GYNECOLOGY

Lifetime physical activity and female stress urinary incontinence

Ingrid E. Nygaard, MD, MS; Janet M. Shaw, PhD; Tyler Bardsley, MS; Marlene J. Egger, PhD

OBJECTIVE: We sought to estimate whether moderate/severe stress urinary incontinence (SUI) in middle-aged women is associated with overall lifetime physical activity (including leisure, household, outdoor, and occupational), as well as lifetime leisure (recreational), lifetime strenuous, and strenuous activity during the teen years.

STUDY DESIGN: Recruitment for this case-control study was conducted in primary-care-level family medicine and gynecology clinics. A total of 1538 enrolled women ages 39-65 years underwent a Pelvic Organ Prolapse Quantification examination to assess vaginal support. Based on Incontinence Severity Index scores, cases had moderate/severe and controls had no/mild SUI. We excluded 349 with vaginal descent at/below the hymen (pelvic organ prolapse), 194 who did not return questionnaires, and 110 with insufficient activity data for analysis. In all, 213 cases were frequency matched 1:1 by age group to controls. Physical activity was measured using the Lifetime Physical Activity Questionnaire, in which women recall activity from menarche to present. We created separate multivariable logistic regression models for activity measures.

RESULTS: SUI odds increased slightly with overall lifetime activity (odds ratio [OR], 1.20 per 70 additional metabolic equivalent of task-h/wk; 95% confidence interval [CI], 1.02—1.41), and were not associated with lifetime strenuous activity (OR, 1.11; 95% CI, 0.99—1.25). In quintile analysis of lifetime leisure activity, which demonstrated a nonlinear pattern, all quintiles incurred about half the odds of SUI compared to reference (second quintile; $P = .009$). Greater strenuous activity in teen years modestly increased SUI odds (OR, 1.37 per 7 additional h/wk; 95% CI, 1.09—1.71); OR, 1.75; 95% CI, 1.15—2.66 in sensitivity analysis adjusting for measurement error. The predicted probability of SUI rose linearly in women exceeding 7.5 hours of strenuous activity/wk during teen years. Teen strenuous activity had a similar effect on SUI odds when adjusted for subsequent strenuous activity during ages 21-65 years.

CONCLUSION: In middle-aged women, a slight increased odds of SUI was noted only after substantially increased overall lifetime physical activity. Increased lifetime leisure activity decreased and lifetime strenuous activity appeared unrelated to SUI odds. Greater strenuous activity during teen years modestly increased SUI odds.

Key words: pelvic floor disorder, physical activity, strenuous activity, stress urinary incontinence

Cite this article as: Nygaard IE, Shaw JM, Bardsley T, et al. Lifetime physical activity and female stress urinary incontinence. Am J Obstet Gynecol 2015;212:x.ex-x.ex.

More than one quarter of nulliparous athletes report stress urinary incontinence (SUI) while doing their activity.[1-4] Even active teenagers leak urine: 80% of trampoline jumpers reported leakage while jumping.[5] Young women exercising at higher intensities are more likely to report SUI during sports than are those whose exercise does not include repetitive impact.[1,2] It is clear that young women notice SUI during strenuous activities, but whether such activity increases the odds of future SUI is not known. Indeed, in middle-aged women, regular low intensity activity is associated with lower odds of new and persistent SUI.[6-9]

The teenage years may constitute a particularly vulnerable time during which strenuous activity may have a greater deleterious effect because of the musculoskeletal, hormonal, and reproductive changes occurring in young women during that time.

Understanding how lifetime physical activity impacts SUI is important: roughly 10-20% of women between ages 40-80 years report moderate or severe incontinence, and over half have symptoms of primarily SUI.[10,11] Physical activity is a modifiable risk factor with the potential for both positive and negative effects on SUI. To date, studies examining this association have not assessed lifetime physical activity or included activities other than leisure.

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Received Oct. 28, 2014; accepted Jan. 27, 2015.

The project described was supported by grant number R01HD057895-01 from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development and by the National Center for Research Resources and the National Center for Advancing Translational Sciences, National Institutes of Health, through grant number 8UL1TR000105 (formerly UL1RR025764).

The contents are solely the responsibility of the authors and do not necessarily represent the official views of the National Institutes of Health.

The authors report no conflict of interest.

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0002-9378/$36.00 • • http://dx.doi.org/10.1016/j.ajog.2015.01.044

The aims of this study were to estimate, in a population of middle-aged women without pelvic organ prolapse (POP) recruited from nontertiary care settings, whether moderate to severe SUI is associated with overall lifetime activity (including leisure, household, outdoor, and occupational), lifetime leisure activity, lifetime strenuous activity, and strenuous activity during the teen years.

Materials and Methods

Local institutional review boards approved this study. All participants completed an informed consent process.

Research nurses recruited women for this study, as well as a separate case-control study exploring physical activity and POP,[12] from 17 primary-care-level gynecologic and family medicine clinics located across the Salt Lake Valley in Utah from Oct. 3, 2009, through Jan. 14, 2013. Women were also initially recruited from community advertising. Complete methods have been published.[13]

We excluded women who were pregnant or within 6 months postpartum, were age <39 or >65 years, had a body mass index (BMI) <18.5 or ≥40 kg/m^2, had prior surgical treatment for POP or urinary incontinence (UI), were not able to walk independently, had medical conditions associated with UI or low physical activity, were currently undergoing cancer treatment, and had moderate to severe urgency incontinence (score of ≥3 on the validated Incontinence Severity Index[14] and either pure urgency incontinence, or mixed urgency predominant incontinence, based on the 3 Incontinence Questions validated tool[15]). We chose our inclusion age range because the physical activity questionnaire used in this study (described below) was validated in women age 39-65 years and because women in this range are both likely to have developed SUI and to maintain physical activity.

Trained research nurses performed the POP Quantification examination to assess vaginal support.[16-18] Participants completed study instruments at home. An exercise science graduate student reviewed missing and improbable response with participants using an established protocol.

To assess lifetime physical activity, we used the self-administered and reliable Lifetime Physical Activity Questionnaire (LPAQ), which is designed for use in women; includes leisure (ie, recreational) activity, outdoor work, and housework; and assesses physical activity over 4 age periods: menarche to age 21 years (the "teen" epoch), 22-34, 35-50, and 51-65 years.[19,20] The LPAQ is scored using metabolic equivalents of task (MET) obtained from the Compendium of Physical Activities[21] to calculate MET-h/wk. As the LPAQ does not include occupational activity, we added the Occupation Questionnaire (OQ), a component of the Lifetime Overall Physical Activity Questionnaire.[22]

To calculate overall lifetime physical activity, we multiplied each activity's MET score by the reported number of h/wk, fraction of mo/y, and fraction of years lived in each age epoch, and added the average MET-h/wk calculated on the OQ. Overall leisure activity included only activities related to traditional exercise and recreation. Strenuous activities included those associated with repetitive impact and/or relatively higher intra-abdominal pressures.[12] Vigorous activities included those with >6 MET.

The LPAQ + OQ was considered insufficient for analysis if women recorded no physical activity of any type for an entire age epoch, no leisure or household activity over the entire LPAQ, overall physical activity exceeding 168 h/wk, or exceeded 671 MET-h/wk in any age epoch.[13]

From the initial participant pool, we excluded women with POP (vaginal descent at or below the hymen)[23,24] and those whose activity questionnaires were either unreturned or of insufficient quality.

Cases had moderate/severe UI defined as a score of ≥3 on the Incontinence Severity Index (which correlates well with incontinence severity according to pad weight, bladder diary, and quality-of-life instruments)[14,25] and pure or predominantly SUI according to responses on the 3 Incontinence Questions[15]; controls had no or mild UI defined as a score of ≤2 on the Incontinence Severity Index and had no POP. Research nurses obtaining outcome measures were masked to LPAQ + OQ results, and exercise science researchers were masked to group assignment.

The sample size of at least 175 cases and 175 controls was calculated a priori to provide 80% power at the 2-sided 5% significance level to detect an odds ratio (OR) of 0.295 for a 1-SD increase in actual physical activity, taking measurement error into account.[26] This sample size also had 80% power at the 2-sided 5% significance level to detect the scenario in which the OR is nonlinear in quintiles of physical activity based on the control group, with an inverted U-shape represented by a distribution of cases from lowest to highest quintile of 10-30%, or more extreme.[26] Computations used nQuery v 6.0 software (Statistical Solutions, Boston, MA).

We planned a priori to frequency match controls and cases for age, BMI, and recruitment source. However, because we recruited only 13 cases from community advertising, but 213 from primary care clinics, we excluded community participants from our final models, as low cell sizes would preclude analysis. Additionally, before beginning data analysis, we elected not to frequency match or adjust for BMI, as 2 prospective cohort studies published after the start of our study reasoned that lifetime physical activity "causes" BMI.[27,28] Thus, BMI is on the direct pathway between lifetime activity and SUI and is an effect of lifetime physical activity; including BMI could eliminate the association of activity with SUI by overadjustment.[29]

We frequency matched controls to cases 1:1 by age (39-49, 50-60, 61-65 years), and selected controls using a computerized random number generator when >1 was eligible.

We grouped physical activity variables into quintiles based on their distribution in the selected control group, assigning the second quintile as the reference such that we could investigate the potential deleterious effect of low activity.[30] We performed logistic regression with variable selection guided by an updated directed acyclic graph, in which BMI was depicted as an intermediate variable, developed using DAGitty version 2.0

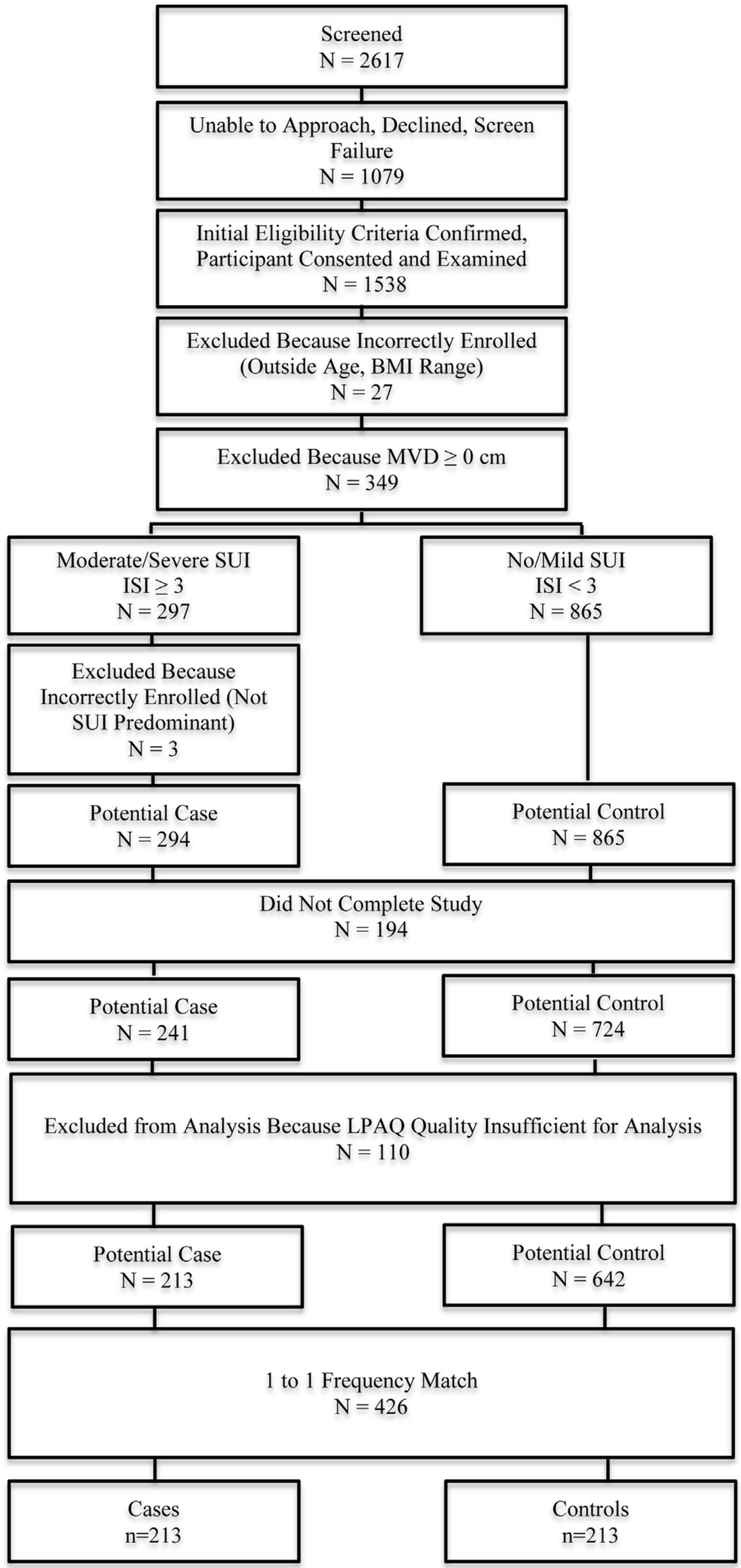
(Johannes Textor, Theoretical Biology & Bioinformatics group, University of Utrecht, Utrecht, the Netherlands).[31,32] We adjusted for education and age and further adjusted for number of vaginal deliveries and hysterectomy status, based on past literature, which was permissible per the directed acyclic graph. Regression diagnostics were checked for multicolinearity and influential observations. We examined the functional form of the relationship between each physical activity variable and SUI by inspecting plots of initial regression coefficients and using the Stata multivariable fractional polynomials procedure to identify the best polynomial fit. In the event of a nonlinear, nonpolynomial pattern, such as a threshold effect, we pooled quintiles with common ORs based on the Akaike Information Criterion. As there were only 2 missing observations in the dataset, we did not perform multiple imputation. As sensitivity analyses, we reestimated ORs using simulation extrapolation,[33] with bootstrapped standard errors to adjust for measurement error and also reestimated ORs comparing cases to controls with no UI (ie, Incontinence Severity Index score of 0).

We generally used a 5% significance level, but considered tests for individual quintiles vs the reference category to be significant if $P < .01$, to adjust for multiple comparisons. All statistical programming calculations were verified by a second independent research team member. Analysis was performed using SAS 9.3 (SAS Institute, Cary, NC) and the multivariable fractional polynomial and simulation extrapolation procedures in Stata 11 and 12 (StataCorp, College Station, TX).

RESULTS

From the primary care clinics, 1538 women met initial screening criteria and were enrolled; an additional 72 were enrolled through community advertising. The participant flow for the primary care clinic population is summarized in Figure 1. After applying exclusion criteria, there were 213 potential cases and 642 potential controls from primary care; and 13 and 31 from the community. All cases were successfully frequency matched by

FIGURE 1
Participant flow diagram for primary care recruitment population



BMI, body mass index; *ISI*, incontinence severity index; *LPAQ*, Lifetime Physical Activity Questionnaire; *MVD*, maximal vaginal descent; *SUI*, stress urinary incontinence.

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TABLE 1
Characteristics of cases and controls

Variable	Measure	Control (n = 226)	SUI case (n = 226)	Univariate OR (95% CI)
Age, y	Mean (SD)	49.76 (7.03)	49.69 (7.09)	NA
39-49	n	121	121	
50-60	n	83	83	
61-65	n	22	22	
Body mass index, kg/m^2	Mean (SD)	25.61 (5.11)	27.09 (4.92)	1.1 (1.0—1.1)
18.5-24.9	n (%)	130 (57.52)	95 (42.04)	1.0
25-29.9	n (%)	52 (23.01)	64 (28.32)	1.7 (1.1—2.6)
30-39.9	n (%)	44 (19.47)	67 (29.65)	2.1 (1.3—3.3)
Parity	Median (range)	2 (0—8)	2 (0—12)	1.2 (1.0—1.3)
0	n (%)	63 (28.00)	39 (17.26)	1.0
1	n (%)	33 (14.67)	39 (17.26)	1.9 (1.0—3.5)
2	n (%)	67 (29.78)	74 (32.74)	1.8 (1.1—3.0)
≥3	n (%)	62 (27.56)	74 (32.74)	1.9 (1.1—3.3)
Missing	n	1	0	
No. of vaginal deliveries	Median (range)	1 (0—8)	2 (0—12)	1.2 (1.1—1.3)
0	n (%)	97 (43.11)	62 (27.43)	1.0
1	n (%)	30 (13.33)	38 (16.81)	2.0 (1.1—3.5)
2	n (%)	49 (21.78)	59 (26.11)	1.9 (1.1—3.1)
≥3	n (%)	49 (21.78)	67 (29.65)	2.1 (1.3—3.5)
Missing	n	1	0	
No. of cesarean deliveries	Median (range)	0 (0—6)	0 (0—6)	0.8 (0.6—1.1)
0	n (%)	174 (77.33)	189 (83.63)	1.0
1	n (%)	28 (12.44)	22 (9.73)	0.7 (0.4—1.3)
2	n (%)	16 (7.11)	11 (4.87)	0.6 (0.3—1.4)
≥3	n (%)	7 (3.11)	4 (1.77)	0.5 (0.2—1.8)
Missing	n	1	0	
Race				NA
Asian	n (%)	7 (3.14)	2 (0.90)	
Black/African American	n (%)	0 (0)	3 (1.35)	
Hawaiian/Pacific Islander	n (%)	1 (0.45)	0 (0)	
American Indian/Alaskan Native	n (%)	2 (0.90)	5 (2.25)	
Caucasian	n (%)	213 (95.52)	212 (95.50)	
Missing	n	3	4	
Ethnicity				
Non-Hispanic	n (%)	219 (97.77)	210 (93.33)	1.0
Hispanic	n (%)	5 (2.23)	15 (6.67)	3.1 (1.1—8.8)
Missing	n	2	1	

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TABLE 1
Characteristics of cases and controls *(continued)*

Variable	Measure	Control (n = 226)	SUI case (n = 226)	Univariate OR (95% CI)
Education				
≤High school	n (%)	24 (10.62)	23 (10.18)	1.0
Some college or college graduate	n (%)	127 (56.19)	135 (59.73)	1.1 (0.6–2.1)
Graduate/professional degree	n (%)	75 (33.19)	68 (30.09)	0.9 (0.5–1.8)
Current smoker	n (%)	9 (3.98)	12 (5.31)	1.4 (0.6–3.3)
Caffeine consumption				
<Once/mo	n (%)	37 (16.37)	35 (15.56)	1.0
Between monthly and daily	n (%)	31 (13.72)	33 (14.67)	1.1 (0.6–2.2)
1-3 times/d	n (%)	138 (61.06)	118 (52.44)	0.9 (0.5–1.5)
>3 times/d	n (%)	20 (8.85)	39 (17.33)	2.1 (1.0–4.2)
Missing	n	0	1	
Prior hysterectomy	n (%)	25 (11.06)	31 (13.78)	1.3 (0.7–2.3)
Menopausal status				
Premenopausal	n (%)	134 (61.75)	140 (63.06)	1.0
Postmenopausal	n (%)	83 (38.25)	82 (36.94)	0.9 (0.6–1.4)
Missing	n	9	4	
Medical conditions				
Seasonal allergy	n (%)	78 (34.51)	95 (42.04)	1.4 (0.9–2.0)
Arthritis	n (%)	36 (15.93)	39 (17.26)	1.1 (0.7–1.8)
Hypertension	n (%)	25 (11.06)	34 (15.04)	1.4 (0.8–2.5)
Major depression	n (%)	17 (7.52)	26 (11.50)	1.6 (0.8–3.0)
Cancer history	n (%)	24 (10.62)	18 (7.96)	0.7 (0.4–1.4)
Sleep apnea	n (%)	7 (3.10)	9 (3.98)	1.3 (0.5–3.5)
Diabetes	n (%)	7 (3.10)	6 (2.65)	0.9 (0.3–2.6)
Chronic cough	n (%)	2 (0.88)	4 (1.77)	2.0 (0.4–11.1)
Myocardial ischemia	n (%)	1 (0.44)	1 (0.44)	1.0 (0.1–16.1)
Current no. of prescription medications	Median (range)	1 (0–9)	1 (0–12)	1.1 (1.0–1.2)
0	n (%)	76 (33.93)	77 (34.22)	1.0
1	n (%)	65 (29.02)	50 (22.22)	0.9 (0.7–1.3)
2	n (%)	31 (13.8)	46 (20.4)	0.9 (0.6–1.3)
3	n (%)	20 (8.93)	13 (5.78)	0.9 (0.6–1.5)
4	n (%)	12 (5.36)	16 (7.11)	0.7 (0.4–1.2)
≥5	n (%)	20 (8.93)	23 (10.22)	0.6 (0.4–0.9)
Missing	n	2	1	

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TABLE 1
Characteristics of cases and controls *(continued)*

Variable	Measure	Control (n = 226)	SUI case (n = 226)	Univariate OR (95% CI)
Self-reported health				
Excellent	n (%)	72 (31.86)	49 (21.68)	1.0
Very good	n (%)	105 (46.46)	113 (50.00)	1.6 (1.0–2.5)
Good	n (%)	47 (20.80)	51 (22.57)	1.6 (0.9–2.7)
Fair	n (%)	2 (0.88)	13 (5.75)	9.5 (2.0–44.1)
Sites				NA
Primary care	n (%)	213 (94.25)	213 (94.25)	
Community	n (%)	13 (5.75)	13 (5.75)	

CI, confidence interval; *NA*, not applicable; *OR*, odds ratio; *SUI*, stress urinary incontinence.

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age group, resulting in a primary care sample of 213 cases and 213 controls, and a community sample of 13 cases and 13 controls. There were no differences in demographic characteristics between women with sufficient vs insufficient LPAQ quality ($P > .05$, data not shown). Women enrolled through community advertising were of similar age, BMI, and race/ethnicity as those enrolled through primary care clinics ($P > .05$, data not shown).

Participant characteristics are summarized in Table 1. Participants had mean (SD) age of 50 (7) years. Compared to controls, SUI cases were more likely to have delivered vaginally, be overweight or obese, and to report lower health status. Among controls, the Incontinence Severity Index scores were 0 in 111 (49.1%), 1 in 58 (25.7%), and 2 in 57 (25.2%) women.

Results for primary exposures

Table 2 summarizes our results.

Overall lifetime activity was associated with slightly increased odds of having SUI (OR, 1.20; 95% confidence interval [CI], 1.02–1.41) per 70 additional MET-h/wk ($P = .03$) in multivariable analysis adjusted for frequency-matched age categories, education, number of vaginal deliveries, and hysterectomy. As lifetime leisure activity demonstrated a nonlinear, nonpolynomial pattern, we compared quintiles of activity between cases and controls and found that compared to the second quintile, the lowest (OR, 0.53; 95% CI, 0.29–0.98) and third (OR, 0.3; 95% CI, 0.2–0.6), but not fourth, quintiles incurred about half the odds of SUI in adjusted analyses (P value across all quintiles = .0092).

The odds of SUI were not associated with lifetime strenuous h/wk (OR, 1.11 per 7 additional h/wk; 95% CI, 0.99–1.25; $P = .06$). However, increasing strenuous activity in the teen years was associated with modestly increased odds of SUI (OR, 1.37 per 7 additional h/wk; 95% CI, 1.09–1.71; $P = .006$) in multivariable analysis. The predicted probability of SUI rose linearly in women exceeding 7.5 hours of strenuous activity/wk during teen years (the top quintile) (Figure 2). Teen strenuous activity had a similar effect on SUI odds when adjusted for subsequent strenuous activity during ages 21-65 years, while subsequent strenuous activity adjusted for teen strenuous activity was not associated with SUI (OR, 1.02; 95% CI, 0.90–1.15).

Results for secondary exposures

Lifetime vigorous activity showed a threshold effect: women in quintiles 2-5 had nearly half the odds of SUI compared to women in the lowest quintile of vigorous activity (adjusted OR, 0.55; 95% CI, 0.34–0.88; $P = .01$). Figure 3 demonstrates the contradictory trends observed for the predicted probabilities of SUI for lifetime strenuous and lifetime vigorous activity.

There were no significant associations between the odds of SUI and total past year activity or strenuous activity during the past year. We found a protective effect of higher levels of leisure activity during the past year on SUI (OR, 0.6 for quintiles 4 and 5 vs quintiles 1-3; 95% CI, 0.43–0.97; $P = .04$).

The direction of associations did not change following simulation extrapolation to adjust for measurement error, although the odds of SUI associated with teen strenuous activity were greater (OR, 1.75; 95% CI, 1.15–2.66; $P = .009$ for a 7-U increase). We found no interaction effect of vaginal delivery (0 vs ≥ 1) on these associations. Adjusting for BMI did not affect results. Finally, the direction of associations was similar when comparing cases to controls with no UI (Incontinence Severity Index score of 0): adjusted ORs were 1.19 (95% CI, 0.97–1.49) for overall lifetime activity, 1.13 (95% CI, 1.00–1.30) for lifetime strenuous activity, 1.31 (95% CI, 1.00–1.72) for teen strenuous activity, and again nonlinear with similar ORs for lifetime leisure activity.

COMMENT

In this study, overall lifetime physical activity was associated with modest increases in SUI odds, while lifetime leisure activity decreased and lifetime strenuous activity appeared unrelated to SUI odds. However, the modest increased odds of SUI was noted only after a substantial increase in lifetime physical activity: an increased odds of SUI of 1.20 per 70

TABLE 2

Odds of stress urinary incontinence by physical activity measure

Physical activity measure	Age-adjusted crude OR (95% CI)	Multivariable adjusted OR (95% CI)[a]	Multivariable OR (95% CI) adjusted for measurement error
Primary exposures			
Overall lifetime activity (U = 70 MET-h/wk[b])	1.206 (1.029–1.413) *P* = .0205	1.196 (1.017–1.407) *P* = .0307	1.321 (1.017–1.714) *P* = .037
Lifetime leisure activity[c]	*P* = .0070	*P* = .0092	NA
Quintile 1	0.508 (0.282–0.916)	0.534 (0.291–0.980)	
Quintile 2	1	1	
Quintile 3	0.302 (0.158–0.578)	0.300 (0.155–0.583)	
Quintile 4	0.621 (0.351–1.097)	0.706 (0.392–1.271)	
Quintile 5	0.592 (0.334–1.046)	0.653 (0.363–1.175)	
Lifetime strenuous activity (U = 7 h/wk[d])	1.113 (0.998–1.241) *P* = .0545	1.112 (0.994–1.244) *P* = .0628	1.161 (0.946–1.424) *P* = .152
Teen epoch[e] strenuous activity (U = 7 h/wk[d])	1.356 (1.091–1.685) *P* = .0061	1.367 (1.094–1.709) *P* = .0061	1.750 (1.153–2.657) *P* = .009
Secondary exposures			
Lifetime vigorous activity (activities with >6 MET; U = 7 h/wk[f])	0.860 (0.517–1.428) *P* = .5590	0.891 (0.528–1.504) *P* = .6664	0.818 (0.310–2.163) *P* = .686
Past year overall activity	1.085 (0.864–1.362) *P* = .4821	1.072 (0.850–1.352) *P* = .5573	1.124 (0.739–1.709) *P* = .583
Past year leisure activity (U = 35 MET-h/wk[g])	0.806 (0.657–0.990) *P* = .0398	0.809 (0.654–1.001) *P* = .0515	0.684 (0.444–1.051) *P* = .083
Past year strenuous activity (U = 7 h/wk[d])	1.235 (0.990–1.541) *P* = .0618	1.227 (0.981–1.534) *P* = .0727	1.364 (0.940–1.980) *P* = .101

CI, confidence interval; *MET*, metabolic equivalent of task; *NA*, not applicable; *OR*, odds ratio.

[a] Adjusted for age, education, hysterectomy, vaginal deliveries; [b] 70 U is equivalent to increase of 10 MET-h/d for each day of week (eg, running at 10 min/mile pace for 1 extra h/d or doing child care for 3.5 extra h/d each day of week); [c] Unable to calculate OR based on continuous measure, as this variable demonstrates nonlinear relationship with stress urinary incontinence; [d] 7 U is equivalent to increase of 1 strenuous h/d for each day of week (eg, doing calisthenics such as push-ups, sit-ups, pull-ups, and lunges for 1 extra h/d); [e] Menarche to age 21 y; [f] 7 U is equivalent to increase of 1 h/d spent doing activities with >6 MET (eg, riding road bicycle at 14–15.9 mph for 1 extra h/d); [g] 35 U is equivalent to increase of 5 MET-h/d for each day of week (eg, playing doubles tennis for 1 extra h/d).

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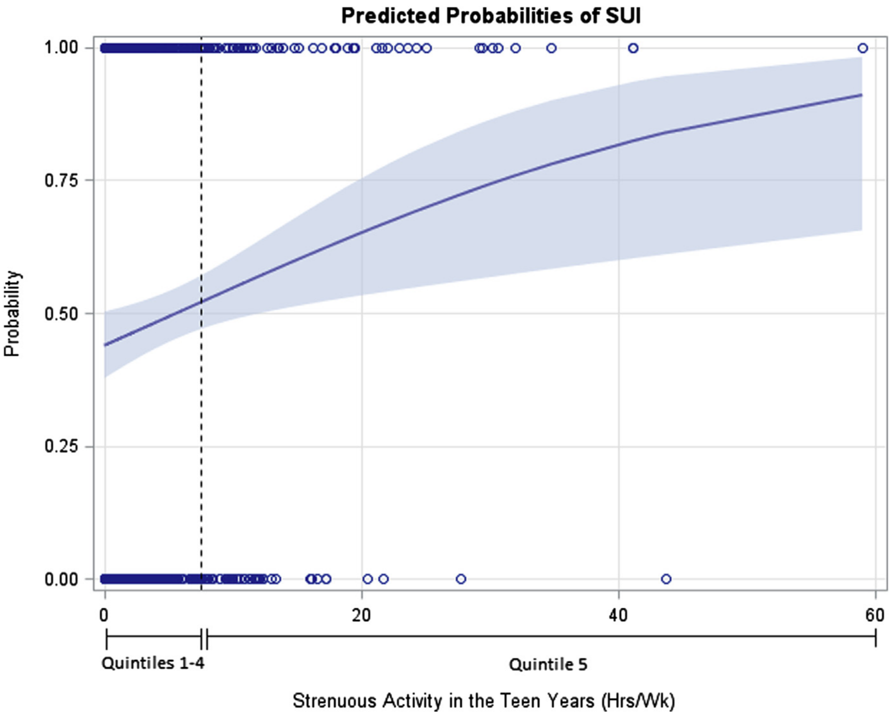
FIGURE 2
Predicted probabilities of SUI by strenuous activity in teen years



Shaded area indicates 95% confidence interval.

SUI, stress urinary incontinence.

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additional MET-h/wk means that a woman would need to do the equivalent of 10 MET-h/d for each day of the week (eg, running at 10 min/mile pace for 1 extra h/d or doing child care for 3.5 extra h/d) to reach even this modest increase.

Greater strenuous activity during the teen years, even accounting for subsequent strenuous activity, was associated with modest increases in SUI odds in later life. Lifetime strenuous activity tended to increase, and lifetime vigorous activity decrease, SUI odds, suggesting that these 2 variables measure different entities.

Similar to others, we found that current leisure activity decreased the odds of SUI.[7,34] While a cross-sectional study is unable to differentiate whether women exercise because they are not incontinent or whether regular exercise prevents incontinence, Danforth et al,[8] in a prospective 12-year analysis of the Nurse's Health Study, confirmed that moderate activity, mainly walking, protected women from developing UI and from having persistent UI. This may in part be mitigated by weight. In a Finnish twin study, persistent physical activity participation was associated with decreased rate of weight gain over a lifetime; this in turn decreases the odds of SUI.[27,35]

In contrast to a large body of literature demonstrating that SUI among young women during high-impact activity is common,[1-4] there are very few studies investigating whether strenuous activity while young increases the odds of SUI later in life. In one, former Norwegian athletes were not more likely to report SUI in midlife compared to controls, while in another, former US Olympians participating in high-impact sports had similar prevalence rates of SUI 25 years later as those participating in swimming.[36,37] However, these studies also differed in their methods. In the first, cases were between ages 13-39 years while representing the senior and junior national teams from 38 different sports, while in the second, all women were performing at much higher levels than most athletes and there was no less-active control group.

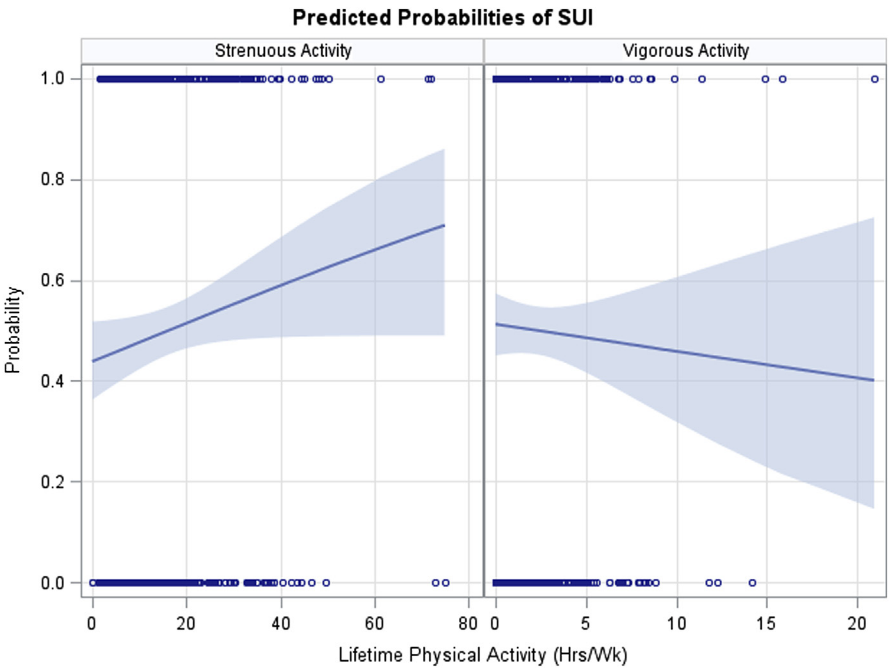
Theoretically, strenuous exercise at younger ages may impact the pelvic floor differently. For example, women engaged in competitive trampoline jumping between mean ages of 11-15 years were queried 5-10 years after they stopped the sport; both duration and frequency of trampoline jumping independently increased the odds of current urinary leakage by about 3-fold.[38]

We previously reported a marginally significant nonlinear relationship between teen strenuous activity and POP with an increase in the log-odds of POP for women reporting ≥21 h/wk of strenuous activity.[12] The teen years may represent a particularly vulnerable time period, given the dramatic changes in hormones, muscle and bone structure, and weight. Given increased risk for connective tissue injury during adolescence in girls,[39] it is biologically plausible that high strenuous activity during this period may affect future pelvic floor function.

Similar to others, we found a modest association between parity, or vaginal deliveries, and UI with little additional risk conferred after the first delivery.[40-42]

Strengths of this study include the recruitment of participants from primary care clinics, rather than from women seeking care for SUI in tertiary care clinics, assessing lifetime activity using a tool validated in middle-aged women, and considering all aspects of physical activity, rather than leisure alone. Further, given the overlap between SUI and POP but the potential for differences in risk factors, we excluded women with vaginal descent at or below the hymen. Our study is most limited by its case-control design; however, a randomized trial assigning girls and women to long-term low vs high levels of activity is impossible, and indeed, unethical. A prospective cohort study in women followed up over a lifetime would be difficult to execute. Therefore, we resorted to a case-control design to study the effect of lifetime physical activity on SUI in

FIGURE 3
Predicted probabilities of SUI by lifetime strenuous and lifetime vigorous activity



Shaded area indicates 95% confidence interval.

SUI, stress urinary incontinence.

Nygaard. Physical activity and SUI. Am J Obstet Gynecol 2015.

women currently middle-aged. Our population is largely Caucasian and relatively healthy and may not be generalizable to other populations and our findings may not apply to women with both SUI and POP. Because of the inaccuracy of recall of obstetric events, other than type of delivery, we did not ask more focused questions about childbirth history.[43] While middle-aged women demonstrate good reproducibility in recalling activity during the teen years,[19] the accuracy of this recall cannot be confirmed. However, by including women not seeking care for SUI who were also masked to the primary goals of the study, it is likely that potential bias was nondifferential. In categorizing controls, we grouped Incontinence Severity Index scores of 0-2 together because sporadic, mild incontinence that waxes and wanes is common in women and generally not bothersome. There is large variation in annual incidence rates when UI is defined broadly ("any" or "monthly") with ranges from 0.9—18.8% and remission rates of 1.2-42% but these rates are more stable for more frequent UI (1.2-4% annual incidence rates), supporting our case designation.[44,45] Sensitivity analysis comparing cases with only controls with no UI yielded similar directions of associations. Finally, it is possible that excluding women with prior SUI surgery may have biased our results towards the null hypothesis.

The relationship between physical activity and SUI is complicated. Sports that are associated with repetitive jumping or bouncing are associated with exercise-provoked SUI. As UI becomes more severe, women are more likely to curtail physical activity to avoid this leakage trigger. However, even in women with severe UI, only one-third reduced or stopped exercise because of UI.[46] It is unlikely that a woman who leaks during strenuous activity could voluntarily stop all domains, including household, occupation, outdoor work, and leisure. While stopping all strenuous activity because of UI would bias our conclusion towards the null hypothesis, stopping some strenuous activity might attenuate the strength of the association but would be unlikely to cancel it out.

Given the many beneficial health effects of physical activity, it is reassuring that our results suggest that overall lifetime physical activity, whether leisure or strenuous, increases odds of SUI either modestly or not at all. However, our finding that the highest levels of strenuous activity during the teen years increase the odds of SUI is concerning. However, this finding needs to be replicated using other populations and study designs before using this information in clinical decision making. Finally, our results should not be used to counsel women at potentially higher risk for SUI, such as those immediately following childbirth or pelvic floor surgery. ■

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of Wei Chen, PhD, MStat, Chang-Chung Chou, MStat, and Khanh K. Thai, MStat for data analysis.

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