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The Effects of Daily Weather on Accelerometer-measured Physical Activity among Adults with Arthritis

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Abstract

Background—This study analyzes Chicago-area weather effects on objectively measured physical activity over a three year period among a cohort of 241 participants in an on-going arthritis physical activity trial.

Methods—Uniaxial accelerometer counts and interview data were analyzed for up to six weekly study waves involving 4823 days of wear. The effects of temperature, rainfall, snowfall and daylight hours were analyzed after controlling for participant characteristics, day of the week, and daily accelerometer wear hours in a mixed effects linear regression model.

Results—Daylight hours, mean daily temperature <20 or ≥ 75 degrees and light or heavy rainfall (but not snowfall) were all significantly associated with lower physical activity after controlling for the significant effects of weekends, accelerometer wear hours, age, sex, type of arthritis, employment, Hispanic ethnicity, obesity, and SF36 physical and mental health scores.

Conclusions—The cumulative effects of weather are reflected in a 38.3% mean monthly difference in daily counts between November and June, reflecting over three additional hours of sedentary time. Physical activity promotion programs for older persons with chronic conditions need lifestyle physical activity plans adapted to weather extremes.

Keywords

accelerometry; arthritis; physical activity measurement; meteorology

Seasonal variation in physical activity has been frequently described.[1] Reports from the U.S. Midwest, based on self-reported leisure time physical activity (LTPA), have shown an approximate 10–20% winter versus summer seasonal difference in physical activity rates.[2] Population-based surveys indicate that higher seasonal LTPA is associated with a greater number of self-reported physical activities[2] and that duration of exercise bouts is longest for outdoor activities.[3] It is not known whether older individuals with arthritis or other functionally limiting health conditions are as sensitive to inclement weather as younger, healthier individuals or children used to regular outdoor exercise. However, given the crucial importance of regular physical activity for maintaining functional status for the elderly and disabled, even modest reductions in activity can have clinically serious consequences.[4–6]

One major deficiency in prior population-based data on arthritis and physical activity,[7] as well as much of the older data on changes in physical activity levels after self-management and exercise interventions,[8] is that results have been largely based on activity questionnaire recall methods. Extrapolating LTPA rates from self-reported weekly exercise may ignore important aspects of work or transportation-related physical activity,[9] while significantly overestimating actual rates of moderate and vigorous physical activity among older adults.[10] Accelerometer measures of physical activity offer a better opportunity for developing more

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realistic models of environmental correlates of physical activity. In particular, accelerometer data better capture light intensity activity among older U.S. adults, for whom vigorous activity is rare and walking remains the most common form of LTPA.[2] In addition, accelerometer measures obtained over a three year period allow us to model the effects of specific daily weather conditions above and beyond longer-term seasonal variations.

The focus of this report, which is based on a study of several hundred Chicago residents with arthritis enrolled in a physical activity promotion study, is the effect of daily weather conditions on accelerometer-measured physical activity. In what is the largest study of its kind that we are aware of, we present data on over 4800 days of observation obtained from participants across the first three years of the study. Our analysis examines the effects of daylight hours, temperature, precipitation in inches, and snowfall, both before and after controlling for participants' sociodemographic, health status and behavioral risk factors. The study is unique in presenting longitudinal physical activity data for participants with arthritis who wore accelerometers while exposed to multiple weather conditions over a three year period.

Methods

The Improving Motivation for Physical Activity in Persons with Arthritis Clinical Trial(IMPAACT)

Study participants were enrolled in the on-going IMPAACT study, a randomized trial of lifestyle physical activity promotion. The study was approved by the Northwestern University Institutional Review Board and written informed consent was obtained from all participants. All participants were enrolled after either x-ray documented knee osteoarthritis or a rheumatoid arthritis diagnosis, with no history of joint replacement surgery within a year. After obtaining informed consent, participants were randomized to receive either the IMPAACT intervention, a tailored physical activity counseling program in addition to a brief physician encounter promoting physical activity, or a control intervention consisting only of the physician advice to increase physical activity. All participants, regardless of trial assignment, agreed to a baseline and five follow-up telephone interviews at three, six, 18 and 24 months, as well as a week of accelerometer wear coinciding with each of these study waves. This report is based on data pooled across up to six follow-up waves reflecting accrual over a three year period, from May 2006 when the first subject was enrolled, to May 2009, when 241 participants had at least baseline data.

Accelerometer Measures and Procedures

Physical activity was monitored in all study participants using a GT1M Actigraph accelerometer. The GT1M Actigraph is a small uniaxial accelerometer that measures vertical acceleration and deceleration. The acceleration signal is filtered and digitized by an 8-bit analog-digital (A-D) converter at 30 samples per second, portioning the dynamic range of the signal into 256 distinct levels. Total activity counts measure both the frequency and the magnitude of the accelerations, with output displayed as vertical movements per one minute epochs. The validity and reliability of Actigraph accelerometers under field conditions have been established in multiple populations including persons with arthritis.[11–15]

Participants were trained to wear the accelerometer at a baseline visit and subsequently mailed the device at each study wave, coinciding with study telephone interviews. Participants were instructed to wear the accelerometer upon arising in the morning, and wear continuously (except for water activities) until going to bed at night for seven consecutive days. The unit was worn on a belt at the natural waistline on the right hip in line with the right axilla. Participants also maintained a daily time sheet to record when the accelerometer was put on in the morning and removed at night.

Total daily accelerometer counts is the dependent variable we use to estimate the effect of daily weather on physical activity. Mean daily total activity counts represents the summed activity counts for all wear hours following the National Cancer Institute accelerometer algorithm (http://riskfactor.cancer.gov/tools/nhanes_pam) developed for the landmark physical activity study from the National Health and Nutritional Examination Survey (NHANES).[10] The magnitude of each one minute count can also be used to describe activity as either light, moderate or vigorous in intensity, using the following thresholds: 1–2019 light exertion, 2020–5998 moderate exertion or >5999 counts vigorous exertion.[10] In our study data, there was a strong correlation of r=0.82 between total daily counts and daily minutes of moderate or vigorous activity computed according to these thresholds. This study focuses on analyzing total daily activity counts so as to include activity of all intensities. However, we also present results for associations between weather and daily minutes of moderate or vigorous activity.

One challenge of uniaxial accelerometry is to distinguish non-wear periods, when a subject may have taken off the accelerometer, from very low counts due to sedentary activity.[16] To distinguish non-wear time from sedentary activity, a rolling window algorithm (i.e., starting from the beginning of each day, scanning each minute and beginning a potential nonwear period when a zero activity count is found) was used to identify non-wear periods. To reflect the very high prevalence of sedentary activity among older adults with chronic joint problems in our sample, a non-wear period was identified by an interval of at least 90 minutes of zero activity counts that contained no more than two minutes of counts between 0 and 100. A non-wear period was ended with either a third minute of activity counts greater than zero or a one minute activity count greater than 100. This approach was a slight modification of the 60 minute non-wear period used for the NHANES population data on U.S. children and adults. Daily wear hours were calculated by subtracting non-wear time from the 24 hour period, a valid day was defined by 10 or more hours of wear time. A total of 339 days (6.5%) were thus excluded from the analysis because daily wear times were less than 10 hours.

Because total daily accelerometer counts reflect the number of hours (>10) the participant chose to wear the accelerometer before taking it off at night, we control for differences in daily wear hours in multivariable analysis. We also include an indicator for whether a wear day was a weekend day versus a weekday. Finally, study findings reflect accelerometer measures obtained exclusively from the Chicago area; data were excluded for six weekly observations with accelerometer measures obtained while participants were on vacation in Florida or Arizona.

Telephone Interview Measures

Sociodemographic data were obtained from baseline in-person interviews and up to five subsequent follow-up telephone interviews with each IMPAACT participant. Fixed participant characteristics included age (four categories), sex, race and ethnicity (white/other, African American or Hispanic), educational level (high school graduate, GED certificate, or less, some college, or college graduate). Time-varying measures, based on self-report at each interview wave, included whether the participant was currently employed full or part time as well as behavioral risk factor questions including current smoking, whether the participant reported drinking alcohol `regularly', and body mass index (BMI) based on self-reported height and weight and computed into four categories: underweight (<=18.5), normal (>18.5 and <=24.9), overweight (>24.9 and <=29.9) or obese (=>30). The SF 36 Health Status Survey was used to compute time-varying 0–100 summary component scores for physical (PCS) and mental (MCS) health status. The SF 36 component scores are based on 50 as a population-based norm with each 10 points above or below reflecting one standard deviation from the norm mean.[17]

Daily Weather Measures

Daily **w**eather data over the three year study period were obtained from the National Weather Service for Chicago (http://mcc.sws.uiuc.edu/prod_serv/prodserv.htm); these data included daily mean temperature, precipitation in inches, and snowfall in inches. Snowfall is the amount of snowfall and ice pellets that have accumulated in the 24 hours prior to the observation time, measured in inches and tenths. Precipitation is the amount of rainfall, or the amount of liquid that has accumulated in the 24 hours prior to the observation, measured in inches. Naval Observatory Data (http://www.usno.navy.mil) on sunset and sunrise times were used to obtain the number of daylight hours for each day across the three year study period.

Mean daily temperatures were used to empirically characterize study days as `cold' based on a mean temperature of less than 20 degrees Fahrenheit. These days often included highs in the 20s or 30s and represent approximately 11% of sample days. `Hot' days were characterized by a mean temperature greater than or equal to 75 degrees (including some days with lows in the 60s, only 7.7% of all sample days). All other days were categorized as `moderate'. Rainfall measured as precipitation in inches was trichotomized as none (0–0.1”), light (0.2”–0.99”), or heavy (1”or more); similarly, snowfall was trichotomized as none, light (0.1” to 0.99”) or heavy (1” or more).

Statistical Analysis

Because total daily count observations are nested within individuals, as well as being nested within study waves, we used PROC MIXED in SAS 9.2. Three level random-effects regression models were first used to separately test the significance of our four weather measures, temperature, precipitation, snowfall, and daylight hours, on daily accelerometer counts, with total daily counts as the level one domain, individuals as the level two domain, and study waves as the level three domain. We then provided a further test of the significance and magnitude of weather measures by estimating a multivariable model with all fixed and time-varying participant characteristics as well as daily wear hours (centered at 10) and whether the wear day was on the weekend. Restricted maximum likelihood estimation was used.

Results

IMPAACT Participant Characteristics

Table 1 displays the number of days of valid accelerometer wear collected at each study wave, as well as the number of participants who had completed each study wave as of May, 2009. There were 34 participants who had completed all six waves of the study, with a total of 209 valid accelerometer wear day observations collected at their final, 24 month wave.

Table 2 provides participants' baseline sociodemographic, behavioral and health characteristics. Three quarters of the 241 participants were female and the same proportion white. RA patients were a majority; the largest age group was between 50–65 (39.3%); one-third of participants were older. Participants were generally highly educated with over 60% reporting a college degree. Baseline SF 36 scores indicated very similar physical health (PCS) and mental health (MCS) scores as the general U.S. population of the same ages. About a third of subjects reported being in each BMI category, comparable to the general

U.S. population of the same age. One third reported drinking alcohol regularly and only 7.5% reported being current smokers.

Total Accelerometer Counts and Minutes of Moderate or Vigorous Activity

Through May 2009, the IMPAACT study had collected 4823 valid daily observations from 241 participants, with a mean of 20.0 (SD=10.0) accelerometer days per subject and a mean daily wear time of 14.6 hours (SD=2.1). Weekend days (n=1304) accounted for 27.0% of all daily accelerometer observations. Figure 1 displays the distribution of daily total counts around a mean of 218991 (SD=134845). Figure 2 displays the distribution of minutes of moderate or vigorous activity based on all minutes with counts >2020. The overall sample mean of 19.9 minutes (SD=24.9) includes a daily mean of 19.0 minutes of moderate and only 0.9 minutes of vigorous activity. Only 87.4% of all sample days had even a single moderate or vigorous exertion minute; less than half (48.0%) of sample days had 10 minutes or more of moderate or vigorous activity. There was an additional mean of 464.5 (SD=121.8) daily minutes of light activity below the 2020+ count cutoff for moderate exertion; however, 192.8 of those light activity minutes were in the very lowest exertion 1–100 count range. This implies that between one half to three quarters of average participant accelerometer wear time, or between seven and 10 hours, was almost completely sedentary.

Figure 3 presents daily mean minutes of moderate or vigorous activity aggregated by month of the year. There is a very large increase in June to about 28 minutes per day followed by a sharp drop in July and monthly lows of less than 15 minutes in November and December.

The Effect of Weather Measures on Daily Minutes of Moderate or Vigorous Activity

Table 3 provides bivariate results for the effect of weather variables on higher intensity activity. The table provides the proportion of total study days affected by each weather condition, median minutes of moderate or vigorous activity based on counts >2020, and the proportion of days in each weather state when participants had zero minutes of any higher intensity activity. Cold days were associated with fewer higher intensity minutes than moderate temperature days and more days of zero minutes of high intensity activity. However, hot days had even more higher intensity activity than moderate weather days. Light and heavy snow days were associated with fewer minutes of high intensity activity. Light rain days had fewer higher intensity minutes than no rain days (which would include many winter days without rain). However, the relatively small number of days (2.9%) with rainfall greater than 1” had anomalous results with higher median minutes than no rain days, but also more days with zero minutes of higher intensity differences. Monthly daylight hours peaked in July at 15.1 and hit a low in January at 9.1 hours. When dividing sample days at 10 hours of daylight or more, there was a very large (55%) difference in median daily moderate or vigorous minutes.

Results of the Multivariable Model of Total Counts

Table 4 presents mixed effects linear regression results estimating the simultaneous effects of weather measures on total daily accelerometer counts after inclusion of participant characteristics, weekend days, and the number of daily accelerometer wear hours in the model. The model explained 37% of the variance at the individual participant level. Daily wear hours were highly correlated with daily total counts and participants were significantly less active on weekend days. Participants with KOA were significantly more active than patients with RA. As expected, being older and female were significantly associated with less physical activity; being 75 or older was associated with dramatically less activity (176215 fewer daily accelerometer counts) than being age <50. Being employed full or part time was associated with fewer daily counts but there were no significant differences by educational attainment. While there was little difference between African American and white/other race participants, being Hispanic was associated with fewer daily counts. Neither current smoking nor regular alcohol use was significant. As compared to normal BMI participants, obesity, but not being overweight or underweight, had a significant negative effect on activity. Additional points of SF36 mental health and especially physical health scores were correlated with higher total counts.

Each additional daylight hour was associated with over 6000 additional counts. However, Table 4 results on the effects of other daily weather conditions provide some contrasts to Table 3 findings on higher intensity minutes. Both light and heavy rain days had significantly lower total activity, and compared to moderate temperatures, both cold days and hot days were associated with significantly fewer daily counts. Thus, in our fully adjusted total counts model, hot days and heavy rain days, which may have bivariate associations with somewhat greater higher intensity activity, had lower overall physical activity levels. Conversely, snow days had bivariate associations with fewer minutes of moderate or vigorous activity but Table 4 results indicate that snowfall was non-significant, with positive total counts coefficients for snow versus non-snow days.

Discussion

These results demonstrate a significant effect of cold weather, rain and daylight hours on objectively measured physical activity. One way to conceptualize the magnitude of the weather effects reported here is to classify daily total counts by imputed minutes of light, moderate or vigorous activity during the mean 14.6 hours of wear time. A regression coefficient of −26000 associated with heavy rain represents an approximate 12% reduction in overall daily mean total counts. Applying this reduction equally to mean daily light and moderate or vigorous minutes implies that on heavy rain days, IMPAACT participants, on average, had about one hour less of any physical activity. Similarly, the 5.7 hour average decrease in daylight hours between January and June was associated with over 14% fewer daily counts, or almost 70 additional minutes of completely sedentary time during the 14.6 hour average daily wear period.

Weather-related restrictions on physical activity are unevenly distributed among participants and may have a differential impact on higher intensity, sustained bouts of activity. This is because higher intensity activity, especially walking significant distances, is more likely to occur outdoors. In this context, while our Table 4 results for total counts indicate that respondents did not undertake any less activity during snow days, our results for higher intensity minutes (Table 3) indicate fewer minutes of moderate or vigorous activity during snowfalls. An opposite finding was that while hot days (and to a lesser extent very heavy rain days) had more average daily minutes of moderate and vigorous activity than moderate temperature days, hot days had significantly lower overall total counts than moderate days after controlling for other variables. Thus hot weather appears to encourage bouts of more intense activity while reducing overall activity across the entire day.

Finally, daily weather effects are cumulative, thus seasonal differences are even more striking. Comparing mean monthly daily counts at their highest in June (277109, SD=160733) to their lowest in November (193210, SD=117204) yields a difference of 83899 counts. When compared to the sample overall mean counts across the whole year, this is equivalent to over 38% less physical activity in November, or more than three additional hours of sedentary activity during the average 14.6 hours of wear time.

Our results mirror the findings of the other accelerometer studies of weather effects that we know of. A study based on 720 days of wear by 127 elderly subjects in a heart failure drug trial in Scotland, with even more extreme variation in daylight hours than Chicago, found a significant effect of daylight hours, temperature, and duration of sunshine.[18] Similar to results reported here, the main effect of weather was on activity intensity rather than on minutes of any activity. A Canadian study of summer physical activity among 48 older adults found a similar negative effect of hot weather.[19]

Limitations

Our study participants were older and all suffered from activity-limiting arthritis and many from other chronic conditions, limiting the generalizability of our findings. Our participants were likely to spend a disproportionate amount of time indoors all year long, thus potentially diminishing weather effects in our sample. Thus bad weather may have an even greater impact on younger, healthier adults and children. This is implied by survey research about walking habits, with findings that bad weather is significantly associated with an increased preference for sedentary behavior.[20, 21] An important further limitation is that some participants in our study only had observations in one season. Thus seasonal differences might reflect differences between participants rather than weather conditions. However, our study is unique to our knowledge in being able to analyze repeated observations of a large proportion of our sample with observations in multiple weather conditions.

The Challenge of Promoting Lifestyle Physical Activity in Bad Weather

Winter in Chicago does not lend itself to a wealth of outside activities for those hampered by functional limitations and safety concerns. Just putting on a heavy coat, boots and gloves can be a challenge for older individuals with severe joint pain related to arthritis. Activities such as walking to the store or post office must be replaced by more purposeful exercise. To decide to be active on a dreary day takes commitment and self-discipline. Many older or disabled persons may be uncomfortable in expensive for-profit indoor exercise venues like gyms and health clubs, where patrons are often young and affluent.

Persons living in apartments or high rises can take advantage of walking in the halls with neighbors, or even the stair wells if safe and well-lit. Cable television offers a plethora of fitness options, ranging from programs structured to be performed from a sitting position to those much more vigorous. Older IMPAACT trial participants have told us that they enjoy putting on big band/swing music and dancing in their homes either alone or with friends/ spouses. Low cost exercise tapes and simple strength-training stretch bands can yield excellent results. Often park districts or YMCAs hold fitness classes for minimal charge, and churches and other religious centers may offer similar programs. Larger indoor shopping centers can sometimes also be used for regular indoor walking.

From the larger population health perspective, there is a great disparity in spending on publically available indoor recreational facilities, in contrast to public investment in outdoor facilities primarily used by the young and healthy. There are very few affordable options available to older urban residents unable to seasonally migrate to warmer areas. Given that physical disability is often accompanied by financial hardship, the lack of accessible transportation to indoor recreational venues may reinforce health disparities.

Our results underscore why having more detailed information about the effects of weather patterns is essential for physical activity promotion programs in areas with climate extremes. For persons with arthritis, narrowly focused exercise interventions conducted in home or gym settings, which often have high attrition rates even for those initially willing to participate, are increasingly being supplemented by individualized behavior change programs aimed at boosting older adults' lifestyle physical activity.[22] Such physical activity promotion programs require providers, coaches or counselors to assess how participants can adapt lifestyle physical activity plans across various `behavioral settings' to the daily weather.[23]

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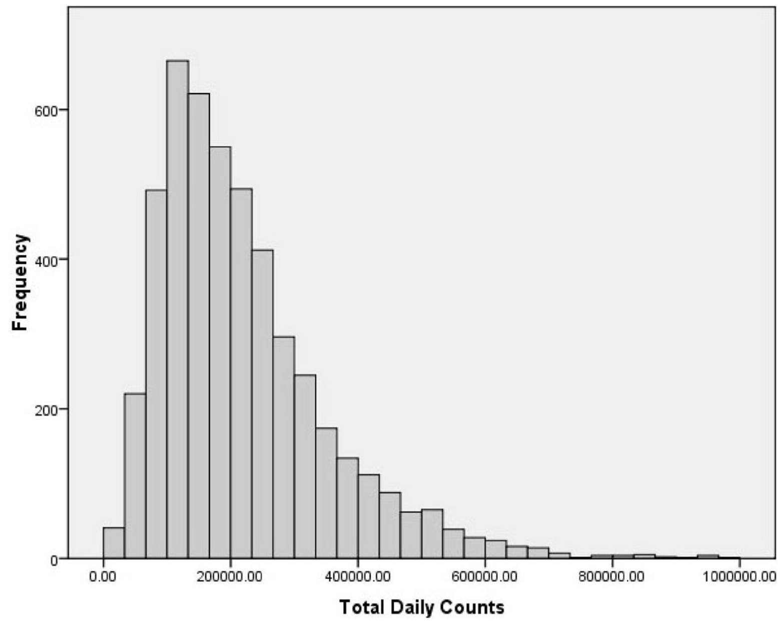
Frequency
600
400
200
0
0.00
200000.00
400000.00
600000.00
800000.00
1000000.00
Total Daily Counts

Fig 1.

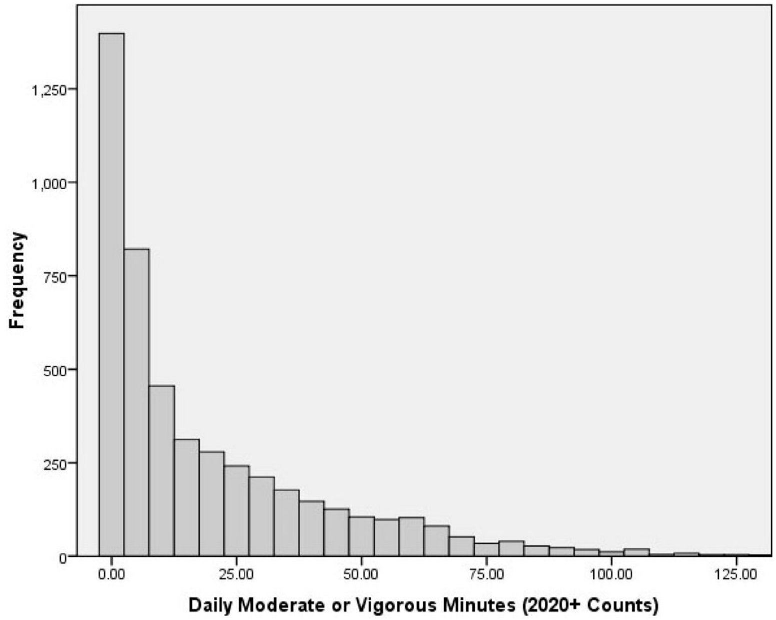
Frequency
1,250
1,000
750
500
250
0
0.00
25.00
50.00
75.00
100.00
125.00
Daily Moderate or Vigorous Minutes (2020+ Counts)

Fig 2.

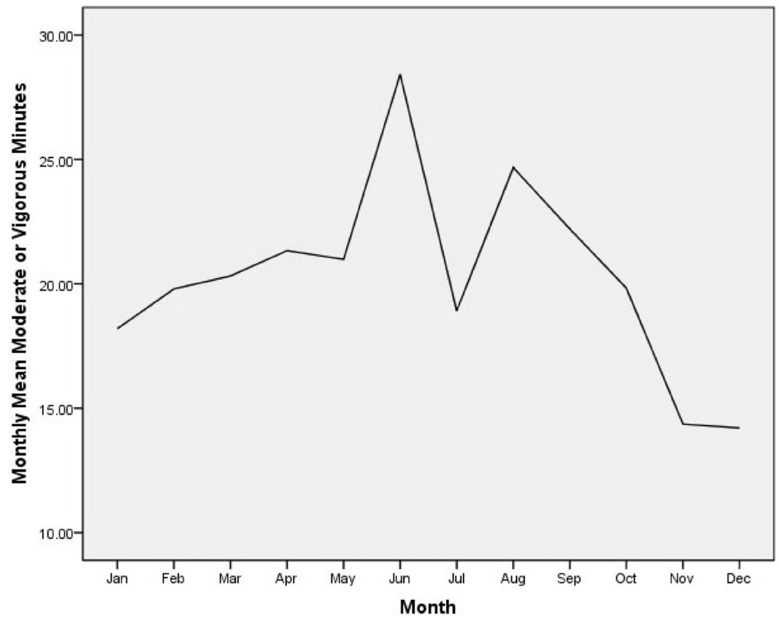
30.00
25.00
20.00
15.00
10.00
Monthly Mean Moderate or Vigorous Minutes
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Fig 3.

Table 1

Data by Study Wave through May, 2009

Study Wave	Number of Valid Accelerometer Days Recorded Each Study Wave	Study Participants' Last Completed Study Wave
Baseline	1481 (30.7%)	36 (14.9%)
Three Months	1135 (23.8%)	32 (13.3%)
Six Months	905 (18.8%)	43 (17.8%)
12 Months	682 (14.1%)	56 (23.2%)
18 Months	411 (8.5%)	40 (16.6%)
24 Months	209 (4.1%)	34 (14.2%)

Table 2

Baseline Characteristics of 241 Participants in the Improving Motivation for Physical Activity in Persons with Arthritis Clinical Trial (IMPAACT)
Enrollment through May, 2009

Knee Osteoarthritis	44.8
Rheumatoid Arthritis	55.2
Sex	
Men	25.3
Women	74.7
Age	
Age <50	26.1
Age 50–65	39.3
Age 66–75	22.2
Age 76+	12.5
Employed Full or Part Time	54.8
Education	
High School/GED	19.1
Some College	20.7
College Graduate	60.2
Race and Ethnicity	
African American	17.8
White/Other	75.1
Hispanic	7.1
Behavioral Risk Factor Measures	
Drinks Alcohol Regularly	34.2
Current Smoker	7.5
BMI Level	
Normal Weight (BMI >18.5 and <24.99)	33.2
Overweight (BMI >24.99 and <29.99)	32.8
Obese (BMI=>30)	31.1
Underweight	2.9
Baseline Health Measures	
Mean (SD) SF36 Physical Health Component Summary Score	44.0 (8.8)
Mean (SD) SF36 Physical Mental Health Component Summary Score	52.7 (7.6)

Table 3

Association of Weather with Daily Moderate or Vigorous Minutes of Activity (2020 + Counts)
4823 Daily Observations for 241 IMPAACT Participants, May, 2006-May, 2008

	Number (%)/ Mean (SD) Days of Observation	Median Daily Moderate or Vigorous Minutes	Proportion of Days with Zero Minutes of Moderate or Vigorous Activity
Temperature			
Moderate Day (20≤Mean Temperature<75)	3907 (81.0)	9.0	12.1%
Cold Day (Mean Temperature<20)	544 (11.3)	7.0	16.5%
Hot Day (Mean Temperature≥75)	372 (7.7)	12.5	11.6%
Snowfall			
No Snowfall	4411 (91.4)	10.0	12.2%
Light Snowfall 0.1–0.99”	182 (3.8)	7.0	16.5%
Heavy Snowfall >=1”	230 (4.8)	7.0	16.5%
Precipitation			
No Precipitation	3841 (79.6)	9.0	11.7%
Light Rainfall 0.1–0.99”	842 (17.5)	8.0	15.9%
Heavy Rainfall >=1”	140 (2.9)	10.0	15.7%
Daylight			
10 or more Daylight Hours	3623 (75.1%)	11.0	12.0%
>10 Daylight Hours	1200 (24.9%)	6.0	14.4%

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Table 4

The Association of Weather Conditions and IMPAACT Participant Characteristics with Daily Accelerometer Counts: Mixed Effects Regression Results*

4823 Daily Observations of 241 IMPAACT Participants, May 2006-May 2008

	B	SE	P
Intercept	21123	35463	0.53
Accelerometer Wear Hours	10292	739	<.0001
Weekend Day	−10687	2814	0.0001
Participant Characteristics			
Rheumatoid Arthritis	Reference		
Knee Osteoarthritis	24471	7835	0.002
Age<50	Reference		
Age50–65	−39884	9076	<.0001
Age 66–75	−98029	11159	<.0001
Age >75	−176215	13751	<.0001
Female	Reference		
Male	11436	8177	0.16
Employed Full or Part Time	−16430	7668	0.03
High School or less	Reference		
Some College Education	−19912	12587	0.11
College Degree	−3167	8378	0.71
White/Other	Reference		
African American	−16892	10443	0.11
Hispanic	−25950	13062	0.05
Current Smoker	10468	14074	0.46
Drinks Alcohol Regularly	−7368	7190	0.31
Underweight (BMI <=18.5)	−20190	23938	0.40
Normal Weight (BMI >18.5 and <24.99)	Reference		
Overweight (BMI >24.99 and <29.99)	−7567	9627	0.43
Obese (BMI=>30)	−40038	9535	<.0001
SF-36 Physical Health Status Score (0–100)	2724	382	<.0001
SF-36 Mental Health Status Score (0–100)	1092	412	0.01
Weather Measures			
Daylight Hours	5493	1630	0.001
No Precipitation	Reference		
Precipitation 0.1–0.99”	−7333	3634	0.04
Precipitation ≥1”	−26000	7808	0.0009
No Snowfall	Reference		
Snowfall 0.1–0.99”	9988	7120	0.16
Snowfall ≥1”	9136	6793	0.18

	B	SE	P
Moderate Day (20≤Mean Temperature<75)	Reference		
Hot Day (Mean Temperature≥75)	−13255	5807	0.02
Cold Day (Mean Temperature <20)	−11002	5429	0.04

*Adjusted for nesting of repeated measures for 241 participants with up to six weekly accelerometer wear waves.