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Validation of a New Physical Activity Questionnaire for a Sedentary Population

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Abstract

Background—Many available physical activity questionnaires (PAQs) are limited due to either focus on recreational activities or burdensome length.

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There are no potential competing personal interests for any of the authors.

Aims—We sought to assess the reliability and validity of a new short PAQ that captures all activity types.

Methods—The 12-item multiple-choice PAQ-M included eight activity domains, providing a total Physical Activity Score (PAS-M) in kcal/kg/week. The new PAQ-M was administered with the previously validated Paffenbarger PAQ to 426 men, ages 50–79, undergoing colon-cancer screening.

Results—The PAQ-M had excellent test–retest reliability (intraclass correlation = 0.87). The PAS-M was moderately correlated with the Paffenbarger Physical Activity Score (PAS-P) (r = 0.31) and inversely correlated with BMI (r = −0.14) and waist circumference (r = −0.17). Adenoma prevalence was inversely associated with the PAS-M (3rd vs. 1st tertile adjusted odds ratio, 0.46; 95% confidence interval, 0.26–0.84) but not with the PAS-P.

Conclusions—Our new short physical activity questionnaire has excellent test–retest reliability, and was correlated moderately with a widely used physical activity questionnaire and obesity measures. Furthermore, the new PAQ was a better predictor of adenoma prevalence in the expected direction than the Paffenbarger questionnaire in this largely sedentary population.

Keywords

Physical activity; Questionnaires; Colorectal neoplasms; Validation studies

Introduction

Physical activity is well recognized to be inversely associated with a number of important health outcomes including diabetes mellitus, cardiovascular disease, and a number of malignancies. However, measurement of physical activity poses a number of methodological challenges [1]. Measurements of energy expenditure such as direct or indirect calorimetry are very accurate, but they are impractical for use in large epidemiologic studies measuring energy expenditure in normal daily living. Objective measures of physical activity by devices such as pedometers or accelerometers do not capture certain activity types, underestimating energy expenditure from non-exercise activities, and the former does not measure duration or intensity of activity. Self-administered diaries may be burdensome to subjects, and questionnaires may be subject to recall bias and, if lengthy, may also be burdensome.

Physical activity can be divided into multiple complementary domains including recreational (“exercise”), occupational, and household. Many physical activity questionnaires (PAQs) cover only recreational activity [1]. There are practical limitations of including large numbers of specific activities on a single questionnaire due to subject burden and reporting difficulties. However, within a largely sedentary population, PAQs that rely entirely on recreational activity may have less discriminatory power for predicting health outcomes than a PAQ that covers all domains. Therefore, one of us (HM) developed a short self-administered PAQ that covers each domain of physical activity. We sought to assess it for reliability and validate it for comparability to the widely used Paffenbarger College Alumnus Questionnaire, which we label here “PAQ-P” [2, 3] for measures of obesity and biochemical derangements associated with obesity. The PAQ-P has been extensively validated over decades of use [2, 4] and it has been shown to be associated at least as well as other questionnaires with directly observed motion measured by an accelerometer and with cardiorespiratory fitness [3]. Furthermore, the activity score derived from the PAQ-P has been found to be inversely associated with an extensive list of health outcomes [5– 7]. However, the PAQ-P covers only recreational activity, walking, and stair climbing. Finally, we compared both PAQs for predicting the presence of one health outcome thought to be

inversely associated with amount of physical activity—the presence of colorectal neoplastic polyps.

Materials and Methods

Questionnaire Development

A 12-item multiple-choice questionnaire was developed, which queries the number of hours spent weekly in recreation or exercise (stratified by light, moderate, and vigorous), occupation (with four broad work types), housework, home repairs or maintenance, yardwork, shopping and errands, care of others, and sitting pastimes (see Appendix). For each question, respondents select from eight response categories reflecting the number of hours spent in each activity per week (0, <1, 1–2, 3–5, 6–9, 10–19, 20–29, and ≥30). In addition, one item assesses the respondent's adherence to the recommendation of the National Institutes of Health regarding days per week accumulating at least 30 min of moderate or vigorous activity. Test–retest reliability was first assessed by administering the questionnaire to a convenience sample of eight hospital workers twice, 2 weeks apart. These respondents also provided open-ended remarks about the formatting and clarity of the questions, which were incorporated in a revised version of the questionnaire.

Colon Cancer Screenees

The revised Morgenstern physical activity questionnaire (PAQ-M), along with the previously validated Paffenbarger College Alumnus physical activity questionnaire (PAQ-P) were self-administered by 426 men (aged 50–79 years) undergoing colonoscopy for colon cancer screening or surveillance at either the Ann Arbor Veterans Affairs Medical Center or the University of Michigan Health System East Ann Arbor Ambulatory Surgical and Medical Procedures Center. Subjects were recruited at the time of presentation to their colonoscopy appointments as part of a larger, ongoing study assessing risk factors for esophageal cancer in which subjects consented to undergo a research upper endoscopy regardless of any symptoms. Potential subjects were excluded if the indication for the colonoscopy was diagnostic (such as bloody stools or occult blood loss). Prior to the colonoscopy, and while standing and dressed only in underwear and a hospital gown, a trained research associate measured weight, height, waist circumference (at the level of the palpated iliac crest) [8, 9], and hip circumference (maximum including the buttocks and the palpated greater trochanters) [10], each in duplicate. Fasting blood samples were obtained prior to the colonoscopy, centrifuged, aliquoted, and stored frozen at −80°C. Findings during the colonoscopy were prospectively abstracted, including polyp locations and estimated sizes. Histologic results were subsequently abstracted from the electronic medical record. Advanced adenomas were defined as those at least 1 cm in size or with high grade dysplasia or adenocarcinoma. The right colon was defined as including the cecum through the transverse colon. In addition to the PAQs, subjects self-administered a general questionnaire that queried topics including family history of colorectal cancer and tobacco use. Questionnaires were typically completed within the week after the procedures and returned via postal mail. The Institutional Review Boards of the University of Michigan Medical School and the Ann Arbor Veterans Affairs Medical Center both approved the study.

Blood Assays

From a random sample of 107 subjects, frozen serum samples were later analyzed in duplicate for insulin, glucose, leptin, and ghrelin. Glucose was assayed on an Alfa-Wasserman ACE. We report the inter-assay coefficients of variation (CVs) of 2.1% (94 mg/dl) and 2.5% (305 mg/dl). Insulin was assayed using the ADVIA Centaur Insulin assay which is a two-site sandwich immunoassay using direct chemiluminescent technology. We report inter-assay CVs of 4.2% at 12 ng/ml, 3.5% at 78 and 4.7% at 167 mU/l. Insulin

resistance was estimated by the homeostasis model assessment of insulin resistance (HOMA-IR), based on fasting serum insulin and glucose results [11]. Ghrelin was assayed using the Milipore (St. Charles, Missouri) sandwich ELISA (for both active and des-octanoyl forms). We report inter-assay CVs of 13.0% at 252 pg/ml and 9.0% at 1,765 pg/ml. Leptin was assayed with a sandwich ELISA from R&D Systems (Minneapolis, MN). We report inter-assay CVs of 15.0% at 1.8 ng/ml and 7.6% at 7.9 ng/ml.

Computed Tomographic Measurement of Adipose Tissue

Eleven subjects volunteered for non-contrast computed tomograms (CT) of the abdomen for quantification of subcutaneous and visceral adipose tissue areas. CT imaging of the abdomen was performed through the mid-portion of the fourth lumbar vertebral body on a 16-slice CT scanner (General Electric, Milwaukee, WI) using ten contiguous 1.25-mm thick slices (mA = 250, KV = 120) perpendicular to the long axis of the vertebral body using a lateral scout image. Tissue volume groups were defined by manually tracing regions of interest. Their corresponding fat volumes were measured in cubic centimeters and displayed in resulting histograms, using an attenuation range of −250 to −50 Hounsfield Units.

Questionnaire Scoring

Each question of the new PAQ-M regarding hours of activities is assigned a score reflecting the average metabolic equivalents (METs) for that category (see Tables 2 and 3) [12]. A MET is the ratio of a person's energy expenditure in that activity to the energy expenditure of that person at rest. The number of hours spent each week in a given activity was coded by the midpoints of the eight response categories, i.e., 0 (none), 0.5 (<1), 1.5 (1–2), 4 (3–5), 7.5 (6–9), 14.5 (10–19), 24.5 (20–29), and 35 (≥35). Energy expenditure at rest (the resting metabolic rate) varies among individuals, but is approximately 1 kcal/kg/h, or 1 kcal/min for a 60 kg person. An individual's sedentary time, including sleep (with MET = 1), is calculated by subtracting the sum of hours spent in each category from the number (168) of hours in 1 week. If sedentary hours were calculated as <35 h per week (less than 5 h per day sedentary, including sleeping), the individual's entire questionnaire was considered unreliable and not included in further analyses. A physical activity score (total PAS-M) is calculated as a weighted sum of hours reported for each category of activity, weighted by the corresponding MET value for each activity. The resulting score is expressed in total kcal expended per kg of body weight per week (kcal/kg/week). Given that our subjects are largely a sedentary group overall, missing data from individual questions were assumed to represent zero hours of weekly activity in that category. In addition to this total PAS-M, we also calculated a moderate PAS-M, which was limited to activities requiring at least moderate exertion (MET > 4.5), i.e., moderate or vigorous recreational activities, yardwork, and occupations requiring walking with heavy manual labor. Finally, a total energy score (TES-M) was calculated by summing the PAS-M with sedentary time (the latter weighted by a MET of 1.0) and expressing it in terms of kcal expended per day assuming all subjects weigh 60 kg.

The Paffenbarger College Alumnus PAQ (PAQ-P) was designed as a postal questionnaire that queries daily blocks walked, daily flights of stairs climbed, and recreational activities (including frequency and duration of each episode) [2, 3]. Each block walked is assumed to expend 8 kcal, and each flight of stairs climbed and descended is assumed to expend 4 kcal. Each recreational activity is assigned a MET value, which is weighted by the duration and frequency of activity episodes to result in recreational kcal expended per week. The scoring implicitly assumes that all subjects are the same weight (60 kg) [2, 13]. A total Paffenbarger physical activity score (PAS-P) (sometimes referred to as the physical activity index) is tabulated by summing these figures for blocks, stairs, and recreational activities [2, 3]. To

facilitate comparison to the total PAS-M and the moderate PAS-M in similar units, we divided the PAS-P by 60 kg, resulting in kcal expended per kg of body weight per week.

Statistical Analyses

The duplicate anthropometrics were averaged for each subject. Body mass index (BMI) was calculated as weight divided by the square of height (kg/m^2). Test–retest reliability for the eight subjects who responded to the PAQ-M twice, 2 weeks apart, was assessed with an intraclass correlation coefficient [14]. Spearman's rho was used to estimate the correlations between the PAQ-M, PAQ-P, anthropometrics, blood assays, and adipose areas in tissue compartments.

Binary logistic regression was used to estimate the crude and adjusted effects (odds ratios [OR] and 95% confidence intervals [CI]) of physical-activity level (categorized in tertiles) on the presence of any adenoma (case vs. noncase) in the total sample and on laterality (left- vs. right-sided) among adenoma cases. Multinomial logistic regression was used to estimate the effects of physical-activity level on adenoma size and grade (advanced vs. non-advanced adenomas, each compared with no adenoma). Adjustments were made for potential confounders: age, waist circumference, tobacco use, indication for colonoscopy, and family history of colorectal cancer. All analyses were performed using SAS for Windows v.9.2 (SAS Institute, Cary, NC).

Results

Among the convenience set of eight hospital workers, the median physical activity score of the PAQ-M was 195 kcal/kg/week (range 111–403 kcal/kg/week) on the initial response. The intraclass correlation with the second test 2 weeks later was 0.87. The remaining results pertain only to the colon cancer screenees.

The characteristics of the 426 colon cancer screenees are summarized in Table 1, demonstrating a substantially overweight population. Sixty percent were undergoing colonoscopy at the University of Michigan Health System East Ann Arbor Ambulatory Surgical and Medical Procedures Center, and 40% at the Ann Arbor Veterans Affairs Medical Center. Fifty-five percent were undergoing their first colonoscopy, 30% were undergoing colonoscopy for a personal history of colon polyps, and 15% had previously had a negative colonoscopy. Ninety-four percent of enrolled subjects returned both the PAQ-M and the PAQ-P ($n = 402$). Three subjects failed to return the PAQ-P, three failed to return the PAQ-M, and 18 failed to return both. The remaining analyses pertain only to subjects who returned both the PAQ-M and the PAQ-P.

The colon cancer screenees' responses to questions regarding each type of activity in the PAQ-M are displayed in Tables 2 and 3. Missing responses for individual questions ranged from three subjects (for both home repairs and for shopping) to 34 subjects (for moderate recreation). Five subjects had calculated sedentary times of less than 35 h per week, and were excluded from analysis. The median total PAS-M of the remaining subjects was 153 kcal/kg/week (IQR = 100–225), the median moderate PAS-M was 38 kcal/kg/week (IQR = 20–83), and the median TES-M was 2,268 kcal/day (IQR = 1,957–2,834). These results reflect a sedentary population overall, e.g., if a 60 kg man expends 2,268 kcal in 24 h, and we assume he slept for 7 of those hours (MET = 1.0), during his waking hours his average activity level must have been low (MET = 1.8). For reference, sitting pastimes and sitting work have MET of 1.6, and light recreational activities have MET of 3.0. The median Paffenbarger PAS-P was 9.8 kcal/kg/week (IQR = 4.5–18.4), and the vast majority of this score was due to walking and stair climbing. Very little recreational physical activity was reported on the Paffenbarger PAQ (median = 0 kcal/kg/week, IQR = 0–1.7).

The calculated measures of physical activity from the Morgenstern physical activity questionnaire (total PAS-M, moderate PAS-M, TES-M) were strongly correlated with each other, and moderately correlated with the number of active days per week (Table 4). These scores and the number of active days were moderately correlated with the Paffenbarger physical activity score (PAS-P). All these measures, including the PAS-P, were weakly inversely correlated with BMI and waist circumference, but not with waist-to-hip ratio, and all with similar correlation coefficients. The scores from both questionnaires were weakly inversely correlated with insulin resistance and serum leptin, and they were weakly positively correlated with serum ghrelin. Scores from both questionnaires were weakly to moderately inversely correlated with both subcutaneous and visceral adipose tissue areas measured by abdominal computed tomography.

One hundred fifty-eight (39.8%) subjects had at least one adenoma, and 31 (7.8%) had at least one advanced adenoma. In five subjects the presence of an advanced adenoma was indeterminate due to unretrieved polyps not examined histologically. Waist circumference appeared to be more closely associated with adenoma prevalence than body mass index or the ratio of the waist circumference to the hip circumference (Table 5). The total PAS-M was inversely and monotonically associated with adenoma prevalence (adjusted OR for middle tertile vs. lowest tertile = 0.57 [95% CI = 0.32, 1.0] and adjusted OR for highest tertile vs. lowest tertile = 0.46 [95% CI = 0.26, 0.84]). Similar adjusted OR estimates were observed for the TES-M, but not for the moderate PAS-M (Table 6). Contrary to expectation, the PAS-P was not inversely or monotonically associated with adenoma prevalence (adjusted OR for middle tertile vs. lowest tertile = 2.6 [95% CI = 1.4, 4.7] and adjusted OR for highest tertile vs. lowest tertile = 1.4 [95% CI = 0.76, 2.7]). We also examined associations between activity scores and adenomas by classifying subjects with a prior history of colon polyps as having an adenoma regardless of findings on the current colonoscopy. We found similar effect estimates for total PAS-M and the PAS-P as in the primary analysis, but stronger negative effects for the moderate PAS-M and TES-M than in the primary analysis (for instance, adjusted OR for TES-M middle vs. lowest tertile = 0.59 [95% CI = 0.32, 1.1], adjusted OR for TES-M highest vs. lowest tertile = 0.41 [95% CI = 0.27, 0.88], *P*-value for trend = 0.02).

Multinomial logistic regression was used to estimate the effects of physical activity level on non-advanced and advanced adenoma compared to no adenomas (Table 7). The total PAS-M and the TES-M were inversely associated with the presence of both non-advanced adenomas and advanced adenomas. The moderate PAS-M, however, was strongly associated inversely with the presence of advanced adenomas but slightly associated in the opposite direction with non-advanced adenomas. The TES-M was more strongly associated inversely with advanced adenomas than with non-advanced adenomas. In contrast, the PAS-P was positively associated, but not monotonically, with both advanced and non-advanced adenomas. The effect of physical activity on adenomas does not appear to be systematically different for left- versus right-sided lesions, but the data are too sparse in individual strata to obtain precise estimates of these relations (data not shown).

Discussion

We have developed a new short physical activity questionnaire that captures multiple complementary domains of physical activity and that has excellent test–retest reliability over at least the short term. The correlations of the scores from the new questionnaire with the Paffenbarger physical activity questionnaire were not as high as one might expect given that both are intended to measure the same factor—physical activity. However, the Paffenbarger questionnaire does not capture most non-recreational forms of activity. Notably, the PAS-P was an order of magnitude lower than the total PAS-M, suggesting that the PAS-P grossly

underestimates the total energy expenditure in this sedentary population. Furthermore, the score from the PAS-P was not inversely associated with colorectal adenoma prevalence. In contrast, our total physical activity score was inversely and monotonically associated with adenomas and our moderate physical activity score was strongly inversely associated with advanced adenomas. Therefore, our new questionnaire appears to measure more accurately the types of physical activity that protect against these important health outcomes in this sedentary population. The moderate correlation between the PAS-M and PAS-P indicates that there is overlap in what they are measuring, but the PAS-M is more strongly inversely associated with the health outcomes of interest in this study.

Numerous previous studies have demonstrated an inverse association between physical activity and colorectal neoplasms [15–24]. The present study adds to that body of literature. In addition, we have found that even in a largely sedentary population, activities requiring relatively low levels of exertion are inversely associated with adenomas. However, the development of advanced adenomas, which represent a higher risk for transformation into invasive cancer, may be most strongly associated inversely with activities of at least moderate exertion.

Validity of instruments can be assessed on multiple domains, including face (the instrument appears to measure what it is intended to measure), convergence (it correlates with other measures expected to be related to the outcome of interest), and discriminance (it does not correlate with measures of other factors expected to be unrelated to the outcome of interest). The current study offers evidence for face and convergent validity, as well as reliability for the new questionnaire. However, validating the new questionnaire against another self-report instrument raises the potential for shared error. The current study is mainly limited by the restricted population of men aged 50–79 and the absence of an objective measure of physical activity. There were also relatively small numbers of advanced adenomas making estimates for that outcome imprecise. The new questionnaire might be strengthened by questions eliciting mode of transportation used, but walking and bicycling are likely rare forms of frequent transportation in the population of the current study. In addition, questions eliciting hours spent sleeping might avoid over-estimates of physical activity. We intend to include such questions in future versions of the questionnaire. Major strengths are the large numbers of subjects recruited from a pool of patients undergoing routine screening or surveillance examinations rather than symptomatic patients, and the comparisons with multiple measures of obesity, biochemical correlates of obesity, another physical activity questionnaire with a long record of prior validation studies, and the relevant outcome of colorectal adenomas.

In summary, we have developed a new short physical activity questionnaire and validated it against important health outcomes in a sedentary population. We expect that this questionnaire will prove useful in future epidemiologic studies of various outcomes, especially in populations that derive much of their energy expenditure from non-recreational activities.

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Abbreviations

BMI	Body mass index
CI	Confidence interval
CT	Computed tomogram
CV	Coefficient of variation
HOMA-IR	Homeostasis model assessment of insulin resistance
IQR	Interquartile range
MET	Metabolic equivalent
OR	Odds ratio
PAQ-M	Morgenstern physical activity questionnaire
PAQ-P	Paffenbarger physical activity questionnaire
PAS-M	Morgenstern physical activity score
PAS-P	Paffenbarger physical activity score
TES-M	Morgenstern total energy score

Appendix

Physical-Activity Questionnaire

On average, how many hours per week do you spend in each of the following types of recreational activities and exercises?

	None	**Less than hr/wk**	**1–2 hrs/wk**	**3–5 hrs/wk**	**6–9 hrs/wk**	**10–19 hrs/wk**	**20–29 hrs/wk**	**30 or more hrs/wk**
1. **Light** e.g., leisurely walking, golfing with a cart, bowling, shuffleboard, croquet, sailing, billiards, darts, playing catch, coaching	☐	☐	☐	☐	☐	☐	☐	☐
2. **Moderate** e.g., brisk walking, golfing without a cart, dancing, stretching or back exercises, yoga, volleyball, softball, badminton, ping pong, fishing, hunting, horseback riding, snorkeling, shooting baskets	☐	☐	☐	☐	☐	☐	☐	☐
3. **Vigorous** e.g., running, hiking on hills, bicycling, swimming, tennis, racquetball, skiing, skating, aerobics, jumping rope, vigorous calisthenics (e.g., push-ups and sit-ups), exercise-machine workout	☐	☐	☐	☐	☐	☐	☐	☐

On average, how many hours per week do you spend in each of the following types of home or work activities and chores?

	None	Less than hr/wk	1–2 hrs/wk	3–5 hrs/wk	6–9 hrs/wk	10–19 hrs/wk	20–29 hrs/wk	30 or more hrs/wk
4. **Work - either work for pay, or volunteer work** If "None", SKIP TO QUESTION 5	☐	☐	☐	☐	☐	☐	☐	☐
5. **Housework** e.g., cleaning, vacuuming, dusting, cooking, serving food, washing dishes, laundry, ironing, making beds, washing floors or windows	☐	☐	☐	☐	☐	☐	☐	☐
6. **Home repairs and maintenance** e.g., carpentry, painting, wallpapering, plumbing or electrical work, refinishing furniture, cleaning gutters or garage, washing car	☐	☐	☐	☐	☐	☐	☐	☐
7. **Yardwork** e.g., gardening, planting, mowing the lawn, raking, digging, chopping, wood, shoveling snow or dirt	☐	☐	☐	☐	☐	☐	☐	☐
8. **Shopping and errands** (excluding sitting while traveling): e.g., grocery or clothes shopping, going to the bank or store	☐	☐	☐	☐	☐	☐	☐	☐
9. **Taking care of others** (exclude inactive sitting): e.g., playing with children; pushing a wheelchair or stroller; lifting, carrying, bathing, or dressing persons	☐	☐	☐	☐	☐	☐	☐	☐

4a. If you work for pay or as a volunteer, which one of the following categories best describes the type of physical activity required on your job? If you have more than one job, refer to one in which you spend the most time.

☐ Mainly sitting with slight arm or foot movements: e.g., desk work, watch repair, seated assembly-line work, taxi or bus driver

☐ Sitting or standing with some walking: e.g., store salesperson, clerk, cashier, bartender, patient care, lab technician, standing assembly-line work, security guard, machine operator

☐ Walking and light manual work: e.g., mail carrier, waiter, gardener, light construction or repair work, service installation, light farm work

☐ Walking and heavy manual work: e.g., stone or concrete mason, heavy farm work, lumberjack, loading/unloading trucks, moving furniture, heavy construction work

	None	Less than hr/wk	1–2 hrs/wk	3–5 hrs/wk	6–9 hrs/wk	10–19 hrs/wk	20–29 hrs/wk	30 or more hrs/wk
10. **Sitting pastimes** (exclude watching TV and reading): e.g., needlework, sewing, crafts, coin or stamp collecting, computer activities, playing a musical instrument, cards, or board games	☐	☐	☐	☐	☐	☐	☐	☐

11. On average, how many days per week do you accumulate 30 minutes or more of moderate or vigorous physical activity, including recreational activity, exercise, heavy work or home activity, and chores?

_____ days per week

References

1. Lee, IM., editor. Epidemiologic Methods in Physical Activity Studies. Oxford: Oxford University Press; 2009.
2. Pereira MA, FitzerGerald SJ, Gregg EW, et al. A collection of physical activity questionnaires for health-related research. Med Sci Sports Exerc. 1997; 29:S1–S205. [PubMed: 9243481]
3. Jacobs DR Jr, Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 commonly used physical activity questionnaires. Med Sci Sports Exerc. 1993; 25:81–91. [PubMed: 8423759]
4. Ainsworth BE, Leon AS, Richardson MT, Jacobs DR, Paffenbarger RS RS Jr. Accuracy of the college alumnus physical activity questionnaire. J Clin Epidemiol. 1993; 46:1403–1411. [PubMed: 8263567]
5. Washburn RA, Smith KW, Goldfield SR, McKinlay JB. Reliability and physiologic correlates of the Harvard alumni activity survey in a general population. J Clin Epidemiol. 1991; 44:1319–1326. [PubMed: 1753263]
6. Paffenbarger RS Jr, Wing AL, Hyde RT. Physical activity as an index of heart attack risk in college alumni. Am J Epidemiol. 1978; 108:161–175. [PubMed: 707484]
7. Paffenbarger RS Jr, Wing AL, Hyde RT, Jung DL. Physical activity and incidence of hypertension in college alumni. Am J Epidemiol. 1983; 117:245–257. [PubMed: 6829553]
8. National Health and Nutrition Examination Survey. Atlanta, GA: Centers for Disease Control; 2004. Anthropometry Procedures Manual. http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/BM.pdf
9. Varia I, Logue E, O'Connor C, et al. Randomized trial of sertraline in patients with unexplained chest pain of noncardiac origin. Am Heart J. 2000; 140:367–372. [PubMed: 10966532]
10. Peghini PL, Katz PO, Castell DO. Imipramine decreases oesophageal pain perception in human male volunteers. Gut. 1998; 42:807–813. [PubMed: 9691919]
11. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: Insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985; 28:412–419. [PubMed: 3899825]
12. Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc. 1993; 25:71–80. [PubMed: 8292105]
13. Bassett DR, Vachon JA, Kirkland AO, Howley ET, Duncan GE, Johnson KR. Energy cost of stair climbing and descending on the college alumnus questionnaire. Med Sci Sports Exerc. 1997; 29:1250–1254. [PubMed: 9309638]
14. Shrout PE, Fleiss JL. Intraclass correlations—uses in assessing rater reliability. Psychol Bull. 1979; 86:420–428. [PubMed: 18839484]

15. Calton BA, Lacey JV Jr, Schatzkin A, et al. Physical activity and the risk of colon cancer among women: a prospective cohort study (United States). Int J Cancer. 2006; 119:385–391. [PubMed: 16489545]

16. Emmons KM, McBride CM, Puleo E, et al. Prevalence and predictors of multiple behavioral risk factors for colon cancer. Prev Med. 2005; 40:527–534. [PubMed: 15749134]

17. Giovannucci E, Ascherio A, Rimm EB, Colditz GA, Stampfer MJ, Willett WC. Physical activity, obesity, and risk for colon cancer and adenoma in men. Ann Intern Med. 1995; 122:327–334. [PubMed: 7847643]

18. Hou L, Ji BT, Blair A, et al. Commuting physical activity and risk of colon cancer in Shanghai, China. Am J Epidemiol. 2004; 160:860–867. [PubMed: 15496538]

19. Juarranz M, Calle-Puron ME, Gonzalez-Navarro A, et al. Physical exercise, use of Plantago ovata and aspirin, and reduced risk of colon cancer. Eur J Cancer Prev. 2002; 11:465–472. [PubMed: 12394244]

20. Larsen IK, Grotmol T, Almendingen K, et al. Lifestyle as a predictor for colonic neoplasia in asymptomatic individuals. BMC Gastroenterol. 2006; 6:5. [PubMed: 16412216]

21. Larsson SC, Rutegard J, Bergkvist L, et al. Physical activity, obesity, and risk of colon and rectal cancer in a cohort of Swedish men. Eur J Cancer. 2006; 42:2590–2597. [PubMed: 16914307]

22. Steindorf K, Jedrychowski W, Schmidt M, et al. Case-control study of lifetime occupational and recreational physical activity and risks of colon and rectal cancer. Eur J Cancer Prev. 2005; 14:363–371. [PubMed: 16030427]

23. White E, Jacobs EJ, Daling JR. Physical activity in relation to colon cancer in middle-aged men and women. Am J Epidemiol. 1996; 144:42–50. [PubMed: 8659484]

24. Wolin KY, Lee IM, Colditz GA, et al. Leisure-time physical activity patterns and risk of colon cancer in women. Int J Cancer. 2007; 121:2776–2781. [PubMed: 17722094]

Table 1

Descriptive characteristics of colon cancer screenees

Finding	Mean (standard deviation) or median (interquartile range)
Age	58.6 years (7.0)
Body mass index (BMI)	30.2 kg/m^2 (5.6)
Waist circumference	108 cm (14)
Waist/hip ratio	1.00 (0.05)
HOMA-IR	1.43 $(mmol \times mU)/l^2$ (0.70–2.55)

HOMA-IR homeostasis model assessment of insulin resistance

Table 2

Responses to individual questions in the Morgenstern physical activity questionnaire (PAQ-M)

Activity	Assigned MET value	Median hours per week (interquartile range)
Recreation—light	3.0	1.5 (0.5–7.5)
Recreation—moderate	4.7	1.5 (0.5–4.0)
Recreation—vigorous	7.0	0.5 (0.0–4.0)
Work for pay or volunteer	See Table 3	24.5 (0.0–35.0)
Housework	2.7	4.0 (1.5–7.5)
Home repairs or maintenance	3.7	1.5 (0.5–4.0)
Yardwork	5.0	1.5 (1.5–4.0)
Shopping and errands	3.0	1.5 (1.5–4.0)
Care of others	4.0	0.0 (0.0–1.5)
Sitting pastimes	1.6	4.0 (1.5–14.5)

MET metabolic equivalent

Table 3

Full or part-time work types (for pay or volunteer)

Work type	Assigned MET value	Proportion of respondents
None	N/A	24.6%
Sitting	1.6	22.4%
Sitting or standing with some walking	2.5	23.1%
Walking and light manual work	4.3	23.0%
Walking and heavy manual work	6.0	7.2%

MET metabolic equivalent, *N/A* not applicable

Table 4

Spearman correlations with questionnaire scores given as rho (*P*-value)

Parameter	Total PAS-M	Moderate PAS-M	TES-M	Active days	PAS-P
Total PAS-M	–	0.72 (<0.0001)	0.98 (<0.0001)	0.32 (<0.0001)	0.31 (<0.0001)
Moderate PAS-M	0.72 (<0.0001)	–	0.76 (<0.0001)	0.44 (<0.0001)	0.30 (<0.0001)
TES-M	0.98 (<0.0001)	0.76 (<0.0001)	–	0.35 (<0.0001)	0.32 (<0.0001)
Active days	0.32 (<0.0001)	0.44 (<0.0001)	0.35 (<0.0001)	–	0.34 (<0.0001)
PAS-P	0.31 (<0.0001)	0.30 (<0.0001)	0.32 (<0.0001)	0.34 (<0.0001)	–
BMI	−0.14 (0.004)	−0.17 (0.0009)	−0.15 (0.003)	−0.15 (0.004)	−0.17 (0.0008)
Waist circumference	−0.17 (0.0009)	−0.18 (0.0004)	−0.17 (0.0009)	−0.16 (0.002)	−0.17 (0.0007)
Waist/hip ratio	−0.09 (0.09)	−0.12 (0.02)	−0.08 (0.11)	−0.11 (0.03)	−0.13 (0.007)
HOMA-IR	−0.09 (0.39)	−0.03 (0.73)	−0.10 (0.34)	−0.07 (0.46)	−0.09 (0.40)
Leptin	−0.16 (0.10)	−0.06 (0.58)	−0.15 (0.14)	−0.06 (0.58)	−0.16 (0.11)
Ghrelin	0.07 (0.49)	0.03 (0.80)	0.05 (0.64)	0.03 (0.77)	0.06 (0.53)
Subcutaneous adipose	−0.23 (0.50)	−0.24 (0.47)	−0.33 (0.33)	0.25 (0.45)	−0.65 (0.03)
Visceral adipose	−0.30 (0.37)	−0.28 (0.40)	−0.35 (0.28)	0.29 (0.39)	−0.49 (0.13)

PAS-M Morgenstern physical activity score, *TES-M* Morgenstern total energy score, *PAS-P* Paffenbarger physical activity score, *BMI* body mass index, *HOMA-IR* homeostasis model assessment of insulin resistance

Table 5

Association of measures of obesity with any adenoma

Parameter	Any adenoma/ no adenoma	Crude OR (95% CI)	Adjusted[a] OR (95% CI)
Body mass index (kg/m^2)			
Underweight (<20.0)	1/1	2.0 (0.12, 33)	1.3 (0.071, 24)
Normal (20.0–25.0)	23/45	1.0 (reference)	1.0 (reference)
Overweight (25.1–30.0)	53/82	1.3 (0.69, 2.3)	1.4 (0.75, 2.7)
Obese (>30.0)	83/109	1.5 (0.84, 2.7)	1.6 (0.87, 2.9)
P-value for trend		0.18	0.15
Waist circumference (cm)			
1st tertile (<101.2)	39/92	1.0 (reference)	1.0 (reference)
2nd tertile (101.2–112.5)	65/67	2.3 (1.4, 3.8)	2.6 (1.5, 4.4)
3rd tertile (≥112.6)	56/78	1.7 (1.0, 2.8)	1.7 (1.0, 3.0)
P-value for trend		0.05	0.06
Waist/hip ratio			
1st tertile (<0.975)	45/87	1.0 (reference)	1.0 (reference)
2nd tertile (0.975–1.018)	62/71	1.7 (1.0, 2.8)	1.5 (0.90, 2.6)
3rd tertile (≥1.018)	53/79	1.3 (0.79, 2.1)	1.3 (0.76, 2.2)
P-value for trend		0.32	0.37

OR odds ratio, *CI* confidence interval

[a] Adjusted for age, tobacco use, first degree family history of colorectal cancer, and indication of colonoscopy

Table 6

Association of physical activity with any adenoma

Parameter	Any adenoma/ no adenoma	Crude OR (95% CI)	Adjusted[a] OR (95% CI)
Total PAS-M (kcal/kg/week)			
1st tertile (<120)	68/63	1.0 (reference)	1.0 (reference)
2nd tertile (120–200)	48/82	0.54 (0.33, 0.89)	0.57 (0.32, 1.0)
3rd tertile (≥200)	42/89	0.44 (0.27, 0.72)	0.46 (0.26, 0.84)
P-value for trend		0.001	0.01
Moderate PAS-M (kcal/kg/week)			
1st tertile (<22)	54/73	1.0 (reference)	1.0 (reference)
2nd tertile (22–67)	60/76	1.1 (0.66, 1.7)	1.2 (0.65, 2.1)
3rd tertile (≥67)	44/84	0.71 (0.43, 1.2)	0.77 (0.41, 1.4)
P-value for trend		0.18	0.38
TES-M (kcal/day)			
1st tertile (<2,027)	65/67	1.0 (reference)	1.0 (reference)
2nd tertile (2.027–2.643)	49/80	0.63 (0.39, 1.0)	0.69 (0.39, 1.2)
3rd tertile (≥2,643)	44/87	0.52 (0.32, 0.86)	0.58 (0.32, 1.1)
P-value for trend		0.01	0.08
PAS-P (kcal/kg/week)			
1st tertile (<5.6)	46/82	1.0 (reference)	1.0 (reference)
2nd tertile (5.6–13.8)	64/71	1.6 (0.98, 2.6)	2.6 (1.4, 4.7)
3rd tertile (≥13.8)	49/82	1.1 (0.64, 1.8)	1.4 (0.76, 2.7)
P-value for trend		0.82	0.33

OR odds ratio, *CI* confidence interval, *PAS-M* Morgenstern physical activity score, *TES-M* Morgenstern total energy score, *PAS-P* Paffenbarger physical activity score

[a]Adjusted for waist circumference, age, tobacco use, first degree family history of colorectal cancer, and indication of colonoscopy

Table 7

Association of physical activity with non-advanced adenomas and advanced adenomas

Parameter	Non-advanced adenoma vs. no adenoma			Advanced adenoma vs. no adenoma		
	Non-advanced adenoma/no adenoma	Crude OR (95% CI)	Adjusted[a] OR (95% CI)	Advanced adenoma/no adenoma	Crude OR (95% CI)	Adjusted[a] OR (95% CI)
Total PAS-M (kcal/kg/week)						
1st tertile (<120)	57/63	1.0 (reference)	1.0 (reference)	11/63	1.0 (reference)	1.0 (reference)
2nd tertile (120–200)	36/82	0.49 (0.29, 0.83)	0.51 (0.27, 0.96)	12/82	0.84 (0.35, 2.0)	0.83 (0.29, 2.3)
3rd tertile (≥200)	34/89	0.42 (0.25, 0.72)	0.47 (0.25, 0.89)	8/89	0.52 (0.20, 1.4)	0.41 (0.13, 1.4)
P-value for trend		0.001	0.02		0.18	0.16
Moderate PAS-M (kcal/kg/week)						
1st tertile (<22)	37/73	1.0 (reference)	1.0 (reference)	17/73	1.0 (reference)	1.0 (reference)
2nd tertile (22–67)	52/76	1.4 (0.80, 2.3)	1.7 (0.89, 3.3)	8/76	0.45 (0.18, 1.1)	0.32 (0.11, 0.95)
3rd tertile (≥67)	38/84	0.89 (0.52, 1.6)	1.2 (0.58, 2.3)	6/84	0.31 (0.12, 0.82)	0.17 (0.044, 0.64)
P-value for trend		0.66	0.81		0.01	0.004
TES-M (kcal/day)						
1st tertile (<2,027)	53/67	1.0 (reference)	1.0 (reference)	12/67	1.0 (reference)	1.0 (reference)
2nd tertile (2,027–2,643)	38/80	0.60 (0.35, 1.0)	0.68 (0.36, 1.3)	11/80	0.77 (0.32, 1.9)	0.76 (0.27, 2.1)
3rd tertile (≥2,643)	36/87	0.52 (0.31, 0.89)	0.65 (0.34, 1.2)	8/87	0.51 (0.20, 1.3)	0.33 (0.095, 1.2)
P-value for trend		0.02	0.18		0.17	0.09
PAS-P (kcal/kg/week)						
1st tertile (<5.6)	38/82	1.0 (reference)	1.0 (reference)	8/82	1.0 (reference)	1.0 (reference)
2nd tertile (5.6–13.8)	49/71	1.5 (0.88, 2.5)	2.4 (1.2, 4.5)	15/71	2.2 (0.87, 5.4)	3.6 (1.2, 11)
3rd tertile (≥13.8)	41/82	1.1 (0.63, 1.8)	1.5 (0.75, 2.9)	8/82	1.0 (0.36, 2.8)	1.2 (0.32, 4.8)
P-value for trend		0.79	0.31		1.0	0.76

OR odds ratio, *CI* confidence interval, *PAS-M* Morgenstern physical activity score, *TES-M* Morgenstern total energy score, *PAS-P* Paffenbarger physical activity score

[a]Adjusted for waist circumference, age, tobacco use, first degree family history of colorectal cancer, and indication of colonoscopy