Short Communication

Cancer Epidemiology, Biomarkers & Prevention

Physical Activity and Risk of Male Breast Cancer

Hannah Arem[1], Louise A. Brinton[1], Steven C. Moore[1], Susan M. Gapstur[2], Laurel A. Habel[3], Kenneth Johnson[4], Laurence N. Kolonel[5], Valerie A. McCormack[6], Karin B. Michels[7,8,9], Howard D. Sesso[10], Giske Ursin[11], Stephen K. Van Den Eeden[3], Elisabete Weiderpass[11,12,13,14], Michael B. Cook[1], and Charles E. Matthews[1]

Abstract

The association between leisure-time physical activity (LTPA) and male breast cancer risk is unclear. In the Male Breast Cancer Pooling Project, with 449 cases and 13,855 matched controls, we used logistic regression with study stratification to generate adjusted ORs and 95% confidence intervals (CI) for LTPA tertiles and male breast cancer risk. Compared with low LTPA, medium and high LTPA were not associated with male breast cancer risk (OR, 1.01; 95% CI, 0.79–1.29; 0.90, 0.69–1.18, respectively). In joint-effects analyses, compared with the referent of high body mass index (BMI; $\geq$25 kg/m^2)/low LTPA, neither medium nor high PA was associated with risk among high BMI men, but normal BMI men (<25 kg/m^2) with low or medium LTPA were at a nonsignificant ~16% reduced risk and those with high LTPA were at a 27% reduced risk (OR, 0.73; 95% CI, 0.50–1.07). Physical activity alone may not confer protection against male breast cancer risk.
Cancer Epidemiol Biomarkers Prev; 24(12); 1898–901. ©2015 AACR.

Introduction

Male breast cancer is a rare disease, with a lifetime risk of 1 in 1,000. Due in part to the rarity of this cancer, relatively few studies have examined lifestyle-related etiologic factors. Leisure-time physical activity (LTPA) has been consistently associated with a lower risk of postmenopausal female breast cancer (1, 2), but associations with male breast cancer are unclear. Previous studies of physical activity and male breast cancer risk suggest inverse—but not statistically significant—associations (3–6), yet were based on small case numbers and study characteristics or designs [proxy respondents (6) and case–control (4, 5)] that may capture physical activity differently than a prospective design with self-reported data. In this analysis, with more cases and predominately prospectively collected data, we hypothesized that moderate to vigorous-intensity LTPA would be associated with a lower male breast cancer risk.

Materials and Methods

Methods for the Male Breast Cancer Pooling Project (MBCPP) have been previously published (7). In short, the MBCPP identified all case–control or cohort studies with $\geq$10 cases using literature searches of PubMed, citations within published manuscripts, and advertisements at the National Cancer Institute Cohort Consortium meetings (7). Of the 21 studies identified for inclusion in the MBCPP, 10 had collected baseline information on LTPA [nine prospective nested case–control studies (8–16) and one retrospective case–control study (4)]. The two cohort studies and 10 case–control studies that were not included in our analysis did not ask detailed information on LTPA and thus were not eligible for this analysis. Characteristics of included studies are presented in Supplementary Table S1. Cases were defined by the International Classification of Diseases, 10th Edition code C50 from cancer registries, medical record, or self-report. All studies contributed de-identified data following approved data sharing agreements, as well as NCI and study center Institutional Review Board clearances. Participants gave informed consent by nature of study participation.

LTPA was harmonized across studies into categories of low, medium, and high. Studies with a single LTPA question on frequency of activity (AARP, JANUS, PHS, PLCO, Kaiser Permanente) ranged from four to six response levels. For example, in the Physicians' Health Study (PHS), the frequency question was "How often do you exercise vigorously enough to work up a sweat?," with six categorical choices ranging from daily to rarely/never. In these studies, we collapsed the categories to create a relatively even distribution for low, medium, and high. For studies with line items for more than one type of activity (Canada,

[1]National Cancer Institute, Division of Cancer Epidemiology and Genetics, Bethesda, Maryland. [2]American Cancer Society, Atlanta, Georgia. [3]Division of Research, Kaiser Permanente Northern California, Oakland, California. [4]Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, Ontario, Canada. [5]Cancer Research Center of Hawaii, Honolulu, Hawaii. [6]International Agency for Research on Cancer, Lyon, France. [7]Obstetrics and Gynecology Epidemiology Center, Department of Obstetrics, Gynecology and Reproductive Biology, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts. [8]Department of Epidemiology, Harvard School of Public Health, Boston, Massachusetts. [9]Channing Laboratory, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts. [10]Divisions of Preventive Medicine and Aging, Brigham and Women's Hospital, Boston, Massachusetts. [11]Cancer Registry of Norway, Oslo, Norway. [12]Karolinska Institutet, Department of Medical Epidemiology and Biostatistics, Stockholm, Sweden. [13]Department of Community Medicine, Faculty of Health Sciences, University of Tromsø, The Arctic University of Norway, Tromsø, Norway. [14]Genetic Epidemiology Group, Folkhälsan Research Center, Helsinki, Finland.

Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

M.B. Cook and C.E. Matthews contributed equally to this article.

Corresponding Author: Hannah Arem, National Cancer Institute, 9609 Medical Center Drive, Rm 6E314, Rockville, MD 20892. Phone: 240-276-7204; Fax: 240-276-7837; E-mail: Aremhe2@mail.nih.gov

doi: 10.1158/1055-9965.EPI-15-0588

CPS II-NC, EPIC, HPFS, MEC), we assigned metabolic equivalent hours per week, using intensity values previously assigned by individual studies and by referencing the updated Ainsworth Compendium of Physical Activities (17). Example activities from the Health Professionals Follow-up Study (HPFS) included separate line items with 10 categorical responses ranging from none to 11+ hour/week for walking outdoors, jogging, running, bicycling, lap swimming, tennis, squash, or calisthenics/rowing. We then divided the study-specific distributions into categories of low (<33rd percentile), medium (33–<66th percentile), and high (≥66th percentile) LTPA.

We used unconditional logistic regression with stratification by study to compute ORs and 95% confidence intervals (95% CI). We first created models adjusted for age and then additionally adjusted for race, education, marital status, diabetes history, alcohol, smoking status, and body mass index (BMI). We created missing categories for race, education, marital status, diabetes, and alcohol, as these covariates were missing for ≤5% of study subjects, and for alcohol, for which 13% were missing. Sensitivity analyses excluding observations with missing data yielded unaltered results. To assess influence by individual studies, we also performed analyses excluding one study at a time.

Because BMI was previously associated with male breast cancer risk in this population (7), and because joint effects of BMI and physical activity have been observed for female breast cancer risk, we created six categories to look at joint effects: high BMI (≥25 kg/m^2) with (1) low (referent), (2) medium, or (3) high activity levels, and normal BMI (<25 kg/m^2) with (4) low, (5) medium, or (6) high activity levels. We also stratified analyses by age, BMI, diabetes, smoking, and family history of breast cancer and assessed interactions using the Wald test. All analyses were performed using SAS V9.3 (SAS Institute Inc.). *P* values <0.05 were considered significant.

Results

This pooled analysis of 10 studies included 449 cases and 13,855 controls. More active men were more likely to be non-Hispanic white, college graduates, have a lower BMI, and were less likely to be current smokers or report diabetes (Table 1).

Compared with men reporting low LTPA, men reporting medium and high LTPA levels did not have a lower male breast cancer risk after adjustment for other risk factors (OR, 1.01; 95% CI, 0.79–1.29; 0.90, 0.69–1.18, respectively; Table 2). Results were similar after excluding one study at a time to test undue influence by an individual study (Supplementary Table S2).

In joint-effects analyses of BMI and LTPA, we found that among high BMI men (≥25 kg/m^2), neither medium nor high LTPA was associated with risk (OR, 1.01; 95% CI, 0.76–1.34; 0.90, 0.66–1.24, respectively) compared with the referent group of low LTPA/high BMI. However, nonsignificant ∼16% lower risks were observed among normal BMI men (<25 kg/m^2) who reported either low or medium LTPA (OR, 0.83; 95% CI, 0.58–1.19; 0.84, 0.59–1.18, respectively), and a nonsignificant 27% lower risk was observed among men who had a normal BMI/high LTPA (OR, 0.73; 95% CI, 0.50–1.07; Table 2).

Stratified analyses did not suggest statistically significant interactions by median age, BMI, diabetes, or family history of breast cancer (all $P_{interaction}$ values ≥0.05; Supplementary Table S3). There was a stronger inverse association between LTPA and male breast cancer among current smokers (OR, 0.25; 95% CI, 0.07–0.85) than among never or former smokers, with the *P* interaction showing borderline significance ($P = 0.05$).

Discussion

Previous studies of LTPA and female breast cancer risk have suggested stronger risk reductions of about 25% among postmenopausal normal weight women compared with no association for obese women (2), which is similar to the magnitude of association we found among active men with a normal BMI.

Published male breast cancer studies have shown nonsignificant inverse associations with LTPA, but were based on limited numbers (range, 81–178; refs. 3–6) and faced challenges of collecting PA data from proxy respondents of deceased men (6) and retrospective (case–control designs), which may

Table 1. Baseline characteristics of the pooled study populations of male breast cancer cases ($n = 449$) and controls ($n = 13,855$)

	Physical activity tertile[a]		
Characteristic	**Low**	**Medium**	**High**
Cases/controls	157/3,884	177/5,757	115/4,214
Age at entry (years), mean (SD)[b,c]	61.0 (7.9)	61.7 (7.6)	62.1 (7.7)
Race, *n* (%) white[b]	3,499 (86.8)	5,293 (89.9)	3,882 (90.2)
Married, *n* (%)	3,316 (85.3)	5,064 (87.3)	3,625 (87.5)
BMI (kg/m^2), mean (SD)	27.3 (4.4)	26.7 (3.8)	26.0 (3.3)
Smoking status, *n* (%)			
Never	1,269 (32.3)	2,006 (34.9)	1,479 (35.2)
Former	1,990 (50.7)	3,131 (54.4)	2,352 (56.0)
Current	668 (17.0)	615 (10.7)	372 (8.9)
Diabetes, *n* (%)			
No	3,333 (91.0)	5,280 (91.7)	3,832 (93.0)
Yes	328 (8.9)	480 (8.3)	288 (7.0)
Alcohol (grams/day), mean (SD)	17.3 (40.6)	15.4 (33.7)	15.7 (30.3)
Educational level, *n* (%)			
Less than high school	683 (17.3)	457 (7.9)	389 (9.2)
High school graduate	625 (15.8)	803 (13.8)	650 (15.3)
Some college/vocational school	914 (23.1)	1,485 (25.5)	985 (23.2)
College graduate	1,728 (43.8)	3,069 (52.8)	2,229 (52.4)

[a]Physical activity tertiles were created from study-specific distributions and then pooled.
[b]Cohort control subjects were incidence-density matched to cases on sex, race, study center, date of birth, date of entry, and exit date.
[c]Case–control subjects were frequency matched on age and were sampled from provincial health insurance plans in Canada (coverage of >95% of Canadians).

Table 2. ORs and 95% CIs for physical activity and risk of male breast cancer (n = 449 cases/13,855 controls)

Physical activity level	Low	Medium	High	*P* trend
N (case/control)	157/3,884	177/5,757	115/4,214	
Model 1[a]	1.00	1.04 (0.81–1.32)	0.92 (0.70–1.19)	0.515
Model 2[b]	1.00	1.00 (0.79–1.28)	0.88 (0.68–1.15)	0.362
Model 3[c]	1.00	1.01 (0.79–1.29)	0.90 (0.69–1.18)	0.443
Joint effects[b]				
High BMI (≥25 kg/m^2)	1.00	1.01 (0.79–1.34)	0.90 (0.66–1.24)	
Normal BMI (<25 kg/m^2)	0.83 (0.58–1.19)	0.84 (0.59–1.18)	0.73 (0.50–1.07)	

[a]Model 1 included stratification by cohort and was adjusted for age.
[b]Model 2 was additionally adjusted for race (white, black, and other), educational level (high school or less, some college, completed college), marital status (married and not married), history of diabetes (yes and no), alcohol consumption (none, 1–2 drinks/day, >2 drinks/day), and smoking status (never, former, and current).
[c]Model 3 was additionally adjusted for BMI (<18.5, 18.5–<25, 25–<30, 30+ kg/m^2).

introduce recall bias (4, 5). Reasons for a possible interaction of LTPA with BMI remain unknown, but may reflect the cumulative effect of reduced estrogen exposure for lean active men, supported by other findings from the MBCPP of elevated risks being associated with both high BMI (7) and higher estradiol (18).

Strengths of this study include the relatively large sample size, prospective data collection in nine of the 10 studies, and use of studies with sufficiently detailed information on LTPA. Limitations of this analysis include the inability to stratify by genetic male breast cancer risk factors such as Klinefelter syndrome or BRCA status, as this information was not available. We also had LTPA and BMI data only from baseline, which does not account for changes in these factors over time. We captured only leisure-time activity in this study and were unable to examine occupational activity or sedentary time, each of which may affect risk. In summary, our findings suggest that physical activity alone may not be protective for male breast cancer risk.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: H. Arem, L.A. Brinton, K. Johnson, L.N. Kolonel, K.B. Michels, S.K. Van Den Eeden, E. Weiderpass, C.E. Matthews
Development of methodology: H. Arem, L.A. Brinton, S.K. Van Den Eeden, E. Weiderpass
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): L.A. Brinton, S.M. Gapstur, L.A. Habel, K. Johnson, L.N. Kolonel, V.A. McCormack, K.B. Michels, H.D. Sesso, G. Ursin, S.K. Van Den Eeden, E. Weiderpass, M.B. Cook
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): H. Arem, L.A. Brinton, S.C. Moore, H.D. Sesso, E. Weiderpass, M.B. Cook, C.E. Matthews
Writing, review, and/or revision of the manuscript: H. Arem, L.A. Brinton, S.C. Moore, S.M. Gapstur, L.A. Habel, K. Johnson, L.N. Kolonel, V.A. McCormack, K.B. Michels, H.D. Sesso, G. Ursin, S.K. Van Den Eeden, E. Weiderpass, M.B. Cook, C.E. Matthews
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): L.A. Brinton, S.K. Van Den Eeden, E. Weiderpass, M.B. Cook, C.E. Matthews
Study supervision: L.A. Brinton, E. Weiderpass, M.B. Cook, C.E. Matthews

Grant Support

H. Arem, L.A. Brinton, S.C. Moore, M.B. Cook, and C.E. Matthews are supported by the Intramural Research Program at the NIH, Bethesda, Maryland. The Physicians' Health Study was supported by grants CA 097193, CA 34944, CA 40360, HL 26490, and HL 34595 from the NIH (to H.D. Sesso). The Health Professionals' Follow-Up Study was supported by research grant CA167552 from the NCI, NIH (to K.B. Michels). Support for MEC was provided by NIH/NCI under grant number R37CA54281 (to L.N. Kolonel). The American Cancer Society funds the creation, maintenance, and updating of the Cancer Prevention Study II cohort (to S.M. Gapstur).

Received June 15, 2015; revised August 20, 2015; accepted August 21, 2015; published OnlineFirst September 24, 2015.

References

1. Monninkhof EM, Elias SG, Vlems FA, van der Tweel I, Schuit AJ, Voskuil DW, et al. Physical activity and breast cancer: a systematic review. Epidemiology 2007;18:137–57.
2. Friedenreich CM, Cust AE. Physical activity and breast cancer risk: impact of timing, type and dose of activity and population subgroup effects. Br J Sports Med 2008;42:636–47.
3. Brinton LA, Richesson DA, Gierach GL, Lacey JV, Park Y, Hollenbeck AR, et al. Prospective evaluation of risk factors for male breast cancer. J Natl Cancer Inst 2008;100:1477–81.
4. Johnson K, Pan S, Mao YGroup CCRER. Risk factors for male breast cancer in Canada, 1994–1998. Eur J Cancer Prev 2002;11:253–63.
5. Ewertz M, Holmberg L, Tretli S, Pedersen BV, Kristensen A. Risk Factors for male breast cancer? A case-control study from Scandinavia. Acta Oncologica 2001;40:467–71.
6. Hsing AW, McLaughlin JK, Cocco P, Chien HTC, Fraumeni JF Jr. Risk factors for male breast cancer (United States). Cancer Causes Control 1998;9:269–75.
7. Brinton LA, Cook MB, McCormack V, Johnson KC, Olsson H, Casagrande JT, et al. Anthropometric and hormonal risk factors for male breast cancer: male breast cancer pooling project results. J Natl Cancer Inst 2014;106:djt465.
8. Schatzkin A, Subar AF, Thompson FE, Harlan LC, Tangrea J, Hollenbeck AR, et al. Design and serendipity in establishing a large cohort with wide dietary intake distributions the national institutes of health–American association of retired persons diet and health study. Am J Epidemiol 2001;154:1119–25.
9. Calle EE, Rodriguez C, Jacobs EJ, Almon ML, Chao A, McCullough ML, et al. The American Cancer Society cancer prevention study II nutrition cohort. Cancer 2002;94:2490–501.
10. Riboli E, Hunt K, Slimani N, Ferrari P, Norat T, Fahey M, et al. European Prospective Investigation into Cancer and Nutrition (EPIC): study populations and data collection. Public Health Nutr 2002;5:1113–24.
11. Giovannucci E, Rimm EB, Liu Y, Leitzmann M, Wu K, Stampfer MJ, et al. Body mass index and risk of prostate cancer in US health professionals. J Natl Cancer Inst 2003;95:1240–4.
12. Cutler JL, Ramcharan S, Feldman R, Siegelaub A, Campbell B, Friedman GD, et al. Multiphasic checkup evaluation study: Methods and population. Prev Med 1973;2:197–206.

13. Sesso HD, Gaziano JM, Van Den burgh M, Hennekens CH, Glynn RJ, Buring JE. Comparison of baseline characteristics and mortality experience of participants and nonparticipants in a randomized clinical trial: the Physicians' Health Study. Control Clin Trials 2002;23:686–702.
14. Prorok PC, Andriole GL, Bresalier RS, Buys SS, Chia D, Crawford ED, et al. Design of the prostate, lung, colorectal and ovarian (PLCO) cancer screening trial. Control Clin Trials 2000;21:273S–309S.
15. Jellum E, Andersen A, Lund-Larsen P, Theodorsen L, Orjasaeter H. The JANUS serum bank. Sci Total Environ 1993;139:527–35.
16. Kolonel LN, Henderson BE, Hankin JH, Nomura AM, Wilkens LR, Pike MC, et al. A multiethnic cohort in Hawaii and Los Angeles: baseline characteristics. Am J Epidemiol 2000;151:346–57.
17. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett Jr DR, Tudor-Locke C, et al. 2011 Compendium of physical activities: a second update of codes and MET values. Med Sci Sports Exerc 2011;43:1575–81.
18. Brinton LA, Key TJ, Kolonel LN, Michels KB, Sesso HD, Ursin G, et al. Prediagnostic sex steroid hormones in relation to male breast cancer risk. J Clin Oncol 2015;33:2041–50.