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Epidemiology

Association of obesity and diabetes with physical activity and fruit and vegetable consumption in stroke survivors

Ryan R Bailey[a,*], John Robinson Singleton[b] and Jennifer J Majersik[c]

[a]Department of Occupational and Recreational Therapies, [b]Neuromuscular Medicine Neurology Division, Department of Neurology and [c]Vascular Neurology Division, Department of Neurology, University of Utah, Salt Lake City, UT, USA

*Correspondence to Ryan R Bailey, Department of Occupational and Recreational Therapies, University of Utah, 520 Wakara Way, Salt Lake City, UT 84108, USA; E-mail: ryan.bailey@health.utah.edu

Abstract

Background: Engaging in unhealthy behaviours [poor diet, insufficient physical activity (PA)] increases risk for recurrent stroke and can be compounded by obesity and diabetes, but the association of obesity and diabetes with poor diet and insufficient PA in stroke survivors is unknown.
Objective: The purpose of this study was to compare prevalences of low fruit and vegetable consumption (low FV consumption, <1 fruit and <1 vegetable daily) and low physical activity (low PA, <150 minutes of weekly moderate-intensity PA) in stroke survivors, stratified by obesity–diabetes status (neither condition, obesity only, diabetes only, both conditions).
Methods: Cross-sectional data from 32 876 non-institutionalized, US stroke survivors aged ≥45 years from the 2015 and 2017 Behavioral Risk Factor Surveillance System were examined. Weighted, age-adjusted prevalence estimates and adjusted odds ratios (AORs) of the investigated unhealthy behaviours (adjusted for sex, age, race, income, education and marital status) and 95% confidence intervals (CIs) were calculated.
Results: Prevalences of low FV consumption and low PA exceeded 50% across all obesity–diabetes categories. Compared with respondents with neither obesity nor diabetes, AORs for low PA were increased for respondents with both obesity and diabetes (2.02, 95% CI: 1.72–2.37) and respondents with obesity only (1.31, 1.13–1.53); AORs for low FV consumption did not differ across obesity–diabetes categories.
Conclusions: Results indicated a joint effect of obesity and diabetes with low PA among stroke survivors. Regardless of obesity–diabetes status, however, prevalence of low FV consumption and low PA exceeded 50%. Targeted interventions that modify these unhealthy behaviours among stroke survivors should be explored.

Key words: Diabetes, diet, obesity, physical activity, primary care, stroke

Introduction

Stroke is a prevalent condition and a leading cause of disability worldwide, affecting an estimated 104.2 million people and contributing to approximately 132 million disability-adjusted life years lost in 2017 (1). In the USA, approximately 23% of annual strokes are recurrent events, and the 10-year cumulative risk of stroke recurrence is 25% (2). An estimated 74% of global stroke risk can be attributed to behavioural risk factors, including smoking, physical inactivity and an unhealthy diet (3). These unhealthy behaviours increase risk for high blood pressure and high cholesterol, insulin resistance and glucose intolerance and obesity, which in turn increase risk for cardiometabolic complications such as cardiovascular disease, diabetes and stroke (2).

Key Messages

- More than 50% of US stroke survivors report low fruit and vegetable consumption.
- More than 50% of US stroke survivors also report low physical activity.
- Obesity and diabetes are jointly associated with low physical activity.

Avoiding physical inactivity and adopting a healthy diet are important for preventing recurrent stroke (4). Guidelines for secondary stroke prevention such as the American Heart Association's (AHA) Guidelines for the Prevention of Stroke in Patients with Stroke and Transient Ischemic Attack recommend lifestyle management of behavioral risk factors (4), which encompasses self-managing health behaviours [e.g. physical activity (PA) and dietary intake] and comorbidities (e.g. obesity and diabetes). PA of approximately 150 minutes of weekly moderate-intensity activity and following a healthy dietary pattern, including consumption of fruits, vegetables, whole grains and low-fat dairy, are specifically recommended. Self-managing glycemic control and cardiovascular risk, and screening for obesity, are also recommended.

It is concerning, therefore, that prevalences of unhealthy behaviours among US stroke survivors are high, exceeding those observed for US adults without stroke for low fruit and vegetable (FV) consumption (51.7% versus 46.0%) and insufficient PA (56.5% versus 49.5%). Similarly, prevalences for overweight/obesity (70.2% versus 64.5%) and diabetes (22.6% versus 9.3%) are also higher in stroke survivors compared with adults without stroke (5). These data suggest that stroke survivors experience marginal and moderate disparities in health behaviours that lead to disparities in cardiometabolic conditions, and are in need of health behaviour intervention. Furthermore, in the general population obesity and diabetes are independently associated with unhealthy behaviours (6,7). In combination, however, obesity and diabetes may interact, resulting in a joint association with unhealthy behaviours that is stronger than would exist with either condition individually. This is concerning because multimorbidity is associated with poor health and all-cause mortality in the general population (8), and likely generalizes to stroke survivors as well.

There is a lack of research on the joint association of obesity and diabetes with unhealthy behaviours among stroke survivors. Such knowledge could be important to identify stroke subpopulations at greatest risk for unhealthy behaviours and in greatest need of health behaviour intervention. Furthermore, it could suggest that different intervention approaches are needed for survivors with different combinations of comorbidity (e.g. obesity only versus diabetes only versus both obesity and diabetes). The purpose of this study, therefore, was to examine the prevalence of low FV consumption and low PA among stroke survivors, and to examine the joint association of obesity and diabetes on these unhealthy behaviours.

Methods

Data sources

Data for this cross-sectional study were obtained from the Behavioral Risk Factor Surveillance System (BRFSS), a national telephone survey that collects health-related data, including risk behaviours, chronic conditions and use of preventive services, among non-institutionalized adults aged ≥18 years in the USA. Data were collected in all 50 US states, the District of Columbia and 3 US territories and are representative of the US population. BRFSS uses random-phone digit dialing to contact potential respondents. For this study, data from the 2015 and 2017 BRFSS surveys were combined to increase the analytical sample size. There were 441 456 respondents in the 2015 survey and 450 016 respondents in the 2017 survey, which together corresponds to 0.36% of the adult US population. Because respondents are chosen at random, overlapping respondent participation across years is unlikely. Additional data about the BRFSS can be accessed online (https://www.cdc.gov/brfss/). This study was exempt from Institutional Review Board approval because all data were de-identified.

Study sample

Data from adults with stroke aged ≥45 years at time of the BRFSS survey were eligible for inclusion in this study. History of stroke was determined by an affirmative response to the question, 'Has a health professional ever told you that you had a stroke?' The age threshold was chosen because ≥45 years is a risk factor for type 2 diabetes. Exclusion criteria included missing data for self-reported height, self-reported weight or missing data for the diabetes-related question, 'Has a health professional ever told you that you have diabetes?'

Variables of interest

Study variables were derived from BRFSS data, and included low FV consumption, low PA and obesity–diabetes status. Demographic characteristics, including sex, age, ethnicity, marital status, education and annual household income (see Table 1 for categorical levels), were included to describe the study sample and to control for potential confounders during statistical analyses.

Low FV consumption was defined as consuming <1 fruit and <1 vegetable daily, and was derived from BRFSS questions about the frequency of fruit, 100% fruit juice, bean and vegetable consumption during the previous month. This variable was chosen as an index of nutritional risk because the 2015–2020 Dietary Guidelines for Americans recommends consumption of approximately 2.0 cup-equivalent of fruit and 2.5 cup-equivalent of vegetables per 2000 calories (9); thus, consuming <1 fruit and <1 vegetable daily would fall below this recommendation.

Low PA was defined as performing <150 minutes of moderate-intensity, <75 minutes of vigorous-intensity or an equivalent combination of moderate- and vigorous-intensity PA, per week, as recommended by the 2018 Physical Activity Guidelines for Americans (10), and was derived from BRFSS questions about time spent in leisure-, household- and exercise-based activities during the previous month.

Obesity–diabetes status is a four-level categorical variable that reflects the presence or absence of obesity and diabetes (i.e. neither condition, obesity only, diabetes only, both conditions). Obesity was defined as a body mass index (BMI) ≥30 kg/m^2 and was calculated from self-reported height and weight. Diabetes was determined by an affirmative response to the BRFSS question, 'Has a health professional ever told you that you have diabetes?' and excluded women who only reported gestational diabetes.

Data analysis

All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC). Data were weighted to account for complex sampling design and to

Table 1. Sociodemographic characteristics of US stroke survivors aged >45 years stratified by obesity–diabetes status (*n* = 32 876), BRFSS, 2015 and 2017

Characteristic	Number of respondents[a]	Neither condition[b]	Obesity only[b]	Diabetes only[b]	Both conditions[b]
		% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
		n = 16 137	*n* = 6284	*n* = 5147	*n* = 5308
Total sample	32 876	46.1 (44.8, 47.4)	21.3 (20.2, 22.4)	15.2 (14.2, 16.1)	17.5 (16.5, 18.4)
Sex					
Male	15 316	50.3 (48.3, 52.4)	44.5 (41.9, 47.2)	54.4 (50.9, 57.9)	51.3 (48.5, 54.1)
Female	19 505	49.7 (47.6, 51.7)	55.5 (52.9, 58.2)	45.6 (42.1, 49.1)	48.7 (45.9, 51.6)
Age, years					
45–64	11 301	39.7 (38.0, 41.3)	53.7 (51.3, 56.1)	36.3 (33.4, 39.1)	51.8 (49.3, 54.2)
≥65	21 575	60.3 (58.7, 62.0)	46.3 (43.9, 48.7)	63.7 (60.9, 66.6)	48.2 (45.8, 50.7)
Ethnicity					
Non-Hispanic White	26 186	72.4 (70.4, 74.5)	66.6 (63.9, 69.4)	57.4 (53.7, 61.0)	62.8 (60.0, 65.6)
Non-Hispanic Black	3945	14.2 (12.6, 15.9)	19.3 (17.0, 21.6)	21.7 (18.4, 25.1)	20.3 (18.0, 22.5)
Hispanic	1629	7.0 (5.7, 8.4)	9.2 (7.1, 11.3)	12.5 (9.7, 15.2)	11.6 (9.4, 13.8)
Other	2404	6.3 (5.2, 7.4)	4.9 (3.7, 6.1)	8.4 (6.3, 10.6)	5.3 (4.3, 6.4)
Marital status					
Married or coupled	14 737	45.6 (43.6, 47.6)	49.8 (47.1, 52.5)	48.2 (44.6, 51.8)	47.1 (44.3, 50.0)
Previously married	16 914	44.9 (42.9, 46.9)	40.1 (37.5, 42.7)	41.9 (38.6, 45.2)	41.3 (38.6, 44.1)
Never married	3034	9.5 (8.4, 10.7)	10.1 (8.4, 11.9)	9.9 (7.0, 12.9)	11.6 (9.7, 13.5)
Education					
Didn't finish high school	4811	21.7 (20.0, 23.4)	23.4 (20.8, 26.0)	24.7 (21.7, 27.8)	25.2 (22.6, 27.9)
Graduated high school	11 680	32.7 (30.9, 34.6)	33.9 (31.4, 36.5)	32.3 (29.1, 35.5)	34.4 (31.7, 37.1)
College, <4 years	9846	29.6 (27.6, 31.6)	28.3 (26.0, 30.6)	30.0 (26.5, 33.5)	29.2 (26.7, 31.8)
College, ≥4 years	8405	16.0 (14.8, 17.1)	14.4 (12.9, 15.9)	13.0 (10.8, 15.2)	11.2 (9.8, 12.6)
Annual household income, $					
<15 000	6286	22.6 (20.7, 24.5)	23.0 (20.3, 25.6)	26.9 (23.5, 30.3)	27.8 (25.1, 30.4)
15 000 to <25 000	7643	26.0 (24.1, 27.9)	24.8 (22.5, 27.1)	29.8 (26.1, 33.6)	30.0 (27.2, 32.9)
25 000 to <35 000	3779	12.0 (10.7, 13.4)	13.1 (11.0, 15.2)	10.8 (9.1, 12.5)	11.7 (9.7, 13.7)
35 000 to <50 000	3782	12.5 (10.9, 14.2)	12.8 (11.1, 14.6)	10.8 (8.8, 12.8)	12.0 (9.8, 14.3)
≥50 000	7119	26.8 (24.9, 28.8)	26.3 (23.7, 28.8)	21.7 (18.1, 25.4)	18.5 (16.1, 20.9)

[a]Unweighted number of respondents. Number of respondents within each demographic characteristic may not sum to sample total because of missing data. Number of respondents with missing data for each respective sociodemographic characteristic: sex, *n* = 13; age, *n* = 1958; ethnicity, *n* = 670; marital status, *n* = 149; education, *n* = 92; annual household income, *n* = 6225.

[b]Estimates are weighted and age-adjusted to the 2000 US standard population except age, for which group-specific percentages are displayed. Percentages may not sum to 100 due to missing data.

adjust for selection probability and non-response bias; data were also age-adjusted to the 2000 US standard population (11). Linear regression was used to compute prevalence estimates and 95% confidence intervals (CIs) of demographic variables and unhealthy behaviours, stratified by obesity–diabetes status. Logistic regression was used to compute adjusted odds ratios (AORs, adjusted for all demographic characteristics) and 95% CIs for unhealthy behaviours. For AORs, the 'neither condition' obesity–diabetes category served as the reference group. *P*-values were not reported for analyses due to the large sample sizes obtained from weighting data, but significance can be inferred by examining 95% CIs (12). For unhealthy behaviours with AORs that differed across obesity–diabetes strata, the relative excess risk due to interaction (RERI) was calculated to assess interaction of obesity and diabetes on an additive scale (13). A RERI value of 0 indicates that no additive interaction is present and a value greater than 0 indicates positive additive interaction.

Results

Most of the 891 472 respondents in the 2015 and 2017 BRFSS surveys were excluded from analysis because they had one or more of the following: no reported history of stroke (*n* = 851 607), were younger than 45 years of age (*n* = 243 302) or had missing data for height, weight or history of diabetes (*n* = 2391). Thus, the resulting analytical sample consisted of 32 876 stroke survivors. Obesity and diabetes were present in 35.3% (*n* = 11 592) and 31.8% (*n* = 10 455) of the sample, respectively.

Weighted, age-adjusted prevalence estimates of sociodemographic characteristics are displayed in Table 1. A majority of respondents were aged ≥65 years and non-Hispanic white, with the remaining sociodemographic characteristics distributed across categorical levels. Additionally, 54% of respondents reported at least one chronic condition (i.e. obesity only, diabetes only or both conditions).

Estimated prevalences of unhealthy behaviours are displayed in Table 2. Prevalences for both unhealthy behaviours exceeded 50% across all obesity–diabetes categories (range: 51.8–71.7%), but prevalences for low PA were higher than prevalences for low FV consumption. Furthermore, prevalences for low PA were lowest for respondents with neither obesity nor diabetes and highest for respondents with both conditions, whereas prevalences for low FV consumption were similar across obesity–diabetes categories.

Table 2. Estimated prevalence of reported unhealthy behaviours among US stroke survivors aged >45 years stratified by obesity–diabetes status (*n* = 32 876), BRFSS, 2015 and 2017

Unhealthy behaviour	Total sample[a]	Neither condition[a]	Obesity only[a]	Diabetes only[a]	Both conditions[a]
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
	n = 32 876	*n* = 16 137	*n* = 6284	*n* = 5147	*n* = 5308
Low FV consumption[b]	52.3 (50.9, 53.7)	51.8 (49.7, 53.9)	52.7 (49.9, 55.6)	53.9 (49.6, 57.1)	53.0 (49.9, 56.0)
Low PA[b]	61.0 (59.6, 62.3)	56.0 (53.9, 58.1)	63.0 (60.2, 65.8)	61.0 (57.1, 64.9)	71.7 (69.1, 74.3)

[a]Estimates are weighted and age-adjusted to the 2000 US standard population.
[b]Number of respondents with missing data for unhealthy behaviours: low FV consumption, *n* = 4590; low PA, *n* = 3448.

AORs for unhealthy behaviours, stratified by sociodemographic characteristics and obesity–diabetes status, are displayed in Table 3. Several sociodemographic characteristics, including sex, age, ethnicity, education and annual household income, were independently associated with the investigated unhealthy behaviours. Females were less likely to report low FV consumption and more likely to report low PA. Respondents ≥65 years, those with higher education and those with higher annual household income were also less likely to report engaging in the investigated unhealthy behaviours.

Obesity and diabetes were jointly associated with low PA after controlling for all sociodemographic characteristics. Compared with respondents with neither obesity nor diabetes, the AOR for low PA was elevated for respondents with both conditions (AOR: 2.02, 95% CI: 1.72–2.37). The RERI was significantly elevated at 0.52 (95% CI: 0.24–0.81), indicating that the joint effect of obesity and diabetes on low PA was 0.52 higher than the risk associated with summing their separate effects. Low PA was also elevated in respondents with obesity only (AOR: 1.31, 95% CI: 1.13–1.53), but not in respondents with diabetes only. In contrast, comparison of AORs for low FV consumption across obesity–diabetes categories revealed no association; thus, the RERI was not calculated for this variable.

Table 3. AORs of reported unhealthy behaviours among US stroke survivors aged >45 years, adjusted for sociodemographic characteristics and stratified by obesity–diabetes status (*n* = 32 876), BRFSS, 2015 and 2017

Sociodemographic characteristic	Low FV consumption[a]	Low PA[a]
	AOR (95% CI)	AOR (95% CI)
Sex		
Male	Referent	Referent
Female	**0.68 (0.61, 0.76)**	**1.30 (1.16, 1.46)**
Age, years		
45–64	Referent	Referent
≥65	**0.75 (0.66, 0.84)**	**0.85 (0.75, 0.96)**
Ethnicity		
Non-Hispanic White	Referent	Referent
Non-Hispanic Black	1.19 (0.99, 1.42)	**1.31 (1.09, 1.58)**
Hispanic	0.79 (0.60, 1.03)	0.87 (0.66, 1.16)
Other	0.93 (0.72, 1.19)	0.88 (0.69, 1.13)
Marital status		
Married or coupled	Referent	Referent
Previously married	1.06 (0.93, 1.22)	1.02 (0.89, 1.17)
Never married	1.05 (0.82, 1.35)	0.88 (0.69, 1.13)
Education		
Did not finish high school	Referent	Referent
Graduated high school	**0.75 (0.63, 0.89)**	**0.74 (0.62, 0.89)**
College, <4 years	**0.67 (0.56, 0.80)**	**0.60 (0.50, 0.72)**
College, ≥4 years	**0.37 (0.31, 0.45)**	**0.47 (0.39, 0.58)**
Annual household income, $		
<15 000	Referent	Referent
15 000 to <25 000	0.96 (0.82, 1.13)	0.89 (0.75, 1.06)
25 000 to <35 000	0.91 (0.74, 1.11)	0.92 (0.75, 1.14)
35 000 to <50 000	0.91 (0.74, 1.13)	**0.79 (0.63, 0.98)**
≥50 000	**0.76 (0.62, 0.94)**	**0.57 (0.46, 0.71)**
Obesity–diabetes status		
Neither condition	Referent	Referent
Obesity only	1.04 (0.90, 1.21)	**1.31 (1.13, 1.53)**
Diabetes only	1.00 (0.85, 1.18)	1.18 (0.99, 1.40)
Both conditions	1.03 (0.88, 1.21)	**2.02 (1.72, 2.37)**

Note: AORs whose CIs do not span the value 1.0 are printed in bold.
[a]Number of respondents with missing data for each outcome variable: low FV consumption, *n* = 4590; low PA, *n* = 3448.

Discussion

Our results indicated that adjusted odds for low PA were 2.02 times higher for stroke survivors with both obesity and diabetes and 1.31 times higher for survivors with obesity only compared with survivors with neither condition. The presence of low PA among respondents with additional comorbidities mirrors findings observed among individuals with diabetes and metabolic syndrome in other studies. Sullivan *et al.* (14) reported that physically inactivity was 2.0 times higher in individuals with diabetes and 1.6 times higher in individuals with obesity compared with individuals with neither condition; and Ford *et al.* (15) reported that the prevalence of physical inactivity was 27% higher among individuals with metabolic syndrome compared with individuals without. Considering these reports, it is unsurprising that our findings demonstrated low PA among stroke survivors with obesity and diabetes. However, the high prevalence of low PA in our study sample—ranging from 56% to 71.7% across obesity–diabetes categories—and the 52% excess risk due to the interaction of obesity and diabetes suggests that different health behaviour interventions may be required for stroke survivors based on their obesity–diabetes status.

One possible explanation for the high prevalence of low PA observed in stroke survivors could be stroke-related motor impairment (e.g. hemiparesis, spasticity), which is further complicated by changes in muscle composition of the affected side (e.g. muscle wasting, fat infiltration, switch from slow-twitch to fast-twitch muscle fibres) (16). Indeed, prevalence of mobility impairment is 13% in the general adult US population but 50.8% in stroke (17,18). Stroke, therefore, increases the likelihood of functional disability, though does not guarantee it. Furthermore, obesity and diabetes are independent predictors of disability in the general population (19,20), and are associated with functional disability in stroke survivors (18). Specifically, odds of functional disability are 2.62 higher among survivors with both obesity and diabetes compared with survivors with neither condition, with respective prevalence estimates for functional disability of 70.3% and 45.4% (18).

It is also important to acknowledge that although our results yielded a significant additive interaction for obesity and diabetes with PA, causation cannot be determined due to the cross-sectional nature of the data. It is plausible that diabetes- and obesity-related disability contributes to reduced PA among stroke survivors. Alternatively, obesity and diabetes may contribute to stroke occurrence, which increases the likelihood of experiencing stroke-related disability that is associated with reduced PA. Rather than implying causation, the additive interaction observed in this study indicates that risk for low PA among stroke survivors with both obesity and diabetes is higher than the risk expected were their separate effects to be summed. Prospective studies are needed to disentangle the separate and interactive effects of stroke, obesity and diabetes on PA to inform development of tailored PA interventions for stroke survivors who experience obesity, diabetes or both conditions.

In contrast, we found no association of obesity–diabetes status with low FV consumption. In population-based studies, FV consumption is lower in individuals with chronic conditions (e.g. diabetes, metabolic syndrome) compared with individuals without chronic conditions. Ford and Mokdad (21) reported age-adjusted odds of 0.69 for consuming one to five servings of FVs among diabetics compared with non-diabetics, and Tian *et al.* (22) reported that adjusted odds of metabolic syndrome were 0.76 for high versus low FV consumption in a meta-analysis of nine observational studies. Given similarities in risk factors and cardiometabolic dysregulation across stroke, diabetes and the metabolic syndrome, we expected that FV consumption among stroke survivors with obesity and diabetes would mirror findings reported for individuals with diabetes and the metabolic syndrome. However, our results indicate that low FV consumption does not differ based on obesity–diabetes status in stroke survivors. The lack of difference across obesity–diabetes categories and the high prevalence (52.3%) among the total sample of stroke survivors suggests that health behaviour interventions for increasing FV consumption among stroke survivors without regard to obesity–diabetes status may be warranted.

From an intervention standpoint, our results indicate that most US stroke survivors are not adherent to PA and dietary behaviour guidelines; thus, clinical interventions aimed at improving health behaviours and managing diabetes and obesity among stroke survivors are needed. Unfortunately, primary care-based interventions for improving unhealthy behaviours among survivors are few. In a recent Australian multi-site trial, survivors were randomized to an intervention group in which a stroke coordinator facilitated discussion between survivors and general practitioners during follow-up appointments every 3 months for 1 year following hospital discharge. Compared with participants in the usual care group, participants in the intervention group reported greater mobility and less functional disability; experienced greater reductions in systolic blood pressure, total cholesterol and triglycerides; and less weight gain (i.e. weight maintenance) (23). Although this study did not address dietary behaviour, it does provide evidence of improvement in health behaviours among stroke survivors in response to primary care intervention. Observational data from the USA further support the efficacy of primary care-based intervention for encouraging healthy behaviours among stroke survivors. Data from the 1999 BRFSS survey demonstrated that a higher percentage of survivors reported engaging in exercise (76.5% versus 38.8%) and practicing healthy dietary behaviours (85.4% versus 56.0%) in response to physician advice compared with survivors who did not receive such advice (24). These studies are encouraging because they suggest that many stroke survivors respond to physician-led lifestyle management intervention. However, there is an unmet need to develop and rigorously evaluate primary care-based health behaviour interventions for stroke survivors, including individualization of advice for stroke-related disability and obesity–diabetes status.

Finally, it is important to note that several sociodemographic characteristics (i.e. sex, age, ethnicity, education and annual household income) were independently associated with the unhealthy behaviours investigated in this study. In the general US population, female sex, older age, higher education and higher income are positively associated with FV consumption; and male sex, younger age, white non-Hispanic ethnicity, higher education and higher income are associated with PA (25–29). Our results mirror these associations, confirming that the associations observed in the general population also exist among stroke survivors. One exception observed was among adults aged ≥65 years, who reported greater PA than did adults aged 45–64 years; further investigation is required to determine why younger age was more associated with low PA than lower age among stroke survivors. Despite the associations between select sociodemographic characteristics and PA observed in our study, we found an excess risk of low PA among survivors with obesity and diabetes that persisted after inclusion of the independent sociodemographic characteristics in our analyses. Thus, tailored clinical interventions focussed on increasing PA and exercise are needed specifically for this high-risk stroke subgroup in addition to those needed for stroke survivors generally.

Strengths and limitations

The present study is the first to examine the joint association of obesity and diabetes with low FV consumption and low PA among US community-dwelling stroke survivors. Data from the BRFSS national public health survey were combined across years, resulting in a large analytical sample size that allowed for stratification across obesity–diabetes status categories and to control for the potential modifying effects of sociodemographic characteristics in the statistical models.

Despite these strengths, there are several limitations inherent to the use of public health survey data. First, as previously noted, data were cross-sectional, therefore causal relationships among investigated factors could not be determined. Second, all data were self-reported and thus subject to self-report bias. Third, respondents were non-institutionalized stroke survivors; thus, data from institutionalized adults—individuals likely engaged in more unhealthy behaviours—were not included in the analysis. As a result, the estimated prevalence of unhealthy behaviours among stroke survivors in the USA may actually be higher. Finally, the BRFSS survey was not specifically intended for stroke survivors; thus, data on stroke-related motor, cognitive and psychosocial deficits were not available for exploration of how these factors might influence the reported associations among diabetes, obesity and the investigated unhealthy behaviours. Similarly, duration since stroke, and the possible additive effects of multiple strokes over time are not captured in the BRFSS dataset. Despite this limitation, the study's findings resulted from a robust sample, and future studies should examine the moderating effect of stroke-related deficits on obesity, diabetes and lifestyle behaviours.

Conclusions

Prevalences of low FV consumption and low PA exceed 50% in US stroke survivors, and survivors with both chronic conditions experience 52% excess risk for low PA due to the dual presence of obesity and diabetes. Stroke survivors experience high risk for poor health, disability and mortality due to the presence of multiple comorbidities and unhealthy behaviours and require health behaviour intervention. Observational and clinical studies suggest that primary care-based health behaviour interventions can be effective for stroke survivors. However, prospective research is necessary to identify best practices for engaging and supporting stroke survivors in successful lifestyle intervention.

Declaration

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Ethical approval: not applicable.

Conflict of interest: Dr Bailey has no conflicts of interest to report. Dr Majersik is funded through NINDS as PI for UT StrokeNet, is an Associate Editor of Stroke and provides stroke consultation to Foldax, Inc. Dr Singleton has received funds from NIDDK and NINDS to explore exercise and health behaviours intervention effects on diabetic neuropathy.

Data availability

Behavioral Risk Factor Surveillance System (BRFSS) data are freely available from the Centers for Disease Control and Prevention and can be accessed online (https://www.cdc.gov/brfss/).

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