>a</sup>, Don E. Willis<sup>a</sup>, Emily Hallgren<sup>a</sup>, Pearl A. McElfish<sup>a,\*</sup>, Holly C. Felix<sup>b</sup>

<sup>a</sup> University of Arkansas for Medical Sciences Northwest, College of Medicine, 1125 N. College Ave., Fayetteville, AR 72703, USA

<sup>b</sup> University of Arkansas for Medical Sciences, Fay W. Boozman College of Public Health, 4301 W. Markham St., Little Rock, AR 72205, USA

## ARTICLE INFO

### Keywords:

T2DM  
SARS-CoV-2  
Physical activity  
Nutrition  
Pandemic

## ABSTRACT

**Aims:** To understand the associations between sociodemographic factors, self-rated health, and COVID-19-related changes in physical activity and diet and the reported number of days per week participants engaged in physical activity and consumed fruits and vegetables for people with type 2 diabetes mellitus (T2DM).

**Methods:** Respondents from Arkansas primary care clinics completed a survey between October 2020 and January 2021. Multivariable regression determined associations between sociodemographic factors, self-rated health, and COVID-19-related changes in physical activity and diet and the reported number of days per week participants engaged in physical activity and consumed fruits and vegetables.

**Results:** Respondents exercised for at least 30 min on a mean of 2.09 days and consumed five or more fruit and vegetable servings on a mean of 3.57 days. Males engaged in one additional day of physical activity compared to women. Respondents with a college degree or higher ate 5 or more fruit and vegetable servings on fewer days per week than those with a high school education or less.

**Conclusions:** Results reaffirm a need for diabetes education programs and health care providers to provide information on the importance of maintaining physical activity and a healthy diet as part of a self-care plan for T2DM, especially during public health emergencies like the COVID-19 pandemic.

## 1. Introduction

Type 2 diabetes mellitus (T2DM) is a chronic condition requiring maintenance of blood glucose levels. The age-adjusted prevalence of adult Americans with diabetes mellitus is ~9%, the majority of whom have T2DM [1,2]. People diagnosed with T2DM are at greater risk of complications from COVID-19 infection, including acute respiratory distress syndrome (ARDS), septic shock, and multiple organ dysfunction syndrome (MODS), and are at greater risk of death [3,4]. Elevated blood glucose levels increases the risk of these complications [4].

The American Diabetes Association recommends adults with T2DM engage in self-care behaviors to manage their T2DM and prevent complications, including being physically active and eating a healthy diet [5]. However, stay-at-home orders during the COVID-19 pandemic have limited options to engage in physical activity and access to fresh, nutrient dense foods (e.g., fresh fruits and vegetables), causing significant disruptions to physical activity and diet patterns [6–9]. These disruptions may lead to increases in glucose levels, putting people with T2DM at risk for both complications from T2DM and worse outcomes if

they are infected with COVID-19 [10,11].

Studies prior to COVID-19 have shown optimal self-rated health, an indicator of subjective physical health, is associated with physical activity and the consumption of fruits and vegetables, with those reporting better health also engaging in more physical activity and consuming more servings of fruits and vegetables [12]. Age and gender have also been shown to influence physical activity, with younger adults and men engaging in more minutes of physical activity compared to older adults and women [13].

Understanding the experiences of people with T2DM during the COVID-19 pandemic is essential in creating educational materials and resources to address the needs of the T2DM community during a public health emergency. The aim of this study was to understand the experiences of adults with T2DM during the COVID-19 pandemic. We aimed to identify if demographic characteristics (age, sex, education, race, and income), self-rated health, food insecurity, and changes in frequency of engaging in physical activity and consuming fruits and vegetables were associated with the number of days a week that adults with T2DM engaged in 30 min of physical activity or consumed five servings or more

\* Correspondence to: 1125 N. College Ave., Fayetteville, AR 72703, USA.

E-mail address: [PAMcelfish@uams.edu](mailto:PAMcelfish@uams.edu) (P.A. McElfish).

<https://doi.org/10.1016/j.pcd.2022.07.004>

Received 9 March 2022; Accepted 18 July 2022

Available online 21 July 2022

1751-9918/© 2022 Primary Care Diabetes Europe. Published by Elsevier Ltd. All rights reserved.

of fruits and vegetables.

## 2. Methods

Respondents were recruited between October 30, 2020 and January 16, 2021 from six primary care clinic sites throughout the state of Arkansas. Research Electronic Data Capture (REDCap) was used to administer the consent and survey. Inclusion criteria for the survey included being an adult (age ≥18) and living, working, and/or receiving health care in the state of Arkansas during the study period. A \$20 gift card was provided after survey completion as compensation for respondents' time. The study was approved by the University of Arkansas for Medical Sciences Institutional Review Board (IRB#261226).

In total, 876 responses were collected. Of those, 809 met the inclusion criteria, and 754 were determined to be non-duplicates who answered questions past the eligibility screeners. The final analytic sample consisted of 101 respondents who reported a diagnosis of T2DM. The percentage of respondents in the data diagnosed with T2DM was 13.4 %, which is higher than the proportion diagnosed with diabetes in the United States (US) population (~9 %) but comparable to the proportion of Arkansans with diabetes in 2018 (~12 %) [1,2].

The physical activity and diet variables were measured as a count of the number of days over the past week the respondent engaged in at least 30 min of additional physical activity and the number of days over the past week the respondent reported eating five or more servings of fruits and vegetables. Sociodemographic factors included were age, sex, education, race/ethnicity, income, and food insecurity (see Table 1). Self-rated health was measured with the question, "Would you say that in general your health is...?" and included response options of *excellent*, *good*, *fair*, and *poor*; however, no respondents chose the excellent response option [14,15]. Change in exercise and fruit and vegetable consumption during the pandemic were coded dichotomously as less than before (=0) and about the same/more than before (=1).

We report descriptive statistics, including means and standard deviations for continuous variables, and the frequency and percentages for categorical variables. Our analysis includes multivariable regression, using full information maximum likelihood estimation to account for missing data, to determine the associations between the sociodemographic factors, self-rated health, and COVID-19-related change in behaviors and physical activity and fruit and vegetable consumption. Analysis was completed using STATA 17 [16], and a p-value of .05 or less was considered statistically significant.

## 3. Results

In Table 1 we present the characteristics of the respondents. The mean age of the participants was 56.1 years ( ± 13.8; range=26.1–88.0). The majority of the respondents were female (66.3 %) and White (75.0 %). Almost half of the respondents (42.4 %) had at least some college education or a technical/vocational degree; 45.7 % reported making less than \$25,000 per year. Forty-three percent of the respondents reported being food insecure. The majority of respondents reported being in good (40.6 %) or fair (38.6 %) health. A third of respondents (31.3 %) reported less physical activity since the beginning of the COVID-19 pandemic (March 2020), and 20.8 % reported consuming less fruits and vegetable since the beginning of the pandemic. The mean number of days per week respondents reported engaging in at least 30 min of physical activity was 2.09 ( ± 2.55), and the mean number of days per week respondents consumed five or more servings of fruits and vegetables was 3.57 ( ± 2.49).

In Table 2 we report the associations between the sociodemographic factors, self-rated health, and changes in physical activity frequency and the number of days respondents engaged in 30 min of physical activity. Compared to females, males reported engaging in one additional day of physical activity ( β = 1.05, p = .040). Self-rated health was positively associated with days of physical activity, with respondents who rated

**Table 1**  
Demographics (n = 101).

	Mean (STD) or n (%)	Range
<b>Age (in years)</b>	56.1(13.8)	26.1 – 88.0
<b>Sex</b>		
Female	67(66.3)	
Male	34(33.7)	
<b>Education</b>		
High school or less	20(20.2)	
Some college or tech school	42(42.4)	
College degree or more	37(37.4)	
<b>Race/Ethnicity</b>		
Black	18(18.0)	
White	75(75.0)	
Other	7(7.0)	
<b>Income</b>		
Under \$25,000	43(45.7)	
\$25,000 to under \$50,000	21(22.3)	
\$50,000 or more	30(31.9)	
<b>Self-Rated Health</b>		
Good	41(40.6)	
Fair	39(38.6)	
Poor	21(20.8)	
<b>Food Insecurity</b>		
Food secure	53(57.0)	
Food insecure	40(43.0)	
<b>Change in Physical Activity Frequency since March 2020</b>		
Less	30(31.3)	
About the same/more	66(68.8)	
<b>Change in Fruit and Vegetable Consumption since March 2020</b>		
Less	20(20.8)	
About the same/more	76(79.2)	
<b>Number of Days with 30 min of Physical Activity</b>	2.09(2.55)	0–7
<b>Number of Days with Five Servings of Fruits And Vegetables</b>	3.57(2.49)	0–7

Note: M=Mean, SD=Standard Deviation.

**Table 2**  
Relationship between Sociodemographic Factors, Self-Rated Health, and COVID-19-Related Changes in Diet and Number of Days with 30 Min of Physical Activity (n = 101).

	β	SE	p	95 % CI	
				Lower	Upper
<b>Age (in years)</b>	-0.01	.02	.608	-0.05	.03
<b>Male</b>	1.05	.51	.040	.05	2.04
<b>Education<sup>a</sup></b>					
Some college or tech school	.57	.65	.382	-0.70	1.83
College degree or more	.18	.78	.815	-1.34	1.70
<b>Race/Ethnicity<sup>b</sup></b>					
Black	1.30	.67	.052	-0.01	2.60
Other race/ethnicity	.80	.97	.408	-1.10	2.71
<b>Income<sup>c</sup></b>					
Under \$25,000	.65	.65	.320	-0.63	1.93
\$50,000 or more	-0.25	.73	.734	-1.67	1.18
<b>Self-Rated Health<sup>d</sup></b>					
Good	1.64	.57	.004	.51	2.76
Poor	-0.26	.66	.699	-1.56	1.05
<b>About the Same or More Physical Activity since March 2020</b>	1.37	.52	.008	.35	2.38

Note: β=Regression Coefficients, SE=Standard Error, CI=Confidence Interval. A p value of .05 or less is considered statistically significant.

<sup>a</sup> ref=High school or less

<sup>b</sup> ref=White

<sup>c</sup> ref=\$25,000 to under \$50,000

<sup>d</sup> ref=Fair

their health as good engaging in more days of physical activity ( $\beta = 1.64$ ,  $p = .004$ ) compared to those respondents who rated their health as fair. Respondents who reported maintaining or increasing their level of physical activity since March 2020 also reported more days of engaging in 30 min of physical activity ( $\beta = 1.37$ ,  $p = .008$ ). None of the other sociodemographic factors were associated with the number of days the respondents engaged in 30 min of physical activity.

In Table 3 we present the associations between the sociodemographic factors, self-rated health, and changes in fruit and vegetable consumption and the number of days per week respondents reported eating 5 or more servings of fruits and vegetables. Respondents with a college degree or more reported eating 5 or more servings of fruits and vegetables on fewer days than those with a high school or less education ( $\beta = -1.51$ ,  $p = .049$ ). Respondents who reported maintaining or increasing fruit and vegetable consumption since March 2020 also reported more days of consuming 5 or more servings of fruits and vegetables per week ( $\beta = 1.53$ ,  $p = .021$ ). Self-rated health and other sociodemographic factors were not associated with the number of days the respondents consumed five servings or more of fruits and vegetables.

#### 4. Discussion

Mitigation measures put into place due to the COVID-19 pandemic, including stay-at-home orders, have limited options to engage in physical activity and access to fresh, nutrient dense foods (e.g., fresh fruits and vegetables), causing significant disruptions to physical activity and diet patterns [6–9]. Our results indicate individuals with T2DM living in Arkansas during the COVID-19 pandemic have experienced changes in physical activity levels and diet. Reduction in physical activity was reported by 31.3 % of respondents, and 20.8 % of the respondents reported eating less fruits and vegetables during the COVID-19 pandemic. Respondents who reported engaging in physical activity or consuming fruits and vegetables the same amount or more often than prior to the pandemic reported engaging in these behaviors more than a full day more often than those who reported engaging in these behaviors less often. The disruptions reported by these individuals put them at risk of

**Table 3**  
Relationship between Sociodemographic Factors, Self-Rated Health, and COVID-19-Related Changes in Diet and Number of Days Consumed 5 + Servings of Fruits and Vegetables (n = 101).

	$\beta$	SE	p	95 % CI	
				Lower	Upper
<b>Age (in years)</b>	.03	.02	0.088	-0.01	0.07
<b>Male</b>	-0.70	.49	0.154	-1.65	0.26
<b>Education<sup>a</sup></b>					
Some college or tech school	.89	.65	0.175	-0.39	2.16
College degree or more	-1.51	.77	0.049	-3.01	-0.01
<b>Race/Ethnicity<sup>b</sup></b>					
Black	.79	.66	0.227	-0.50	2.08
Other race/ethnicity	-0.21	.93	0.819	-2.03	1.60
<b>Income<sup>c</sup></b>					
Under \$25,000	-0.26	.64	0.683	-1.53	1.00
\$50,000 or more	.74	.70	0.293	-0.64	2.12
<b>Food Insecure<sup>d</sup></b>	-0.03	.60	0.966	-1.19	1.14
<b>Self-Rated Health<sup>e</sup></b>					
Good	.08	.57	0.890	-1.04	1.20
Poor	-0.63	.64	0.329	-1.88	0.63
<b>About the Same or More Fruit and Vegetable Consumption since March 2020</b>	1.53	.67	0.021	.23	2.84

Note:  $\beta$ =Regression Coefficients, SE=Standard Error, CI=Confidence Interval. A p value of .05 or less is considered statistically significant.

<sup>a</sup> ref=High school or less  
<sup>b</sup> ref=White  
<sup>c</sup> ref=\$25,000 to under \$50,000  
<sup>d</sup> ref=Food secure  
<sup>e</sup> ref=Fair

increases in glucose levels, leading to an increase in the risk of complications from COVID-19 if they were to be infected [10,11]. This is especially important to keep in mind given the mean age of the sample ( $56.1 \pm 13.8$  years) which indicates this population is already at risk of severe infection and death from COVID-19 [17].

Men reported engaging in at least 30 min of physical activity more often than women. Research has shown women have taken on more of the burden resulting from mitigation efforts by reducing paid work hours and assuming more of the childcare and housework responsibilities, which has previously been shown to have an effect on physical activity levels [18–21]. Future research should seek to understand how gender roles affect the level of physical activity for people with T2DM during the COVID-19 pandemic. Additionally, future work should investigate the potential for long-term negative health outcomes for women with T2DM because of potential gender differences in responsibilities and expectations during the pandemic.

Studies conducted prior to COVID-19 have shown self-rated health, an indicator of subjective physical health, is associated with physical activity and the consumption of fruits and vegetables, with those reporting better health also engaging in more physical activity and consuming more servings of fruits and vegetables [12]. Although none of the respondents self-reported being in excellent health, our results do indicate that individuals with T2DM who self-report good health engage in 30 min of physical activity more often than those who report being in fair health. These findings suggest there is a need to understand how people appraise their health and a need to address the importance of physical activity in managing T2DM and preventing complications with those who rate their health as fair or poor.

Previous research has shown college educated individuals tend to eat five or more servings of fruits and vegetables on more days than those with lower educational attainment [22,23]. Our results are counter to previous findings, with college-educated respondents in our sample reporting fewer days of adequate fruit and vegetable consumption compared to those with a high school or less education. Prior research in Europe has shown a decrease in the frequency of food shopping and fresh food consumption during the COVID-19 pandemic [24]. Our findings may be evidence of a similar phenomenon in the US. Reductions in the frequency of in-person food shopping may be disproportionately found among college-educated populations who have been more likely to work remotely [25] and have been more likely to avoid unnecessary trips outside the home, limiting access to fresh fruits and vegetables [26]. Given the increase in online food shopping and restaurant delivery during the pandemic, one potential option for addressing the lower fruit and vegetable consumption is to encourage online vendors to make fresh produce available for purchase and to promote these options to patrons while shopping.

#### 4.1. Limitations

The study is not without limitations, and the results should be interpreted with these limitations in mind. Our sample was limited to people with T2DM who were current or past patients and had been seen at one of six clinic sites throughout Arkansas; therefore, the results may not be generalizable to the general Arkansas or US populations with T2DM. Additionally, Arkansans have low levels of physical activity and fruit and vegetable consumption compared to residents of other US states [27,28], which limits generalizability. Second, all of the measures used in this study were self-reported and are reliant on respondent recollections, which may result in respondent bias. Third, the data is cross-sectional; therefore, no causal or temporal claims should be made regarding the findings. Finally, the survey did not include information on negative health behaviors (e.g., sedentary time, consumption of unhealthy foods) which may have potentially added to these findings.

Despite the limitations, our study makes a significant contribution to the literature. The results lead to a better understanding of the experiences of adults with T2DM during the COVID-19 pandemic. The findings

provide a basis for additional research, as well as interventions, to address T2DM health outcomes during and after the COVID-19 pandemic and future public health emergencies. The results reaffirm a need for diabetes education programs and health care providers to provide information on the importance of maintaining both physical activity and a healthy diet as part of a treatment plan for T2DM, even during a public health emergency such as the COVID-19 pandemic. The results also show the need for health care providers to communicate with patients about their self-appraisal of their health status, to ensure they are addressing the need to maintain healthy levels of physical activity among people with T2DM who report lower levels of self-rated health. Finally, the results indicate that there is a need for additional support for women with T2DM to maintain healthy levels of physical activity, including providing opportunities to engage in physical activity for women who may take on a larger portion of the home and family responsibilities during a public health emergency.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Data Availability

The deidentified data underlying the results presented in this study may be made available upon request from the corresponding author, Dr. Pearl A. McElfish, at [pamcelfish@uams.edu](mailto:pamcelfish@uams.edu). The data are not publicly available in accordance with funding requirements and participant privacy.

### Acknowledgments

Support was provided by University of Arkansas for Medical Sciences (UAMS) Translational Research Institute funding through the National Center for Research Resources and National Center for Advancing Translational Sciences of the National Institutes of Health (UL1 TR003107). Additional support was provided by the UAMS Rural Research Network. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

### CRedit authorship contribution statement

JAA and HCF conceived and designed the analysis. JAA performed the analysis, and all authors contributed to the interpretation of the analysis. JAA and HCF wrote the original draft of the paper. PAM revised for important intellectual content. All authors provided final approval of the version to be published and agree to be accountable for the work.

### References

- [1] Centers for Disease Control and Prevention. *National Diabetes Statistics Report 2020: Estimates of Diabetes and Its Burden in the United States*, U.S. Dept of Health and Human Services, Atlanta, GA, 2020.
- [2] Centers for Disease Control and Prevention. *United States Diabetes Surveillance System*, 2021 [cited 2021 February 25]; Available from: (<https://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html>).
- [3] L. Zhu, et al., Association of blood glucose control and outcomes in patients with COVID-19 and pre-existing type 2 diabetes, *Cell Metab.* 31 (6) (2020) 1068–1077. e3.
- [4] F. Zhou, et al., Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study, *Lancet* 395 (10229) (2020) 1054–1062.
- [5] American Diabetes Association, Standards of medical care in diabetes - 2021, *Diabetes Care* 44 (Suppl 1) (2021) S1–S232.
- [6] J. Faulkner, et al., Physical activity, mental health and well-being of adults during initial COVID-19 containment strategies: a multi-country cross-sectional analysis, *J. Sci. Med. Sport* 24 (4) (2021) 320–326.
- [7] J. Ingram, G. Maciejewski, C.J. Hand, Changes in diet, sleep, and physical activity are associated with differences in negative mood during COVID-19 lockdown, *Front. Psychol.* 11 (2020), 588604.
- [8] S. Wolf, et al., Is Physical activity associated with less depression and anxiety during the COVID-19 pandemic? a rapid systematic review, *Sports Med.* (2021) 1–13.
- [9] L. Jacob, et al., The relationship between physical activity and mental health in a sample of the UK public: a cross-sectional study during the implementation of COVID-19 social distancing measures, *Ment. Health Phys. Act.* 19 (2020), 100345.
- [10] N.G. Boulé, et al., Effects of exercise on glycemic control and body mass in type 2 diabetes MellitusA meta-analysis of controlled clinical trials, *JAMA* 286 (10) (2001) 1218–1227.
- [11] J.P. Kirwan, J. Sacks, S. Nieuwoudt, The essential role of exercise in the management of type 2 diabetes, *Cleavel. Clin. J. Med.* 84 (7 Suppl 1) (2017) S15–S21.
- [12] M. Södergren, et al., Associations between fruit and vegetable intake, leisure-time physical activity, sitting time and self-rated health among older adults: cross-sectional data from the WELL study, *BMC Public Health* 12 (1) (2012) 551.
- [13] Y.-C. Lin, et al., Physical activity status and gender differences in community-dwelling older adults with chronic diseases, *J. Nurs. Res.* 18 (2) (2010).
- [14] E.L. Idler, Y. Benyamini, Self-rated health and mortality: a review of twenty-seven community studies, *J. Health Soc. Behav.* 38 (1) (1997) 21–37.
- [15] O. Lundberg, K. Manderbacka, Assessing reliability of a measure of self-rated health, *Scand. J. Soc. Med.* 24 (3) (1996) 218–224.
- [16] STATACorp, Stata Statistical Software: Release 17, StataCorp LLC, College Station, TX, 2021.
- [17] F.B. Ahmad, et al., Provisional mortality data - United States, 2020, *MMWR Morb. Mortal. Wkly Rep.* 70 (14) (2021) 519–522.
- [18] T.M. Yildirim, H. Eslen-Ziya, The differential impact of COVID-19 on the work conditions of women and men academics during the lockdown, *Gen., Work Organ.* 28 (2021) 243–249.
- [19] C.S. Czymara, A. Langenkamp, T. Cano, Cause for concerns: gender inequality in experiencing the COVID-19 lockdown in Germany, *Eur. Soc.* 23 (sup1) (2021) S68–S81.
- [20] Farré, L., et al., How the COVID-19 lockdown affected gender inequality in paid and unpaid work in Spain. 2020.
- [21] C. Benke, et al., Lockdown, quarantine measures, and social distancing: Associations with depression, anxiety and distress at the beginning of the COVID-19 pandemic among adults from Germany, *Psychiatry Res.* 293 (2020), 113462.
- [22] B. Thompson, et al., Baseline fruit and vegetable intake among adults in seven 5 a day study centers located in diverse geographic areas, *J. Am. Diet. Assoc.* 99 (10) (1999) 1241–1248.
- [23] H.M. Blanck, et al., Trends in fruit and vegetable consumption among U.S. men and women, 1994–2005, *Prev. Chronic Dis.* 5 (2) (2008).
- [24] M. Janssen, et al., Changes in food consumption during the COVID-19 pandemic: analysis of consumer survey data from the first lockdown period in Denmark, Germany, and Slovenia, *Front. Nutr.* 8 (60) (2021).
- [25] A. Bick, A. Blandin, K. Mertens, *Work from Home After the COVID-19 Outbreak*, Federal Reserve Bank of Dallas, 2020.
- [26] S. Hamidi, A. Zandiatashbar, Compact development and adherence to stay-at-home order during the COVID-19 pandemic: a longitudinal investigation in the United States, *Landsc. Urban Plan.* 205 (2021), 103952.
- [27] S.H. Lee-Kwan, et al., Disparities in state-specific adult fruit and vegetable consumption-United States, 2015, *Mmwr. Morb. Mortal. Wkly. Rep.* 66 (45) (2017) 1241.
- [28] S.J. Lange, L.V. Moore, D.A. Galuska, Peer reviewed: data for decision-making: exploring the division of nutrition, physical activity, and obesity's data, trends, and maps, *Prev. Chronic Dis.* 16 (2019).