Leisure Time Physical Activity and Metabolic Syndrome in Asian Indian Immigrants Residing in Northern California

Kiran B. Misra, PhD, RD; Sarah W. Endemann, MS; Mandeep Ayer, MD

Objective: Immigrant Asian Indians possess major lipid and non-lipid risk factors that constitute features characteristic of metabolic syndrome. First-line therapy recognized in risk management of this syndrome is weight reduction and increased physical activity. We investigated the relationship of intensity and duration of leisure time physical activity (LTPA) to physiological indices of metabolic syndrome in Asian Indian immigrants.

Methods: Fifty-six apparently healthy men (43.7 years ± 7.1; body mass index [BMI] 21–34) and women (43.1 years ± 6.9; BMI 21–36) were screened to participate in this cross-sectional study. Leisure time physical activity (LTPA) was determined by Minnesota LTPA questionnaire. Anthropometric measurements were recorded by using standard procedures. Blood samples taken after an overnight fast were analyzed for measures defined by the NCEP ATP III criteria for metabolic syndrome.

Results: Prevalence of metabolic syndrome was 33.9% (age 29–59 years; average BMI 26.1 ± 3.7) suggesting development of syndrome at younger age. While participants reported little LTPA, men were more active than women (total activity metabolic index (AMI) per week: 533 vs 204, respectively). In men, moderate activity was associated with a lower prevalence of metabolic syndrome, lower fasting glucose (r=−0.44), 2-hour glucose tolerance (r=−0.40), and lower serum triglyceride (r=−0.63). Only heavy activity was inversely associated with waist girth for both men (r=−0.46) and women (r=−0.41). Leisure activity levels reported by women were not significantly associated with any other risk factors. Low levels of physical activity were associated with prevalence of low high-density lipoprotein cholesterol (HDL-C), but reported LTPA levels were not significantly associated with favorable changes in serum HDL-C or blood pressure in both sexes.

Conclusion: We provide evidence that Asian Indians who are physically active have a more favorable metabolic syndrome risk factor profile. Results highlight need to encourage physical activity in Asian Indian immigrants, particularly women, to reduce prevalence of metabolic syndrome. (*Ethn Dis*. 2005;15:627–634)

Key Words: Asian Indian, Physical activity, Exercise, Metabolic Syndrome, Insulin resistance, Diabetes, Coronary heart disease

Introduction

High rates of prevalence and mortality from coronary artery disease (CAD) in Asian Indian immigrants have been consistently documented worldwide.[1] As a result, the Asian Indian immigrant population has been identified as an "at risk" special population in *Healthy People 2010*.[1] High risk of coronary heart disease[1–4] and type 2 diabetes[2,3,5–7] despite low body mass index (BMI) and absence of traditional risk factors in Asian Indians such as elevated low-density lipoprotein cholesterol (LDL-C) and total cholesterol[1,3,8,9] appear to have its basis in impaired glucose tolerance and insulin resistance associated with pronounced central or abdominal obesity,[3,6,10–12] features now identified as part of metabolic syndrome.[13] As a fast-growing Asian immigrant group in the United States,[14] the importance of effective prevention strategies to reduce risk of chronic disease in this population cannot be underestimated.

First-line therapy recognized in risk management of metabolic syndrome in the general population is weight reduction and increased physical activity.[13] At present much research investigating relationship of physical activity to metabolic syndrome has focused on middle-aged Caucasian men[15–17] in whom increased physical activity has been associated with decline in risk factors constituting metabolic syndrome. The relationship is similar in women across Caucasian, Native American, and African-American groups.[18] Although these studies establish the role of physical activity in treating metabolic syndrome, data on type and levels of activity associated with improvement in metabolic profile may not be extrapolated to Asian Indians, as they possess adverse risk factor profiles at waist circumference and BMI values lower than most other ethnic groups.[10,11,19–23]

Research efforts to examine existing physical activity patterns and their relationship to physiologic risk factors in Asian Indians are limited.[11,12,21,24] In a study of British residents, Dhawan et al[21] classified adults into sedentary and non-sedentary groups and concluded that British Asian Indians were more sedentary compared to Caucasian British and native Indians in India. Yagalla et al[24] performed a study of American physicians of Asian Indian origin and observed that 70% of physicians exercised for more than an hour per week, with the average exercise duration being 136 minutes/week. Additional studies are needed to describe the qualitative and quantitative attributes of physical activity patterns in the general Asian Indian population.[1]

The Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) have recommended that every US adult participate in at least 30 minutes of moderate-intensity activity on most, preferably all days of the week.[25]

From the Department of Exercise and Nutritional Sciences, San Diego State University, San Diego (KM, SE); in private practice, Monte Sereno (MA); California.

Address correspondence and reprint requests to Kiran B. Misra, PhD, RD; Department of Exercise and Nutritional Sciences, San Diego State University; 5500 Companile Drive; San Diego; CA 92182; 619-594-0813; 619-594-6553 (fax); kmisra@mail.sdsu.edu

We conducted a cross-sectional exploratory project to examine physical activity patterns of Asian Indian immigrants and to determine their relationship to physiologic risk factors associated with metabolic syndrome.

Due to lack of available data, it is unclear whether Asian Indians meet this recommendation and if meeting this recommendation has a favorable relationship with risk factors making up metabolic syndrome in this population. We conducted a cross-sectional exploratory project to examine physical activity patterns of Asian Indian immigrants and to determine their relationship to physiologic risk factors associated with metabolic syndrome.

METHODS

Study Participants

The San Diego State University Institutional Review Board approved this study, and all participants provided written informed consent after risks, benefits, and procedures were explained to them in accordance with institutional guidelines. Asian Indian immigrants residing in the San Francisco Bay Area were recruited via newspaper advertisement in a weekly West Coast Asian Indian Newspaper (*India West*) for a period of four weeks, through use of flyers posted at community centers, temples, doctors' offices, and community grocery stores, and by word of mouth. Free professional health counseling, but no monetary incentive, was offered for participation in the study. Participants were interviewed for health risks with a health risk screening questionnaire. This questionnaire was designed to screen adults with previously diagnosed coronary artery disease, liver disease, diabetes mellitus, and endocrine disorders and to identify individuals for whom physical activity may be inappropriate or those who should seek medical advice concerning type of activity most suitable for them. A total of 70 apparently healthy individuals were available for participation in the study. Following initial enrollment, eight dropped out due to time constraints, three dropped out for personal reasons, and two were noncompliant with the study protocol. Additionally, one subject was removed from the current analysis because of missing data. Based on available data, no apparent differences were seen between subjects who completed the study and those who dropped out. A total of 56 subjects were included in the present analysis (age range=29–59 years, men n=31, women n=25).

Physical Measurements

Demographic information and personal and family health history were obtained through use of an interviewer-administered questionnaire. Demographic information included gender, date of birth, place of origin, number of years in the United States, and type of occupation. Health history questions included checklist of personal and family history for medical problems including alcohol abuse and specific questions pertaining to smoking, alcohol consumption, and current medications.

All anthropometric and blood chemistry measures were taken in the morning after an overnight fast. Body height and weight were measured with a calibrated clinical scale and stadiometer by using standard procedures with shoes removed. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Waist was measured horizontally three times with the subject standing with feet together by using a flexible measuring tape without undue pressure. Waist girth was measured at the narrowest circumference between the lower costal margin and the iliac crest. A total of three waist measurements were taken to the nearest 0.1 cm. After voiding their bladders and resting for 5 minutes, subjects had blood pressure measurement taken with a random-zero mercury sphygmomanometer. Three measurements were taken at five-minute intervals with the arm supported at the heart level; mean systolic and diastolic blood pressures were calculated.

Blood Chemistry Measures

Venous blood samples were obtained by using standard venipuncture techniques to estimate fasting glucose, glucose 2 hours after a 75-g oral glucose tolerance test, triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C) . Samples were collected and analyzed by an independent certified clinical laboratory (Quest Diagnostics Inc, Teleboro, NJ). Serum TG was measured enzymatically after hydrolyzing to glycerol (Olympus AU 5400 analyzer, Olympus America Inc, Mellville, NY). Serum HDL-C and glucose concentration were assayed by standard enzymatic techniques using Olympus AU 5400.

Physical Activity Assessment

Leisure time physical activity (LTPA) was assessed with the Minnesota Leisure Activity (MLTPA) questionnaire.[26,27] The Minnesota LTPA questionnaire is an interviewer-administered questionnaire validated for use in studies examining relationship of physical activity to coronary heart disease in the North American population.[26] It has been validated against caloric intake-resting energy expenditure (r=0.17, no P value), duration of treadmill exercise (r=0.45, P<.05), treadmill peak oxygen consumption, VO_2 peak (r=0.47, P<.05), and percent body fat (r=−0.24, P<.05).[28] The reliability of the questionnaire has also been tested for one-month retest (r=0.88, P<.05) and one-year retest (r=0.92, P<.05).[28] A trained interviewer assessed duration and frequency of all LTPA each participant reported to have engaged in during the preceding 12-month period according to standardized procedures outlined by Taylor et al.[26] Leisure time activities were expressed as a score of activity metabolic index (AMI) using a Taylor Intensity Code reported for each activity listed on the questionnaire.[26] The AMI units participated in during the past year were calculated for light (Taylor Intensity 2.0, 2.5, 3.0, 3.5 and 4.0), moderate (Taylor Intensity 4.5, 5.0, 5.5), and heavy intensities (Taylor Intensity ≥6.0) according to the following formula: (Intensity code x duration x number of occasions/month x number of months/year) ÷ 52 wk/year=AMI/week.[26]

The Minnesota LTPA questionnaire is valid for use in most urban US populations and was used as presented by Taylor et al.[26] Since the list of activities on the questionnaire does not cover every American population, including immigrants from cultures outside North America,[26] additional recording space on the questionnaire was used to report leisure activities that were carried out but not listed. Few participants reported performing "additional" or "new" activities. The intensity or metabolic equivalents (MET) of these activities were obtained from the Compendium of Physical Activities.[29] These additional activities were playing cricket (Compendium code 15150, 5 METS), performing yoga (Compendium code 02100, 2.5 MET) and meditation (Compendium code 07075, 1.0 MET). The latter was not included in the analysis due to low MET intensity for MLTPA (Taylor codes ≥2.5).

Classification for Metabolic Syndrome

The NCEP ATP III criteria were used to identify metabolic syndrome. In addition, measurement of 2-hour postprandial glucose was used to uncover diagnosis of diabetes (2-hour glucose ≥200 mg/dL) or impaired glucose tolerance (2-hour glucose 140–199 mg/dL). Persons were classified as having metabolic syndrome if they met three of five of the following NCEP ATP III criteria modified to include 2-hour oral glucose tolerance test: waist girth >102 cm males, >88 cm females; fasting blood glucose ≥110 mg/dL and/or 2-hour blood glucose ≥140 mg/dL; HDL-C <40 mg/dL males, <50 mg/dL females; TG≥150 mg/dL; and systolic blood pressure ≥130 mm Hg and/or diastolic blood pressure ≥85 mm Hg or taking anti-hypertensive medications.

Statistical Analyses

All statistical analyses were performed by using SPSS, version 11.0 for Windows (SPSS Inc., Chicago, Ill.). Means and standard deviations were calculated for descriptive purposes. All variables for the metabolic syndrome were normally distributed. Due to significant physical inactivity, the LTPA data exhibited positive skewness and were log transformed as follows: log AMI=$\log_{10}$ (AMI/wk + 1). Subjects with and without the metabolic syndrome were compared for levels of physical activity with analysis of covariance (ANCOVA) based on age-adjusted data. All Pearson partial correlations were calculated while controlling for age; those involving blood pressure were controlled for age, use of antihypertensive medications, and self-reported alcohol abuse; partial correlations involving TG and HDL-C were controlled for age, use of lipid-lowering medication, and alcohol abuse; partial correlations for waist girth were controlled for age and alcohol abuse. One outlier that yielded a significant but physiologically inexplicable correlation was excluded from correlational analysis of TG with physical activity. All statistical analyses were conducted for the whole sample and by gender. P values are not provided because of the relatively smaller sample size for the various sub-groups.

RESULTS

Demographic data revealed that participants had been living in the United States an average of 13 years; 72% had emigrated from the Punjab province of Northern India, 8% from Gujarat, 12% from Maharashtra, and 8% from Kerala. All of the male and 75% of the female participants worked outside the home in a variety of different occupations, described mostly as sedentary in nature. Health history questionnaire revealed that 61% of men and none of the women reported consuming alcohol. Of the men, 16% reported alcohol abuse as a medical problem, while the rest reported alcohol consumption of three drinks or fewer per week. None of the women and 10% of the men reported past history of smoking. Only one man was a current smoker while all others reported having quit smoking one or more years ago.

On average, participants were middle aged (>40 years), had non-obese waist circumference (<102 cm for men, <88 cm for women), and had an average BMI close to normal (26.1 ± 3.7). Forty percent of men and nearly one third of women (28%) had metabolic syndrome as defined by the NCEP ATP III criteria (Table 1). Among physiologic variables, the most consistently prevalent risk factor in both men and women was low HDL-C levels. Other, more prevalent risk factors were hypertriglyceridemia and high blood pressure in men and high waist circumference in women (Table 1).

Types of activities reported by men and women in the study sample have been summarized in Table 2. Walking for pleasure or walking during work breaks was the most prevalent activity;

Table 1. Characteristics of study participants, reported in mean (SD) unless otherwise noted

	Total	Men	Women
Subjects, *N*	56	31	25
Number of years in United States	13.6 ± 7.7	14.2 ± 7.3	13 ± 8.1
Age (years)	43.4 ± 6.9	43.7 ± 7.1	43.1 ± 6.9
BMI (kg/m^2)	26.1 ± 3.7	25.9 ± 3.1	26.5 ± 4.3
Waist circumference (cm)	89.0 ± 10.5	93.2 ± 9.2	83.8 ± 9.8
Systolic BP (mm Hg)	123.4 ± 14.7	125.2 ± 12.9	121.3 ± 16.5
Diastolic BP (mm Hg)	75.1 ± 8.1	76.7 ± 8.8	73.3 ± 6.7
Fasting glucose (mg/dL)	91.5 ± 12.1	93.9 ± 12.4	88.4 ± 11.1
Two-hour glucose (mg/dL)	112.4 ± 46.3	110.6 ± 50.1	114.5 ± 42.0
Triglycerides (mg/dL)	147.1 ± 64.7	168.8 ± 73.7	121.9 ± 41.1
HDL-C (mg/dL)	44.0 ± 11.3	39.4 ± 8.1	49.7 ± 12.2
High fasting or 2-hr glucose* (%)	18	16	20
High waist circumference† (%)	32	23	44
Hypertriglyceridemia‡ (%)	45	61	24
Low HDL-C§ (%)	55	55	56
High blood pressure‖ (%)	42	50	32
Positive for metabolic syndrome¶ (%)	33.9	40	28

* Fasting glucose =110 mg/dL and/or postOGTT glucose =140 mg/dL.
† Waist circumference: males >102 cm, females >88 cm.
‡ Plasma TG =150 mg/dL.
§ Plasma HDL-C: males <40 mg/dL, females <50 mg/dL.
‖ Systolic BP =130 mm Hg or diastolic BP =85 mm Hg or taking antihypertensive medications.
¶ Meets at least three of the five criteria above (*, †, ‡, §, ‖).

40% of men and 32% of women reported walking for pleasure. Men were twice as active as women (total AMI/week: 533 vs 204, respectively). Nearly 40% of women reported no participation in LTPA compared to 10% of men. Both men and women more frequently reported home exercise (28%) than health club exercise (10.7%). With exception of cross-country hiking and mountain climbing, women did not report swimming or engaging in any sport for exercise. Men engaged in bicycling, swimming, hiking, playing tennis, volleyball, golf, cricket, and basketball. Men performed home repair and related activities, such as gardening, more frequently than women. Both men and women reported using stairs instead of an elevator more often than any other activity of heavy intensity.

Table 3 presents age-adjusted comparison of LTPA levels between subjects with and without metabolic syndrome. Light intensity physical activity was not associated with the prevalence of metabolic syndrome or risk factors for metabolic syndrome in either group or by gender. Men with metabolic syndrome reported a consistent pattern of less moderate and heavy activity compared to those without the syndrome. Women with metabolic syndrome reported higher moderate-level activity than those without the syndrome. No association was seen between other levels of LTPA and metabolic syndrome in women.

Correlations of AMI for LTPA with physiological indicators of metabolic syndrome are reported in Table 4. Significant negative correlations were observed between AMI from moderate intensity LTPA and serum fasting glucose ($r=-0.44$), 2-hour glucose ($r=-0.40$) and TG levels ($r=-0.63$) for men. A negative correlation of AMI from heavy intensity LTPA was observed with waist girth for men ($r=-0.46$) as well as women (r=−0.41). Light AMI correlated with lower HDL-C levels ($r=-0.39$). Although higher AMI in total physical activity showed a positive association with higher HDL-C levels for men, overall physical activity was not related to HDL-C.

DISCUSSION

Although higher prevalence of glucose intolerance, abdominal obesity, hyperinsulinemia, and hypertriglyceridemia as compared to Caucasians has been reported previously for Asian Indians,[22] at the present time no estimates of prevalence of metabolic syndrome as defined by NCEP ATP III criteria are available for the Indian-American population in the United States.

Prevalence of metabolic syndrome in Indian-American immigrants in our study was 33.9% at age 29–59 years (average BMI of 26.1 ± 3.7) and increased to 42% for those between 40–59 years (average BMI 26.8 ± 3.8). These findings are similar to those of Gupta et al,[30] who reported overall prevalence of 31.6% (age >20 years), 34.2% (30–59 years), and 40.2% (40–59 years) in their study conducted in India on 1091 adults by using NCEP ATP III criteria for defining metabolic syndrome. Our data suggest that prevalence of metabolic syndrome in Indian Americans was similar to rates reported in native Indians and higher than the national prevalence estimate of 20.8% for Asian Americans listed in the "other" category reported by Ford et al[31] from the third US National Health and Examination Survey (USNHANES III). As noted earlier,[32] the NHANES findings were underrepresentative of subgroups within the Asian American category. In another study conducted in India, Ramachandran et al[33] reported 41.1% prevalence for 475 urban Indian subjects (age 20–75 years, average BMI 25 ± 3.3 and 25.6 ± 4.7 for men and women, respectively). These higher prevalence rates could be attributed to the lower waist circumference criteria (men ≥95 cm; women ≥85 cm) employed in their study. Consistent with

Table 2. Physical activity patterns in study sample (% reporting at least some)

	Total (*N*=56)	Men (*N*=31)	Women (*N*=25)
LIGHT AMI*	204.3 ± 274.7	273.5 ± 322.5	118.4 ± 170.3
Intensity code 2.5			
-Yoga	7.1	6.5	8
Intensity code 3.0			
- Weight lifting	16.1	28.1	0
- Bowling	1.8	3.1	0
- Carpentry in workshop	1.8	3.1	0
Intensity code 3.5			
- Walking for pleasure	37.5	40.6	32
- Walking during work breaks	17.9	21.9	12
Intensity code 4.0			
- Bicycling to work or for pleasure	7.1	12.5	0
- Walking to and from work	1.8	0	4.0
- Volleyball	1.8	3.1	0
- Raking lawn	1.8	3.1	0
Average duration min/week*	59.0 ± 79.3	79.5 ± 93.2	33.6 ± 48.6
MODERATE AMI*	69.9 ± 141.1	88 ± 118.3	47.4 ± 164.9
Intensity code 4.5			
- Home exercise	28.6	37.5	20
- Use of treadmill (brisk walk at zero incline)	25	32.2	20
- Use of stationary bike	3.6	5.3	0
- Mowing lawn with motorized push	8.9	15.6	0
- Weeding and cultivating garden	5.4	9.4	0
- Inside home repairs such as painting	5.4	6.3	4.0
Intensity code 5.0			
- Spading and filling garden	7.1	9.4	4.0
- Cricket	1.8	3.1	0
- Golf, walking, and pulling club	1.8	3.1	0
Average duration min/week*	14.8 ± 30.8	18.3 ± 25.2	10.5 ± 36.6
Heavy AMI*	111.7 ± 211.4	180.1 ± 250	26.9 ± 103.4
Intensity code 6.0			
- Health club exercise	10.7	15.6	4.0
- Swimming at least 50 m in a pool	7.1	12.5	0
- Jog-walk combination	10.7	15.6	4.0
- Cross-country hiking	7.1	9.4	4.0
- Mowing lawn with non-motorized push	16.1	21.9	8.0
- Tennis doubles	5.4	9.4	0
- Basketball, non-game	1.8	3.1	0
Intensity code 7.0			
- Soccer	3.6	6.3	0
Intensity code 8.0			
- Taking stairs instead of elevator	19.6	21.9	16.0
- Running	3.6	6.3	0
- Tennis singles	3.6	6.3	0
- Mountain climbing	1.8	0	4.0
Average duration min/week*	17.5 ± 33.4	26.7 ± 36.0	6.1 ± 26.1
TOTAL AMI*	385.9 ± 408	533 ± 445.7	203.5 ± 265.5
Total activity average duration min/week*	91.3 ± 97.1	124.5 ± 107.8	50.2 ± 62.3

* Data expressed as mean ± SD.
AMI=activity metabolic index.

findings of Ramachandran et al[33] and of others reporting on clustering of risk factors,[6] insulin resistance,[10,11] coronary heart disease,[2,3,19,21] and diabetes[7,12] for Asian Indians living in the United Kingdom,[5] the United States,[4,11,23] and other countries[1,4,7,22] our results show increased prevalence of metabolic syndrome at BMI in the upper normal or slightly overweight range.

As evident from large standard deviations in LTPA (Table 2), reported variations in physical activity were high with as many as 50% reporting light or no leisure activity. Of the 23% who reported no leisure activity, 40% were women and 10% were men. The 2002 Behavioral Risk Factor Surveillance System trends data[34] reported 24.4% of adults nationwide (21% male; 27.2% female) and 22.7% in California (20.1% men; 25.3% female) did not participate in any leisure activity. Although the results from our sample were similar to the national average, significant disparities occurred when grouped by gender. Unlike in men, sedentary living was extremely common among Indian women. Analysis of physical activity patterns suggests men were more active and performed a relatively wider range of activities in each intensity category compared to women. Walking for pleasure or walking during work breaks was the most prevalent activity of light intensity. Treadmill use equivalent to "brisk walk" was the most frequently reported home exercise of moderate intensity by men and women in our sample (Table 2). Health club exercise, swimming, jogging/walking, mowing lawn with non-motorized push mower, and taking the stairs instead of elevator were activities of heavy intensity most frequently reported by men (Table 2). With the exception of swimming, women reported performing similar heavy activities as men, but percentage reporting and duration of time spent in each of those activities was consistently lower than men (Table 2).

Intensity and frequency are major contributors to fitness when busy schedules may preclude long periods of activity.[26] In the study by Yagalla et al[24] Asian Indian male physicians reported an average total leisure physical activity of 136 min/week, most frequently involving walking, jogging, playing golf, and tennis. The average per week duration of total leisure activities for men (125 ± 108 min/week) in our sample compared well with Yagalla et al.[24] However, intensity levels were not assessed in their study. Data from Table 2 indicate that the fraction

Table 3. LTPA levels in normal and metabolic syndrome groups (mean ± SD)

	No. of Subjects (*N*)	(–) Metabolic Syndrome	(+) Metabolic Syndrome
Log_{10} (Light AMI/week)			
Total	56	1.38 ± 1.17	1.57 ± 1.27
Men	31	1.59 ± 1.13	1.86 ± 1.19
Women	25	1.02 ± 1.19	1.08 ± 1.35
Log_{10} (Moderate AMI/week)			
Total	56	0.89 ± 1.07	0.67 ± 0.96
Men	31	1.30 ± 1.10	0.60 ± 0.95
Women	25	0.37 ± 0.80	0.80 ± 1.03
Log_{10} (Heavy AMI/week)			
Total	56	1.21 ± 1.14	0.41 ± 0.81
Men	31	1.80 ± 0.94	0.64 ± 0.96
Women	25	0.47 ± 0.87	0 ± 0
Log_{10} (Total AMI/week)			
Total	56	1.97 ± 1.14	1.81 ± 1.19
Men	31	2.34 ± 0.91	2.10 ± 1.07
Women	25	1.43 ± 1.23	1.32 ± 1.32

LTPA=leisure time physical activity; AMI=activity metabolic index.

of the total time spent in leisure activities of light intensity was 64% for men and 68% for women. An average weekly duration of 45 ± 48 minutes for men and 16 ± 44 minutes for women was spent in moderate-to-heavy intensity activities. This duration is below the current CDC and ACSM physical activity recommendation for all US adults of 30 min/day of moderate intensity physical activity on most days of week.[25] Our results highlight need for encouraging physical activity in Asian Indians, particularly among women.

Men and women with metabolic syndrome generally reported lower levels of physical activity (Table 3). The lack of difference in prevalence of metabolic syndrome in men and women reporting light physical activity was similar to results reported by Laaksonen et al,[16] who reported lower incidence of metabolic syndrome for physical activity of at least moderate intensity (≥4.5 METs). While light intensity physical activity is traditionally not associated with decreased incidence of cardiovascular disease, dyslipidemia, or insulin resistance, increased moderate and heavy intensity physical activity have been associated,[15–17,27,35] which explains lower incidence of metabolic syndrome among men of these activity levels in our study (Table 3). Similar results were not obtained for women, however. As evident in Table 2, the most frequently reported activity of moderate intensity by women was use of treadmill; the average reported frequency and duration of this and other less frequently reported activities of moderate intensity appear to be insufficient to treat metabolic syndrome in this group.

Physical activity is thought to increase insulin sensitivity directly by enhancing glucose uptake by muscle and indirectly by decreasing central and general adiposity.[35,36] For men, moder-

Table 4. Pearson partial correlations of log_{10} (AMI/week) with physiological indicators of metabolic syndrome (*r*)

	Fasting Glucose* (mg/dL)	2-hour Glucose* (mg/dL)	Waist Girth† (cm)	TG‡ (mg/dL)	HDL-C‡ (mg/dL)	SBP§ (mm Hg)	DBP§ (mm Hg)
Log_{10} (Light AMI/week)							
Total	0.08	−0.05	0.12	0.10	−0.39	0.18	0.16
Men	0.14	0.01	0.01	0.04	−0.31	0.15	0.15
Women	−0.15	0.01	−0.05	−0.01	−0.28	0.09	0.07
Log_{10} (Moderate AMI/week)							
Total	−0.16	−0.20	0.21	−0.15	−0.16	0.06	0.10
Men	−0.44	−0.40	−0.05	−0.63	0.13	0.05	−0.01
Women	0.04	−0.04	0.29	0.32	−0.21	0.11	0.20
Log_{10} (Heavy AMI/week)							
Total	−0.05	−0.15	−0.06	−0.02	−0.18	0.18	0.19
Men	−0.24	−0.02	−0.46	−0.33	0.37	0.11	0.11
Women	−0.16	−0.27	−0.41	−0.02	−0.01	0.03	0.10
Log_{10} (Total AMI/week)							
Total	−0.12	−0.20	0.08	0.08	−0.35	0.08	0.12
Men	−0.30	−0.31	−0.18	−0.28	−0.11	−0.07	−0.07
Women	−0.20	−0.12	−0.12	−0.04	−0.24	0.09	0.21

* Adjusted for age.
† Adjusted for age and alcohol abuse.
‡ Adjusted for age, cholesterol medication, and alcohol abuse.
§ Adjusted for age, blood pressure medication, and alcohol abuse.

Low physical activity levels for the total sample in our study were similar to those seen in national estimates,[34] while prevalence of metabolic syndrome was higher than national average.[31]

ate intensity activity averaging 18–20 min per week (Table 2) was associated with factors related to insulin sensitivity such as fasting glucose, 2-hour glucose, and serum triglyceride levels (Table 4). Similar associations were not evident in women because of the smaller proportion of active women. Among cardiovascular risk factors, light activity was inversely associated with HDL-C levels (Table 4). Further analysis indicated that HDL-C concentrations were lower among men and women over a range of reported activities of light intensity compared with moderate and heavy physical activity. For men, this finding was indicated by a notable shift toward increasing physical activity, but no meaningful conclusions could be drawn for women because of low levels of activity reported by women. These findings demonstrate that low levels of physical activity may contribute to greater prevalence of lower HDL-C levels among Asian Indians.

Prevalence of abdominal obesity is a significant health concern among Asian Indians. High waist circumference (>88 cm) was the most prevalent risk factor for metabolic syndrome among women in this study. Increased abdominal obesity may have resulted from changes associated with premature menopause or transition to menopause.[8] Postmenopausal status, however, is not a plausible explanation as all correlations were adjusted for age, and most (88%) women were below age 50. Individually, waist data correlated inversely with heavy AMI for both male and female participants (Table 4). When combined, the waist data did not show a correlation. Further analysis revealed that males on an average had higher absolute waist circumference values and there was a greater proportion of sedentary females with a wider spread in waist circumference. Consequently, when two sets of data were combined, resultant data did not show any correlation. However, a point worth noting is that heavy activity was necessary for lower waist circumference in Asian-Indian men and women.

CONCLUSION

Although the cross-sectional nature of our study precludes assumption of causality, this study has strengths that contribute to the understanding of physical activity and metabolic syndrome in Asian Indians. In this study we considered the intensity and duration of leisure physical activity in Asian-Indian immigrants to examine their potential relationship to physiologic factors associated with metabolic syndrome. Low physical activity levels for the total sample in our study were similar to those seen in national estimates,[34] while prevalence of metabolic syndrome was higher than national average.[31] Low activity and high prevalence of metabolic syndrome noted at a younger age in this study clearly demonstrate the need to initiate preventive efforts early on and encourage more physical activity among Asian-Indian immigrants in the United States. A strong tendency toward central obesity observed in Asian Indians requires a high level of physical activity to treat metabolic syndrome. Studies with larger sample sizes examining the association between different types of physical activity and metabolic syndrome among Asian Indians are necessary to confirm the results of this descriptive study.

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AUTHOR CONTRIBUTIONS

Design and concept of study: Misra, Ayer
Acquisition of data: Misra, Ayer
Data analysis and interpretation: Misra, Endemann
Manuscript draft: Misra
Statistical expertise: Endemann
Acquisition of funding: Misra
Administrative, technical, or material assistance: Misra, Endemann, Ayer
Supervision: Misra