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Author manuscript
Prev Med. Author manuscript; available in PMC 2016 August 01.

Published in final edited form as:
Prev Med. 2015 August ; 77: 137–140. doi:10.1016/j.ypmed.2015.05.010.

The Association of C-Reactive Protein and Physical Activity Among a Church-Based Population of African Americans

Swann Arp Adams, PhD,
College of Nursing and the Department of Epidemiology and Biostatistics, Cancer Prevention and Control Program, University of South Carolina, Columbia, SC 29208, Phone: 803.576.5620, Fax: 803.576.5624

Michael D. Wirth, MSPH, PhD,
Department of Epidemiology and Biostatistics, Cancer Prevention and Control Program, University of South Carolina, Columbia, SC 29208, Phone: 803.576.5646, Fax: 803.576.5624

Samira Khan, MSW,
Cancer Prevention and Control Program, University of South Carolina, Columbia, SC 29207, Phone: 803.576.5616, Fax: 803.576.5624

E. Angela Murphy, PhD,
Department of Pathology, Microbiology and Immunology, School of Medicine, University of South Carolina, Columbia, SC 29209, Phone: 803.216.3414, Fax: 803.216.3413

Sue P. Heiney, PhD, RN, FAAN,
College of Nursing, University of South Carolina, Phone: 1-803-777-8214, Fax: 803.576.5624

Lisa C. Davis, M.Ed,
Cancer Prevention and Control Program, University of South Carolina, Columbia, SC 29208, Phone: 803.576.5613, Fax: 803.576.5624

Briana Davis, MPH,
Cancer Prevention and Control Program, University of South Carolina, Columbia, SC 29208, Phone: 803.576.5648, Fax: 803.576.5669

Ruby F. Drayton, MBA,
Cancer Prevention and Control Program, University of South Carolina, Columbia, SC 29208, Phone: 803.576.5669, Fax: 803.576.5669

Corresponding author: Swann Arp Adams, PhD, College of Nursing and the Department of Epidemiology and Biostatistics, Cancer Prevention and Control Program, University of South Carolina, Columbia, SC 29208, swann.adams@sc.edu, Phone: 803.576.5620, Fax: 803.576.5624.

Trial Registration Identifier: NCT01412203 (www.ClinicalTrials.gov)

Conflicts of Interest:
Steven N. Blair serves on the scientific advisory boards of Technogym, Clarity, and Santech. He has received research funding from Coca-Cola Company, BodyMedia, Technogym, the U.S. Department of Defense, and the National Institutes of Health. He receives book royalties from Human Kinetics.

Thomas G. Hurley, MS,
Cancer Prevention and Control Program, University of South Carolina, Columbia, SC 29208, Phone: 803.576.5621, Fax: 803.576.5624

Steven M. Blair, PED, and
Departments of Exercise Science and Epidemiology/Biostatistics, Arnold School of Public Health, University of South Carolina, 921 Assembly Street, Columbia, SC 29208, Phone: 803 777 0567, Fax: 803 777 2504

James R. Hébert, MSPH, ScD
Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Director, Statewide Cancer Prevention & Control Program, Arnold School of Public Health, University of South Carolina, Contact: Cancer Prevention and Control Program, 915 Greene Street, Suite 241-2, Columbia, SC 29208, Telephone: (803) 576-5666, Fax: (803) 576-5612/803-576-5624

Swann Arp Adams: swann.adams@sc.edu; Michael D. Wirth: wirthm@mailbox.sc.edu; Samira Khan: khans@mailbox.sc.edu; E. Angela Murphy: angela.murphy@uscmed.sc.edu; Sue P. Heiney: heineys@mailbox.sc.edu; Lisa C. Davis: ldavis@mailbox.sc.edu; Briana Davis: BRIANAD@mailbox.sc.edu; Ruby F. Drayton: draytonr@mailbox.sc.edu; Thomas G. Hurley: thurley@mailbox.sc.edu; Steven M. Blair: sblair@mailbox.sc.edu; James R. Hébert: jhebert@sc.edu

Abstract

Objective—Regular physical activity can reduce systemic inflammation and, thereby, the burden of chronic inflammatory-related conditions. This study examined whether regular physical activity, measured subjectively (Rapid Assessment of Physical Activity [RAPA]) and objectively (Bodymedia's SenseWear® activity monitor [SWA]), is associated with inflammatory or glycemic control markers.

Methods—Subjects were 345 participants of the Healthy Eating and Active Living in the Spirit (HEALS) lifestyle intervention among African-American (AA) churches in South Carolina in 2009. Linear regression analyses were performed to assess the relationship between both subjectively- and objectively- measured physical activity and inflammatory markers including high sensitivity c-reactive protein (CRP), interleukin-6 (IL-6), and glycosylated hemoglobin (HbA1c).

Results—Those who participated in regular physical activity (RAPA) had lower CRP values compared to those who were sedentary (2.3 vs. 3.8 mg/L, $p<0.01$). Lower levels of CRP or IL-6 were observed among those in the highest quartile of active energy expenditure (CRP: 2.0 vs. 3.6 mg/L, $p=0.01$) or moderate-vigorous physical activity minutes (CRP=1.7 vs. 4.5 mg/L, $p<0.01$; IL-6=1.5 vs. 2.1 pg/mL, $p=0.01$) compared to their lowest respective quartiles as measured by the SWA.

Conclusion—Physical activity may improve chronic inflammation, which is a primary pathophysiological mechanism for numerous chronic disorders, especially among minority populations.

Keywords

physical activity; inflammation; African American; c-reactive protein

INTRODUCTION

Physical activity is associated with decreased risk of chronic diseases including several cancers, cardiovascular disease, stroke, and diabetes.[1] Inflammation has been associated with many of the same chronic diseases.[2,3] Consequently, it has been postulated that inflammation may mediate the association between physical activity and chronic diseases.[4,5] Previous studies have shown that physical activity contributes to anti-inflammatory effects.

Racial-ethnic health disparities in the United States have been well-recognized, especially for African Americans (AA). AAs have higher prevalence of obesity and certain cancers,[6,7] higher levels of inflammation,[8–10] and less engagement in physical activity compared to European Americans (EA).[11] Given that less physical activity among AAs may link elevated inflammatory levels and high morbidity of chronic diseases, there is a lack of studies regarding physical activity and inflammation among AA populations. We hypothesized that greater levels of physical activity would be associated with lower levels of inflammation or glycosylated hemoglobin among AAs.

METHODS

Study Overview

The Healthy Eating and Active Living in the Spirit (HEALS) intervention (2009–2012) aimed to improve diet, increase physical activity, and reduce stress. HEALS was designed using principles of community-based participatory research and included a year-long healthy diet and physical activity program combined with stress reduction. Participant's eligibility was based on age, and absence of cancer diagnosis or unstable co-morbidities that might limit participation.[12] Additional details about the intervention and all data collection protocols can be found elsewhere.[12] Research protocols were approved by the Institutional Review Board of the University of South Carolina.[12]

Data Collection

Only baseline data were included for these analyses. Demographic, lifestyle factors, and health history data were collected using questionnaires. Prior to the clinic visit, participants were mailed questionnaire packets, which included the Rapid Assessment of Physical Activity (RAPA), a nine-item questionnaire assessing levels of physical activity.[13] Physical activity measured by RAPA was categorized as 'Sedentary or Infrequent', '< Recommended Activity' (i.e., regular physical activity but <150 minutes of moderate-vigorous physical activity [MVPA] per week), and '≥ Recommended Activity' (i.e., ≥ 150 minutes of MVPA per week, based on the World Health Organization [WHO] recommendations).[14]

Anthropometric and laboratory-derived data

During the clinic visits, height, hip and waist circumference, weight and percent body fat (obtained via bioelectrical impedance assessment using the Tanita TBF-300WA Body Composition Analyzer), were obtained.[12] Participants' blood samples were collected to analyze inflammatory or glycemic control markers [high-sensitivity c-reactive protein (CRP), interleukin-6 (IL-6), and glycosylated hemoglobin (HbA1c percent)]. All samples were run in duplicate (CRP: CV=3.9%, sensitivity = 0.022ng/ml; IL-6: CV=3.7%, sensitivity = 0.110ρg/ml.

Objectively measured physical activity data

Participants were provided Bodymedia's SenseWear® armband monitors (SWA) which uses tri-axial accelerometry technology augmented by 2 heat sensors. The monitors provide valid assessments of energy expenditure and various levels of physical activity.[15,16] Participants were required to wear the monitors for seven days to ensure at least four days of adequate data (i.e., a minimum of twenty hours of 'accounted-for data' based on SWA usage and sleep and wake times from the Pittsburg Sleep Quality Index).[17] We utilized active energy expenditure and MVPA minutes (summarized by SWA software based on metabolic equivalents ≥3.0) categorized into quartiles for this analysis.

Statistical Analyses

Analyses were performed using SAS 9.3 (SAS Institute, Cary, NC)®. Descriptive statistics were computed using frequencies or means ± standard deviations. Due to the non-normal distribution of model residuals for CRP, IL-6 and HbA1c percent analyses; those were log-transformed and least square means were back-transformed for interpretation. General linear models computed least square means of each outcome among the physical activity measures. A backward variable selection procedure was used to develop the final models. The selected confounders for each model were indicated as footnotes in the tables.

RESULTS

A total of 345 subjects had at least one outcome and physical activity measure. Whereas 340 had RAPA responses, only 212 have evaluable physical activity from the SWA. This primarily older population (mean age: 54.8±11.4) was mostly women (79%), married (60%), employed full time (53%), and had a minimum of a high school education (82%). About 45% of the study population reported participating in ≥150 minutes of MVPA per week according to the RAPA. However, the population was, on average, obese (mean BMI: 33.5±7.5) (Table 1).

CRP was statistically significantly lower among those who met recommended physical activity levels compared to those who were sedentary as measured by the RAPA (2.3 vs. 3.8 mg/L, respectively, p<0.01). HbA1c percent between those who met recommended activities levels was lower than those who did not. The highest quartile of active energy expenditure had significantly lower CRP levels compared to those in the lowest energy expenditure quartile (2.0 vs. 3.6 mg/L, respectively, p=0.01). The highest quartile of MVPA minutes compared to the lowest quartile showed differences in both CRP and IL6 (CRP=1.7 vs. 4.5 mg/L, respectively, p<0.01; IL-6=1.5 vs. 2.1 pg/mL, respectively, p=0.01, Table 2).

DISCUSSION

We observed significantly lower CRP and IL-6 in subjects with higher levels of physical activity among AA men and women. Individuals who were exercising at moderate or vigorous intensity levels for >60 minutes per day had a 62% lower CRP and a 29% lower

IL-6 compared to those that were exercising <21 minutes per day. We noted those who exercised at recommended physical activity levels, according to WHO recommendations, had a 3% lower HbA1C compared to those who were sedentary or infrequent exercisers.

The results of this study are consistent with previous studies demonstrating an inverse association between physical activity and inflammatory indices in a variety of populations.[18] Results in the current study were significant after adjustment for factors associated with chronic inflammation including obesity, comorbid conditions, smoking status, alcohol consumption, and shift work. It suggests that physical activity may reduce risk of elevated inflammatory markers in people who are at risk of chronic inflammation.

This is one of the first reports of physical activity and inflammatory markers in a population of AAs who are more likely to suffer from several chronic diseases (e.g., diabetes, cardiovascular disease, and cancer) with strong links to chronic inflammation than other racial-ethnic groups. Similarly, it is worth noting that we found higher levels of inflammatory markers than have been noted in past populations.[19] As with any cross-sectional epidemiological investigation, the results of this study do not necessarily reflect the direction of the causality between physical activity and inflammatory indices. Since we measured physical activity at a single point in time, it may not be an accurate depiction of longitudinal activity habits. We had a relatively high rate of “non-compliance” with the objective measure of physical activity, thus this may have introduced some bias into findings. We found that many participants “forgot” to put on the monitor after taking it off for sleeping. Post hoc analyses indicated that those who were compliant with the armband protocols had a significantly lower BMI [mean BMI (kg/m^2: compliant = 32.8; non-compliant = 34.5, p=0.03), compared to those who were not. However, self-reported physical activity did not differ by those who were and were not compliant for the armband protocols. Self-reporting bias also may affect findings of physical activities measured by RAPA. Our study population consisted predominately of women (79%) and so we were not able to explicitly examine any gender differences in either physical activity or biomarker response; however, we determined gender did not confound our associations. In addition, our study population was obese on average; thus their CRP level and its relationship with physical activity may differ from the general population. Consequently, our findings may have limited generalizability beyond obese women. The CPR level measured might be influenced by the participants’ recent sickness or involvement high-intensity of exercises on the day of blood measurement, which we did not ask about.

A relatively large sample size enabled us to have greater power to examine differences in our exercising and non-exercising participants. In addition, the fact that we had evidence for an association with both self-report and objective measures of physical activities adds greater credence to this potential causal pathway.

In conclusion, our work points to a promising potential benefit of physical activity on chronic inflammation, which has the potential to influence numerous chronic diseases in a population that bears an unequal burden of these diseases. Future work is needed to further our understanding of these mechanisms as well as culturally sensitive and appropriate public health interventions which can lead to change in physical activity behaviors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Financial Support

Funding was provided by the National Cancer Institute, National Institute on Minority Health and Health Disparities (NIMHD) [**R24 MD002769** Hebert, JR (PI)]. Dr. Hébert was supported by an Established Investigator Award in Cancer Prevention and Control from the Cancer Training Branch of the National Cancer Institute (K05 CA136975) and a grant to the South Carolina Cancer Disparities Community Network from the Center to Reduce Cancer Health Disparities of the National Cancer Institute (U54 CA153461).. Dr. Wirth's participation was partially supported through an ASPIRE-II Grant from the University of South Carolina Office of Research and by the South Carolina Cancer Prevention and Control Research Network funded under Cooperative Agreement Number 3U48DP001936-01 from the Centers for Disease Control and Prevention and the National Cancer Institute. Dr. Murphy was supported by a Career Development Award from the National Center for Complementary and Alternative

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Highlights

- People participating in regular physical activity had lower c-reactive protein.
- People participating in regular physical activity levels had lower HbA1c values.
- Physical activity may reduce chronic inflammation among African Americans.

Table 1

Descriptive statistics of study population at baseline

Characteristic	Frequency (%) or Mean ± STD (n = 345)
Age	
Mean ± STD	54.8 ± 11.4
Sex	
Female	275 (79%)
Male	712 (21%)
Marital Status	
Married or living w/partner	199 (60%)
Widowed	33 (10%)
Divorced or separated	57 (17%)
Single, never married	45 (13%)
Education Status	
High school or less	61 (18%)
Some college	116 (35%)
Complete college	85 (26%)
Postgraduate	71 (21%)
Employment Status	
Full time	176 (53%)
Part time	28 (8%)
Retired	103 (31%)
Not employed	28 (8%)
Perceived Health	
Excellent or very good	115 (34%)
Good	168 (50%)
Fair or poor	51 (15%)
Smoking Status	
Current or Former	64 (19%)
Never	282 (82%)
Alcohol Use	
Current	118 (35%)
Former	110 (33%)
Never	108 (32%)
Years of Night Shift Work	
None	114 (34%)
1 – 6 years	112 (34%)
>6 years	105 (32%)
Physical Activity Level[a]	
Sedentary or Infrequent	99 (29%)
< Recommended activity	87 (26%)
≥ Recommended activity	154 (45%)

Characteristic	Frequency (%) or Mean ± STD (n = 345)
Number of Inflammatory Conditions	
0	272 (82%)
>0	61 (18%)
Number of Chronic Conditions	
None	56 (17%)
1	96 (29%)
2	96 (29%)
3	53 (16%)
>3	33 (10%)
Body Mass Index	
Mean ± STD	33.5 ± 7.5
Waist-to-Hip Ratio	
Mean ± STD	0.87 ± 0.09

Column percents may not equal 100 due to rounding. Frequencies my not equal population total due to missing data.

[a]Based on recommendation of at least 30 minutes of moderate to intense physical activity 5 days a week or more; measured using Rapid Assessment of Physical Activity (RAPA)

Table 2

Mean inflammatory marker levels by physical activity

PA Characteristic	CRP (mg/L)	p-value	MCP-1 (pg/mL)	p-value	IL-6 (pg/mL)	p-value	HbA1c %	p-value
RAPA								
Sedentary or Infrequent	3.8 (2.9–5.0)		201 (189–212)		1.9 (1.7–2.1)		6.5 (6.3–6.7)	
< Recommended Activity	3.5 (2.6–4.7)		202 (188–215)		2.1 (1.8–2.4)		6.3 (6.1–6.5)	
≥ Recommended Activity	2.3 (1.8–2.9)	<0.01	196 (185–207)	0.53	1.7 (1.6–1.9)	0.32	6.3 (6.1–6.4)	0.05[a]
Active Energy Expenditure								
Quartile 1: 0–122 kcal	3.6 (2.6–5.0)		205 (185–225)		1.9 (1.6–2.3)		6.4 (6.1–6.7)	
Quartile 2: 123–203 kcal	2.6 (1.9–3.6)		229 (209–249)		1.7 (1.4–2.0)		6.4 (6.0–6.7)	
Quartile 3: 204–343 kcal	3.4 (2.4–4.7)		212 (193–232)		1.9 (1.6–2.3)		6.4 (6.1–6.7)	
Quartile 4: >343 kcal	2.0 (1.4–2.8)	0.01	215 (196–234)	0.40	1.5 (1.3–1.8)	0.05	6.2 (6.0–6.5)	0.41
MVPA minutes								
Quartile 1: 0–21	4.5 (3.1–6.5)		199 (181–218)		2.1 (1.8–2.5)		6.6 (6.3–6.9)	
Quartile 2: 22–38	2.6 (1.8–3.6)		213 (195–231)		1.8 (1.5–2.1)		6.5 (6.2–6.8)	
Quartile 3: 39–59	2.6 (1.9–3.7)		212 (205–240)		1.9 (1.6–2.2)		6.4 (6.1–6.7)	
Quartile 4: >60	1.7 (1.2–2.4)	<0.01	201 (183–218)	0.91	1.5 (1.2–1.8)	0.01	6.3 (6.0–6.6)	0.17

Values for CRP, IL-6 and HbA1c % were log-transformed and least square means were back-transformed for presentation. P-values represent differences between the extremes (i.e. 'Sedentary or Light' vs. 'PA at recommendation' and 'Quartile 1' vs. 'Quartile 4'). RAPA classification based on recommendation of at least 30 minutes of moderate to intense physical activity 5 days a week or more.

Adjustments for RAPA: CRP = employment status, marital status, and WHR; MCP-1 = employment status, education level, age, and WHR; IL-6 = education level and night shift work; HbA1c Percent = number of chronic diseases, age, and WHR. **Adjustments for Active Energy Expenditure**: CRP = perceived health; MCP-1 = gender, employment status, alcohol consumption, smoking status, education level, number of chronic diseases, and WHR; IL-6 = education level, number of chronic diseases, and night shift work; HbA1c Percent = gender, number of chronic diseases, and WHR. **Adjustment for MVPA minutes**: CRP = employment status; MCP-1 = gender, smoking status, education level, number of chronic diseases, night shift work age, and WHR; IL-6 = number of chronic diseases and night shift work; HbA1c Percent = gender, perceived health, number of chronic diseases, and WHR. **Abbreviations:** PA = physical activity; RAPA = Rapid Assessment for Physical Activity; CRP = c-reactive protein; MCP = monocyte chemotactic protein; IL = interleukin; MVPA = moderate-vigorous physical activity.