Original Article

Association Between Fecal Incontinence and Objectively Measured Physical Activity in U.S. Adults

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Abstract

Background: Brisk physical activity may facilitate fecal incontinence due to physical activity-induced colonic motility. However, there currently are no studies that have examined the relationship between fecal incontinence and free-living physical activity behavior. **Aim:** Therefore, the purpose of this study was to examine the association between fecal incontinence and objectively measured physical activity among adults. **Materials and Methods:** A national sample of adults in the United States (n = 2565, 20-85 years) completed the Fecal Incontinence Severity Index questionnaire and wore an accelerometer for a week to objectively measure physical activity behavior. **Results:** After adjustments, fecal incontinence was positively associated with moderate-to-vigorous physical activity ($\beta = 0.85$, $P = 0.04$), suggesting that lower perceived severity of fecal incontinence was associated with greater engagement in moderate-to-vigorous physical activity. Fecal incontinence was not significantly associated with light-intensity physical activity ($P = 0.27$). **Conclusion:** Our results suggest that adults in the United States with greater perceived severity of fecal incontinence engage in less moderate-to-vigorous physical activity; however, those with greater severity of fecal incontinence do not appear to have different levels of light-intensity physical activity behavior. Given the emerging research showing beneficial effects of light-intensity physical activity, health care professionals should encourage light-intensity physical activity to their patients with fecal incontinence.

Keywords: Bowel health, Epidemiology, Exercise

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Introduction

Fecal incontinence is often defined as the involuntary passage or inability to control the discharge of fecal matter through the anus,[1] and affects up to 7.1% of individuals in the United States.[2] Fecal incontinence not only causes considerable embarrassment, but it reduces self-esteem, induces social isolation, and impairs quality of life.[3,4]

There is also some, albeit limited, evidence to suggest that brisk physical activity, particularly after meals or upon waking, may predispose to fecal incontinence due to physical activity-induced colonic motility.[5] For example, Rao *et al*.[6] showed that after acute exercise, the number and amplitude of propagated colonic waves increased, suggesting that the post-exercise increase in propagated activity may induce bowel movement. Consequently, among individuals with fecal incontinence, vigorous physical activity may initiate and exacerbate symptoms. As a result, individuals with fecal incontinence may be less inclined to participate in physical activity, ultimately increasing their risk of other comorbidities due to an inactive lifestyle.

However, to our knowledge, there currently are no studies that have examined the relationship between fecal incontinence and free-living physical activity behavior. To determine whether individuals with greater severity of fecal incontinence are indeed less physically active, the purpose of this study was to examine the association between fecal incontinence and objectively

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measured physical activity among U.S. adults. We hypothesize that higher intensity physical activity, but not lower intensity physical activity, will be associated with fecal incontinence. To increase generalizability, data from the National Health and Nutrition Examination Survey, which is a nationally representative sample of non-institutionalized Americans, was used for the present study.

Materials and Methods

Design

Data from the 2005-2006 National Health and Nutrition Examination Survey (NHANES) was used, with details on the study design found elsewhere.[7] Briefly, participants were interviewed in their home and then subsequently examined in a mobile examination center within their county. National Health and Nutrition Examination Survey was conducted by the National Center for Health Statistics (NCHS), and all procedures for data collection were approved by the NCHS ethics review board. All participants provided written informed consent before data collection.

Assessment of fecal incontinence

Participants of 20 years of age and older completed the Fecal Incontinence Severity Index (FISI) questionnaire during the Bowel Health section of the mobile examination center interview, which consisted of asking participants the frequency with which they had accidental bowel leakage.[8] Bowel leakage addressed here includes passage of mucus, liquid stool, or solid stool. Participants were asked, "How often during the past 30 days have you had any amount of accidental bowel leakage that consisted of [mucus, liquid stool, or solid stool]". Response options included;

1. 2 or more times a day,
2. Once a day,
3. 2 or more times a week,
4. Once a week,
5. 1-3 times a month, or
6. Never.

To create the FISI, responses for each of the three items were summed, with a lower FISI indicating greater perceived symptom severity.

Measurement of physical activity

At the mobile examination center, participants who were able to walk were asked to wear an ActiGraph 7164 accelerometer on their right hip for 7 days. Accelerometers were affixed to an elastic belt that was worn around the participant's waist near the iliac crest. Participants were asked to wear the accelerometer during all activities, except water-based activities and while sleeping. The accelerometer measured the frequency, intensity, and duration of physical activity by generating an activity count proportional to the measured acceleration. The accelerometer output is digitized using an analog-to-digital converter, and once digitized, the signal passes through a digital filter that detects accelerations ranging from 0.05 to 2.00 g in magnitude with frequency responses ranging from 0.25 to 2.5 Hz to filter motion outside normal human movement. The filtered signal is then rectified and summed over a pre-determined epoch period. After the activity count is sorted into an epoch, it is stored in the internal memory and then the integrator is reset to zero. Detailed information on the ActiGraph accelerometer can be found elsewhere.[9]

Estimates for light-intensity and moderate-to-vigorous physical activity were summarized in 1-minute time intervals. Activity counts between 100 and 2019 counts per minute were classified as light-intensity physical activity, and activity counts greater than or equal to 2020 were classified as moderate-to-vigorous physical activity intensity.[10] Vigorous-intensity physical activity was combined with moderate-intensity because participants spent very little time in vigorous activity (mean = 0.96 min/day; standard error = 0.08). To determine the amount of time the monitor was worn, nonwear was defined by a period of a minimum of 60 consecutive minutes of zero activity counts, with the allowance of 1-2 minutes of activity counts between 0 and 100.[10]

Measurement of covariates

To control for potential confounding variables, the following covariates were included in the analytic models: Age, gender, race-ethnicity, education, poverty level, protein consumption, carbohydrate consumption, fat consumption, fiber consumption, caffeine consumption, smoking, comorbid illness, accelerometer wear time, medications used to treat functional bowel disorders, and depression symptoms.

Information about age, gender, race-ethnicity, education, and comorbidity index,[11] were obtained from a questionnaire. Participants were classified as having 0 or 1+ comorbidities based on self-report of the following chronic diseases/events: Arthritis, coronary heart disease, stroke, congestive heart failure, cancer, heart attack, emphysema, chronic bronchitis, asthma, hypertension, diabetes, and obesity (measured body mass index ≥ 30 kg/m^2). As a measure of socioeconomic status, poverty-to-income ratio (PIR) was assessed, with a PIR value below 1 considered below the poverty threshold. The PIR is calculated by dividing the family income by the poverty guidelines, which is specific to the family size, year assessed, and state of residence. To assess

consumption (in gm) of dietary protein, carbohydrate, fat, and fiber, as well as caffeine consumption (in mg), dietary interviewers used the Dietary Data Collection (DDC) system, which is an automated standardized interactive dietary interview and coding system.

Participants also reported whether they were taking any medications for functional bowel disorders. Serum cotinine was measured as a marker of active smoking status or environmental exposure to tobacco (i.e., passive smoking). Serum cotinine was measured by an isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry. Accelerometer wear time (number of hours the accelerometer was worn per day) was included as a covariate as wear time can influence physical activity estimates.[12]

To assess symptoms of depression, participants completed the Patient Health Questionnaire-9 (PHQ-9) during the computer-assisted personal interview.[13] Sample items included, "over the last two weeks, how often have you been bothered by": "feeling down, depressed or hopeless", "feeling tired or having little energy", and "trouble concentrating on things, such as reading the newspaper or watching television". For each question, participants responded using a 4-point Likert scale, with responses including *not at all* (0), *several days* (1), *more than half the days* (2), and *nearly every day* (3). Items were summed, with higher scores indicating greater severity of depression. Depression severity was defined by using the following established cut-points from the total PHQ-9 score: No depression (0-4), mild depression (5-9), moderate-depression (10-14), moderately severe depression (15-19), and severe depression (20-27).[13] For the analyses presented herein, we defined depression status as *no depression symptoms* (0-4) and *some depression symptoms* (≥5), as few participants were categorized as having moderate depression, moderately severe depression and severe depression.

Statistical analysis

All statistical analyses were performed using procedures from sample survey data using Stata (version 13.0, College Station, TX) to account for the complex survey design used in NHANES. To account for oversampling, non-response, non-coverage, and to provide nationally representative estimates, all analyses included the use of survey sample weights, clustering, and primary sampling units. In an effort to maintain nationally representative estimates, the sample weights for those with 4 or more days of valid accelerometry data were ratio-adjusted to maintain the age, sex, and race-ethnicity distribution of the full sample.

To examine the association between bowel health (using the FISI index score) and physical activity (outcome variable), a multivariable linear regression analysis was employed. Two separate models were employed: One for moderate-to-vigorous physical activity and the other for light-intensity physical activity. Model covariates included age, gender, race-ethnicity, education, poverty level, protein consumption, carbohydrate consumption, fat consumption, fiber consumption, caffeine consumption, smoking, comorbid illness, accelerometer wear time, depression, and medication use. All covariates were entered into the model at the same time as there was no evidence of multicollinearity. Evidence of multicollinearity is likely to exist if there is a correlation >0.8 between two covariates; if the mean variance inflation factor is >6 or if the highest individual variance inflation factor is >10; or if the tolerance statistic is <0.1; for the present study, the highest correlation between two covariates was 0.58; the mean variance inflation factor was 1.4; the highest individual variance inflation factor was 2.4; and all individual tolerance statistics were >0.4.Statistical significance was established $P < 0.05$.

Results

Demographics

In the 2005-2006 NHANES cycle, 2565 adults (20+ years) provided data on the study variables.

Characteristics of the analyzed sample are shown in Table 1. In all, 51.2% of the sample was female; 73.8% were non-Hispanic white; 17.2% had some depression symptoms, and on average, participants engaged in 24 and 350 minutes a day of moderate-to-vigorous physical activity and light-intensity physical activity, respectively.

Effects of FISI on physical activity

The association between FISI and physical activity is shown in Table 2. After adjustments, FISI was positively associated with moderate-to-vigorous physical activity ($\beta = 0.85$, $P = 0.04$), suggesting that a higher FISI (i.e., lower perceived severity of FISI) was associated with greater engagement in moderate-to-vigorous physical activity. FISI was not significantly associated with light-intensity physical activity ($P = 0.27$).

Effect of stool characteristics on physical activity

Secondary analyses were computed to examine if physical activity was associated with passage of mucus, liquid stool, or solid stool individually. After adjustments, light-intensity physical activity was not associated with mucus ($\beta = -0.12$, $P = 0.97$), liquid stool

(β = 9.43, *P* = 0.08), or solid stool (β = 3.34, *P* = 0.63). Similarly, and after adjustments, moderate-to-vigorous physical activity was also not associated with mucus (β = −0.55, *P* = 0.45), but was significantly associated liquid stool (β = 1.97, *P* = 0.005) and solid stool (β = 2.90, *P* = 0.01).

Table 1: Characteristics of the analyzed sample, NHANES 2005-2006 (*N* = 2565)

Variable	Mean/Proportion (95% CI)
FISI Index, mean	17.83 (17.80-17.85)
Moderate-to-vigorous physical activity (min/day)	24.1 (22.7-25.5)
Light-intensity physical activity (min/day)	350.7 (343.0-358.3)
Accelerometer wear time (hrs/day)	14.3 (14.2-14.4)
Age (yrs)	46.2 (44.5-47.9)
% Female	51.2 (49.7-52.6)
% Non-Hispanic white	73.8 (68.0-79.6)
Poverty-to-income ratio	3.2 (3.0-3.4)
% Some college or more	60.8 (55.6-66.1)
Protein (gm/day)	86.0 (83.8-88.2)
Carbohydrate (gm/day)	266.6 (259.6-273.7)
Fiber (gm/day	16.0 (15.5-16.6)
Fat (gm/day	85.7 (82.6-88.9)
Caffeine (mg/day)	197.1 (181.1-213.0)
Serum cotinine (ng/mL)	57.7 (50.4-65.1)
% 1+ Comorbidities	65.3 (62.1-68.4)
% Taking medications for functional bowel disorders	0.1 (0.0-0.2)
% Depression symptoms	17.2 (14.6-19.7)

Discussion

Given the preliminary evidence to suggest that higher intensity physical activity may precipitate fecal incontinence, the purpose of this study was to examine the association between fecal incontinence and objectively measured, free-living physical activity. The main finding of this study was that individuals with worse perceived severity of fecal incontinence engaged in less moderate-to-vigorous physical activity, but not light-intensity physical activity.

It is plausible to suggest that individuals with greater perceived severity of fecal incontinence may restrict their engagement in higher intensity physical activity because the physiological events associated with strenuous movement may increase colonic motor activity and transit,[6] ultimately precipitating fecal incontinence. As a result, it is plausible to suggest that the lower moderate-to-vigorous physical activity levels among those with worse perceived fecal incontinence may increase their risk of other comorbidities, as there is irrefutable evidence that regular moderate-to-vigorous physical activity is favorably associated with numerous health outcomes, such as cardiovascular disease, diabetes, cancer, hypertension, and obesity.[14]

Importantly, our analyses did not demonstrate a significant association between fecal incontinence and light-intensity physical activity. This suggests that, unlike moderate-to-vigorous physical activity, individuals

Table 2: Multivariable linear regression analyses examining the association between FISI (Fecal Incontinence Severity Index) and physical activity, NHANES 2005-2006 (*N* = 2565)

Variable	β (95% CI)	
	Moderate-to-Vigorous physical activity	Light-Intensity physical activity
FISI, 1 unit higher	0.85 (0.02 to 1.68)	3.29 (-2.89 to 9.48)
Covariates		
Age, 1 yr older	−0.39 (−0.45 to −0.33)	−1.12 (−1.42 to −0.83)
Female vs. Male	−10.54 (−12.86 to −8.22)	17.15 (4.83 to 29.47)
Other vs. Non-Hispanic white	−0.51 (−3.08 to 2.05)	12.71 (0.04 to 25.38)
Protein, 1 gm higher	−0.01 (−0.05 to 0.01)	−0.04 (−0.21 to 0.13)
Carbohydrate, 1 gm higher	0.002 (−0.01 to 0.01)	0.06 (0.01 to 0.10)
Fiber, 1 gm higher	0.06 (−0.09 to 0.21)	−0.25 (−0.90 to 0.39)
Fat, 1 gm higher	0.01 (−0.02 to 0.03)	0.08 (−0.04 to 0.22)
Caffeine, 1 mg higher	0.002 (−0.002 to 0.007)	0.03 (0.01 to 0.05)
Cotinine, 1 ng/mL higher	−0.007 (−0.01 to −0.0001)	0.01 (−0.01 to 0.05)
1+ Comorbidities vs. none	−3.52 (−5.62 to −1.41)	−3.52 (−12.97 to 5.91)
Accelerometer wear time, 1 hr higher	1.76 (1.19 to 2.34)	23.40 (20.36 to 26.44)
Taking functional bowel disorder medication vs. not taking	−12.81 (−22.59 to −3.03)	−80.53 (−100.95 to −60.10)
Poverty-to-income ratio, 1 unit higher	0.55 (−0.03 to 1.13)	−2.83 (−6.23 to 0.56)
Some college vs. high school or less	1.01 (−1.21 to 3.25)	−35.23 (−46.08 to −24.38)
Some depression vs. none	−4.19 (−6.84 to −1.54)	−23.42 (−36.84 to −10.01)

FISI = Fecal incontinence severity index, Bold indicates statistical significance (*P* < 0.05)

with greater perceived severity of fecal incontinence may not completely restrict their engagement in light-intensity physical activity. This is an important finding as emerging evidence demonstrates that even light-intensity physical activity is associated with numerous positive health outcomes.[15-17]

Conclusion

In conclusion, our results suggest that U.S. adults with greater perceived severity of fecal incontinence engage in less moderate-to-vigorous physical activity; however, those with greater severity of fecal incontinence did not have lower levels of light-intensity physical activity behavior. Given the emerging research showing beneficial effects of light-intensity physical activity, health care professionals should consider advocating light-intensity physical activity to patients with fecal incontinence. Major strengths of this study include examining this novel association, employing an objective measure of free-living physical activity behavior, and using a nationally representative sample of U.S. adults. However, given the inherit limitations of cross-sectional studies, future prospective and experimental work on this topic is warranted. Further, quality of life measures were not assessed in NHANES; therefore, future studies examining the association between fecal incontinence and physical activity may wish to take into consideration quality of life measures as both fecal incontinence and physical activity are associated with quality of life.

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