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This Girl Can? The Effect of Promoting Physical Activity on Health Outcomes

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Abstract

Physical activity likely improves health. Yet, even as health outcomes are positively associated with physical activity, confounding bias exists. We examine a large-scale government campaign to encourage physical activity among women in the United Kingdom as a source of an exogenous increase. Our difference-in-differences estimates confirm a large increase in activity associated with the campaign. We use this as the basis of IV estimation indicating that physical activity leads to a reduction in BMI and a lower chance of obesity, but we find no change in other health conditions over our four-year window. Implications for policy and future research are discussed.

JEL classification

I12, I18, D90

Keywords

public service campaign, physical activity, women's health

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1. INTRODUCTION

Sedentary lifestyles and inactivity are major contributors to poor health outcomes and increased health care costs. Ding et al. (2016) estimate that physical inactivity worldwide causes $US 54 billion in health care costs and $US 14 billion in productivity losses per year. Thus, policies that successfully promote physical activity are often seen as imperative.

Responding to this imperative, and to evidence that inactivity was increasingly widespread among women, the UK government invested heavily in the "This Girl Can" campaign of public service announcements and related activities. The campaign encouraged increased exercise and sports for all women of different ages, sizes, and ability. The effects of this campaign, if any, are in themselves important. In addition, if it successfully increased physical activity among women, it provides plausibly exogenous identification to help resolve whether the relationship between exercise and health found in observational studies is causal or explained by confounding bias (for example common underlying causes or reverse causality).

We undertake two closely related examinations focusing on the This Girl Can campaign. First, we provide plausibly causal evidence showing that the campaign did increase physical activity. We use men as a control and our result appears robust to a range of potential confounding factors, including refinements of the comparison group. We believe this is the first UK examination of this type focusing on a public service announcement campaign. Our finding fits with the recent literature examining the effect of incentives and interventions on healthy habit formation such as exercise intentions and activity (Carrera *et al*., 2018; Charness and Gneezy, 2009; Rohde and Verbeke, 2017; Beatty and Katare, 2018), smoking cessation (Gine et al., 2 010; Volpp et al., 2006 and 2009), weight loss (Volpp et al., 2008) and influenza immunization (Moran et al., 1996).

Second, we use the exogenous variation in physical activity associated with the campaign to examine whether women's health outcomes improve. We confirm a strong negative relationship between the increased physical activity and both BMI and obesity. Thus, we argue that the government campaign improved these critical measures of women's health.

Importantly, we do not find relationships between physical activity and other measures of health beyond BMI and obesity. This absence is striking as strong contemporaneous correlations clearly exist between physical activity and these health measures prior to instrumenting. Thus, our results highlight the importance of confounding bias in observational studies of physical activity and health. Nonetheless, we caution that it remains possible that continued physical activity by the women in our study could eventually improve their health. Such longer term improvement might take place beyond the years of our survey window.

In what follows, the next section places our study in context and describes the This Girl Can campaign. The third section presents the data we use taken from the Health Survey of England. The fourth section summarizes the methodology for exploring our two examinations. The fifth section presents the core results, and the sixth section explores robustness and heterogeneity. The last section concludes.

2. BACKGROUND

Physical inactivity can have both direct effects on health outcomes and indirect effects through increased body mass index (BMI). Research shows that physical inactivity has been directly associated with coronary heart disease; hypertension; type 2 diabetes; some types of cancer; and osteoporosis [Humphreys *et al*., (2014) and see Warburton *et al*., (2006) and Sherwood and Jeffery (2000) for reviews of the literature on the effects of physical activity on health outcomes]. Sari (2009) also finds that physical inactivity increases hospital stays and the use of physician and nurse services. Physical activity improves self-assessed health (Forbes *et al*., 2017; Lechner, 2019; Humphreys *et al*., 2014) and increases psychological well-being (Warburton *et al*., 2006).

The medical literature identifies an indirect effect through obesity (high BMI) as it reduces life expectancy (Fontaine *et al*., 2003; Franks *et al*., 2010; Peeters *et al*. 2003; Dixon, 2010; Smith *et al*., 2009) and constitutes a major risk factor for type 2 diabetes, hypertension (Wellman and Friedberg, 2002; Must *et al*., 1999; Mokdad *et al*., 2003), high cholesterol (Mokdad *et al*., 2003), asthma (Mokdad *et al*. 2003), stroke (Wellman and Friedberg, 2002; Must *et al*., 1999), osteoarthritis (Dixon, 2010; Must *et al*., 1999; Mokdad *et al*., 2003), cardiovascular disease, certain types of cancer (Kopelman, 2000; Dixon, 2010; Hu, 2008; Wellman and Friedberg, 2002) and depression (Dixon, 2010; Wellman and Friedberg, 2002).[1] In the United States, there exists long-standing evidence that each one point increase in BMI above normal is associated with an increased annual health care cost of $253 per person and the sum of health care expenditures associated with excess BMI were $174 billion (Ward, 2001). These costs are concentrated among the obese. In the UK obesity predicts disability, functional limitations, increased probability of long-term care and increase health care costs (Nizalova et al., 2020). While not all these costs result from physical inactivity, increasing physical activity can reduce BMI and the associated cost. Thus, reducing BMI and obesity constitutes an important policy objective especially as the prevalence of obesity has increased dramatically. In England, two thirds of adults are overweight and 29% are obese (NHS, 2019).

A historical decline in physical activity broadly matches the rise in obesity. While physical activity in leisure time has been *increasing* over the last decades, BMI has also been increasing (Aguiar and Hurst, 2007; Cutler *et al*., 2003; Department of Health, 2005). This

[1] The economics literature has found a direct causal effect of weight on outcomes such as wages (Averett and Korenman 1996; Cawley, 2004; Kline and Tobias, 2008; Lechner, 2019).

increase in leisure activity is likely outweighed by inactivity due to reduced job strenuousness, increased commuting time, and home sedentarism (Philipson and Posner, 2003; Lakdawalla and Philipson, 2009).[2] Thus, less than half of the adult U.S. population engages in the recommended levels of physical activity. The same is true in England where 33% of men and 45% of women do not engage in activity levels considered healthy, while 19% of men and 27% of women are physically inactive (Public Health England, 2014). These figures highlight long-standing gender differences in activity levels reflecting serious inactivity problems for women in the UK (Farrell and Shields, 2002).

The government launched the This Girl Can campaign in January 2015. Its development followed continued concern that there were two million fewer women participating in exercise and sports than men (Sport England's Active People Survey, 2014).[3] The campaign promoted exercise and sports for all women regardless of age, size, or ability. It consisted of a wide range of TV, cinema, outdoor and social media advertising including a Twitter campaign using the hashtag #thisgirlcan. In addition, there was substantial engagement offline in the forms of collaborations with sports clubs, taking part in charity events, and selling active logo wear. The campaign motivated women to get moving (walking, kicking, lifting, stretching, or sprinting) however they prefer without being judgemental. The website www.thisgirlcan.ac.uk provided information about potential different exercises and sports through its activity finder.[4] The

[2] This pattern also appears over the business cycle. Ruhm (2000, 2005), Tekin *et al*., (2013), Xu (2013) and Colman and Dave (2013) find that leisure physical activity increases during economic downturns. However, this increase does not fully offset the decline in work-related exertion due to job-loss (Colman and Dave, 2013).

[3] The physical activity gap by gender is larger in the UK than in the US. This is sometimes blamed on the absence of a specific statute such as Title 9 in the US requiring equal access by gender to school sports (Birdsall-Strong 2015).

[4]The list of promoted activities is extensive including home exercise, running and jogging, this girl can classes, walk, swimming, park workouts, cycling, yoga and Pilates, Disney dance alongs, hula hooping, weightlifting, working out with pets, golf, hit, tennis, sailing, basketball, exercising with your child, wheelchair basketball, netball, climbing, Zumba, school run, football, squash, rowing, spinning, ballet, medau, canoeing, bootcamp, exercising with your baby, wrestling, flag American football, croquet, bowls, kendo, jagtag, skateboarding, stair workouts, tug of war, kickboxing, dragon boat racing, korfball, personal training, group exercise, angling and speed golf, amongst others.

campaign and website provided motivation via the possibility to meet other participants and get to know their stories. It also allowed women to become “official supporters” (mentors) of other women who are newly engaged in these activities. Sport England developed the campaign, and the funding, £30 million, came from the National Lottery. Appendix 1 provides examples of the advertisements.

Our paper contributes to two main strands of literature. First, there is long-standing interest in the efficacy of information campaigns in changing individuals’ activity patterns. Kahn et al. (2002) provide a systematic review of the earlier literature and highlight that there was insufficient evidence to assess the effectiveness of mass media campaigns to increase physical activity or improve fitness. More recently, Abioye et al. (2013) undertook a meta-analysis of before and after studies concluding that media campaigns increased moderate intensity walking but did not help to achieve the recommended higher levels of activity. The result on walking depended on the inclusion or exclusion of a single study and the authors conclude that further research is warranted. The communications and psychology literatures have long studied the perceived effectiveness of public service announcements using quasi experimental methods (Shen, 2010, Bigsby et al., 2013, Erickson and Greiner, 2019). Often missing in this research is the link between intention and action. Thus, Erickson and Greiner (2019) show that public service announcements encouraging physical activity vary in their perceived effectiveness and that this effectiveness strongly influences the *intention* of those in their sample to engage in such activity. Yet, they have no longitudinal element to observe actual changes in physical activity among those in their sample. Despite the lack of a compelling body of evidence, campaigns built around public service announcements remain popular in part because of their relatively low cost.

Second, we contribute to the economic research estimating the causal effect of exercise on health by exploiting exogenous sources of variation. Cawley *et al.*, (2007) uses variation in state laws mandating minimal Physical Education (PE) requirements. These laws increase girls' overall physical activity but provide no evidence that the resulting PE lowers either BMI or the probability of being overweight. Kaestner and Xu (2007) exploit school-based interventions and find both an increase in girls' participation in high school sports and a subsequent reduction in BMI. Kaestner and Xu (2007) also demonstrate marked increases in girls sport participation following the passage of Title IX in the US. Humphreys *et al*., (2014) exploit the sense of belonging to the community as an exogenous source of variation in physical activity (especially sports). They show that physical activity reduces the reported incidence of diabetes, high blood pressure, heart disease, asthma and arthritis as well as being in fair or poor health. Sarma *et al*., (2015) uses average local temperatures surrounding the respondents' interview month as source of variation in physical activity. They find that physical activity (walking 1 hour or more per day) reduces the probability of obesity but fail to find an effect on the probability of chronic conditions.

Our paper differs from these papers in important respects. The intervention we examine targets all women rather than adolescents and it does not work through schools. Moreover, we are examining a specific government intervention as the source of variation rather than policy differences or changes that likely reflect the inherent characteristics of a place, school district or community. This obviously provides policy relevance. We also examine a wide variety of health outcomes. Finally, we uniquely examine these relationships in the UK.

Our paper finds a significant negative correlation between physical activity and many health problems. This is in line with Humphreys *et al*., (2014), Sarma *et al*., (2015), Warburton *et al*., (2006), Forbes *et al*., (2017), Lechner (2019) and Sari (2009). Yet, once we take endogeneity into account by using This Girl Can as a source of exogenous variation, we fail to find a contemporaneous effect of physical activity on health outcomes other than BMI and obesity. Nonetheless, this latter remains an important policy finding for UK policy makers as obesity and the associated health risks are large and continue to rise.

3. Data

Our main data source is the Health Survey for England (HSE). We use the years 2013 to 2016 as they contain the periods immediately before and after the public service campaign, while also containing variables critical to our analyses. For the years prior to 2013, the critical activity question is different and not easily comparable to the one we use. The HSE is an annual cross sectional household survey commissioned by the Department of Health and conducted by the Joint Health Surveys Unit of Social and Community Planning Research and the Department of Epidemiology and Public Health at University College London. Conducted annually since 1992, it includes face-to-face interviews, self-completion questionnaires and medical examinations of a representative sample of the population over age 15 living in England. The HSE provides information on health outcomes and health behaviours as well as economic and demographic characteristics. Widely used in studies of health behaviours, the HSE includes a rotating selection of modules, one of which measures exercise and physical activity.

Our initial sample contains 44,875 persons across the four waves. Observations are dropped if physical activity measures or health indicators are not recorded leaving us with 28,341 individuals. In robustness checks we further limit the sample hoping to standardize the constraints on time allocation faced by respondents. This smaller sample includes only respondents aged twenty-one through sixty-five who are neither students nor retirees.

The basic physical activity question asks "How much time did you usually spend doing moderate/vigorous physical activities in the last 7 days? Think only about those physical activities that you did for at least 10 minutes at a time. Moderate/vigorous activities refer to activities that take moderate/hard physical effort and make you breathe somewhat/much harder than normal." The first variable is *active*, a dummy equal to 1 if an individual exercises for 150 mins or more per week or more on a regular basis and 0 otherwise. This stands as a common standard for basic physical activity on both sides of the Atlantic (see CDC 2023). The second variable is simply the number of hours per week (measured in 10-minute increments) that the individual engages in moderate/vigorous physical activity.

The health outcomes analysed as the dependent variables include a body mass index measure of overweight, self-assessed general health, diabetes, an indicator for lack of stamina, difficulty breathing or easily fatigued (fatigue), the presence of diabetes, two measures of cholesterol, evidence of endocrine and metabolic conditions, of mental health disorders, of heart and circulatory problems, of respiratory system problems, digestive system problems and musculoskeletal system problems. The exact definitions of these health measures are in appendix Table A1.

The survey also contains a rich set of demographic factors which include age, gender, ethnicity, education and marital status, and questions about economic factors like income and occupational status. The HSE reports income only in ranges (for the different income quintiles). The ranges in the survey are less or equal to £12,803, between £12,804 and £19,500, between £19,501 and £29,865, between £29,866 and £49,015, and greater than £49,015.

Table 1 provides descriptive statistics. Over the waves of our sample 58% of the respondents meet the definition of active: moderate/vigorous physical activities in the last 7 days for at least 10 minutes. The average amount of time per week spent participating in physical activity was 7.4 hours per week representing about four percent of the hours in a week. Importantly for our study, men are significantly more likely to be active than women (63 percent vs. 55 percent) and participate in significantly more hours of physical activity (9.1 hours vs. 6.1 hours).

Table 1 also shows that most adults (64%) are overweight with the average BMI being around 27. The most prevalent health conditions are those of the musculoskeletal system (18%), heart and circulatory system (12%), metabolic problems (9.5%), diabetes (8.5%) and respiratory system (7.7%). The proportion of respondents with mental disorders is 6.3% and those suffering from a condition from the nervous system is 4%.

4. Methods

Our initial approach aims to estimate the effect of the program on exercise activity. To do this we estimate a difference in differences model between women (the treated) and men (the control):

$$E_{it} = \boldsymbol{\beta}'\boldsymbol{X}_{it} + \gamma Fem_i + \delta Policy_t + \theta Policy_t * Fem_i + y_t + \varepsilon_{it} \quad (1)$$

Where E is an exercise indicator, $\boldsymbol{X}$ is a vector of controls, *Fem* indicates a female respondent, *Policy* indicates a period after the This Girl Can campaign began. The estimate includes year dummies and θ is our parameter of interest.

Two identifying assumptions to interpreting θ causally deserve emphasis. First, the standard parallel trend assumption requires that the conditional trend in exercise by gender were parallel prior to treatment (and so in expectation would follow the same trend in the absence of treatment). While we are limited by the short time dimension of our data we explore the sensitivity of our results to potential violations of the parallel trend assumption.

Second, the stable treatment assumption requires that men are unaffected by the policy. On this, we see two potential sources of concern. The first, and we believe more likely, is the existence of intra-household spillover effects. Increased physical activity by a female household member may change (likely increase) the exercise activity of male household members. Second, males may have simply been influenced by the policy independent of the activity of any women in their household. They saw the campaign and, even though explicitly not directed at them, they changed their activity level. We explore the first concern by exploiting variations in household structure. For instance, by comparing married males versus single males. We also emphasize the remarkably strong emphasis on women in the campaign. Men do not appear in the campaign at all, and the appeal is explicitly and uniquely to women.

We then seek to explore whether the exercise effects of the policy lead to changes in health outcomes. This amounts to using equation (1) as the first stage (and again the differential trends estimate) in a two-stage estimation strategy:

$$E_{it} = \boldsymbol{\beta}'\boldsymbol{X}_{it} + \gamma Fem_i + \delta Policy_t + \theta Policy_t * Fem_i + y_t + \varepsilon_{it} \quad (2)$$

$$H_{it} = \boldsymbol{\beta}'\boldsymbol{X}_{it} + \gamma Fem_i + \delta Policy_t + \delta E_{it} + y_t + \varepsilon_{it} \quad (3)$$

This instrumental variable approach requires the additional assumption that the policy only affected health outcomes through its effect on exercise. It seems highly unlikely that the advertisements alone improved health outcomes. Moreover, we are not aware of any influences from the campaign that would influence health other than through increased physical activity, but we recognize it remains at least a theoretical possibility.

5. Results

We set the stage for our estimation by showing the naïve estimates of including physical activity as a statistical determinant of the health outcomes for women using all the available controls. The estimates are ordinary least squares and so are often linear probability estimates. They are shown in Table 2. The estimates are virtually unanimous in the picture they present. Almost regardless of the outcome, physical activity predicts better health. This is true both for the dichotomous measure of active and for the more detailed hours of physical activity. Taking but two illustrations, an extra hour of physical activity a week is associated with a 4.2

percentage point decrease the likelihood of having an overweight BMI and an 0.1 percentage point decrease in the likelihood of mental health conditions.

We have emphasized that the estimates in Table 2 likely reflect confounding bias. Individuals with health problems are more likely to be inactive and if active, to exercise less. Thus, the causation may be reversed. Moreover, decisions to invest in activity are likely highly correlated with other decisions to invest in health such as eating a proper diet, avoiding smoking and getting regular sleep and health care. In this case, the correlations shown in Table 2 could reflect a third influence such as individual patience or rates of discount. To avoid such confounding bias, we examine whether the government publicity campaign generated a believably exogenous increase in physical activity for women.

5.1 Did the Intervention Change Exercise Activity?

Table 3 provides estimates of (1) for the measure at the extensive margin (have you been active in the last week) and at the intensive margin (how many hours have you exercised in the last week). For both, we report estimates across alternative specifications. These include a standard difference in differences estimate without the other covariates, a further estimate that accounts for all the covariates and a similar estimate that accounts for all the covariates and for potential differential trends across genders. These each indicate marked effects of the information campaign on women's exercise. Conditional on specification, there was an increase of approximately 9 to 16 percentage points in being active, and an increase of approximately 2.5 to 3.5 hours of exercise per week. These are sizeable effects. The average hours of exercise for women over the sample is 6.1 hours.

As emphasized, a standard concern is a violation of the parallel trends assumption. As the third column shows, testing for the existence of differential trends confirms significantly different trends although this is admittedly based on our small panel length. Consequently, we take the best causal estimate of the effect on activity to be at the high end of range and the best causal estimate of the effect on hours to be at the low end of range. These are the estimates in the third column of Table 3.

We next examine heterogeneity in this first stage result focusing on that estimate with differential trends. We divided the sample across a series of potentially important covariates and redo the estimate within each division. For example, we estimated the first stage separately on those in an urban setting and in a non-urban setting. Similarly, we estimated the first stage among those under age 45 and among those age 45 or older. The estimates remained significant in each of these divisions and showed very little difference in magnitudes.

In the top panel of Table 4 we summarize the difference in difference estimates across five income categories. The pattern across the five income categories is shown first for activity participation and then for hours of activity. All estimates for both variables emerge as statistically significant, suggesting a broad pattern of increased activity. The patterns across income categories are roughly similar for the two activity measures. For both measures the largest estimates are in the middle of the income distribution. For the influence on activity the estimate in the middle category is nearly twice that in the highest income category. In the hours of activity estimates, the middle category is much larger (again almost twice as large) as that in either the lowest or highest income categories. The seemingly smaller influence among those at the top of the income distribution may reflect their already high level of physical activity (Farrell and Shields, 2002).

The bottom panel of Table 4 shows the difference in estimates across three educational categories. Again, for both activity measures the estimates are statistically significant across all three categories. While not as dramatic, the middle category again has the largest estimate. Thus, the suggestion of an inverted u-shape across income and education emerges. The largest increases in activity are not among those with the least education and income nor among those with the most education and income but rather those in the middle.

As we discussed earlier, additional concerns relate to the spillovers between treatment (women) and comparison (males). We will return to this concern and examine a series of robustness tests in Section 6.

5.2 Does Increased Physical Activity Improve Health Outcomes?

We take the previous estimates to suggest that the government campaign created a plausibly exogenous increase in the physical activity of women. We now use this increase to provide a plausible instrumental variable. This accounts for endogeneity and confounding bias that we suspected in the original estimates of the health outcomes.

Table 5 repeats the earlier estimates taking endogeneity into account. Again, we continue to use the estimates with the differential trends. The first stage (2) is not a weak instrument, but its use dramatically changes the nature of the resulting associations. First, we continue to find a substantial influence of physical activity on BMI and obesity. Indeed, as is often the case with IV estimation, the estimates exceed those in the naïve estimates. This can reflect both correcting for bias and the fact that measurement error does not diminish the IV estimates. It may also reflect that, under the LATE interpretation of our IV estimates, the complier sub-population (those women who increase exercise due to the campaign) experience larger BMI reductions. An improvement in BMI is in line with studies from other contexts including Kaestner and Xu (2007), Sarma *et al*., (2015) and Charness and Gneezy (2009). Importantly, the influence on BMI is sufficiently large that there is significant reduction in obesity associated with the additional physical activity caused by the campaign. As we have stressed, such a reduction if persistent would be associated with long term improvements in health and likely reductions in the enormous health care costs associated with obesity.

Second, we fail to find a contemporaneous effect of physical activity on any other health outcomes. We note that these health outcomes often take years to develop and while increased physical activity may eventually improve them, our window may be too short to identify such improvement. It would obviously depend upon the increase in physical activity that we confirm continuing for the longer term. Thus, our failure to find changes in the health outcomes other than BMI and obesity speak to the routine confounding influence of contemporaneous studies. While these outcomes were clearly correlated with health outcomes, causation remains in doubt. Nonetheless, the clear influence on BMI and obesity suggests not only that the campaign increased activity but that the resulting activity improved at least these dimensions of health.

6. Robustness

We first return to the issues of whether spillovers within households influence the tenor of our estimates. We do this in two ways. First, we examine the influence of the campaign on men married to, or cohabitating with, women to its influence on single men. This should isolate the role of any household spillover. The results of this comparison are summarized in Table 6. The difference in difference in Panel A suggests a very small and weakly significant influence of the campaign on whether men living with women are more likely to be active. There is no evidence of an influence on the hours of physical activity. Indeed, the coefficients are negative. This suggests any bias in our original results is very modest.

Second, we used single men as the comparison to women. Again, here the comparison should not be influenced by household spillover. The results are in Table 7. The difference-in-difference shows a robust influence of the campaign on activity in Panel A. In the IV in Panel B, the result sizes are larger than in our base result reflecting the possibility of spillover within households. This is sufficiently noticeable that an additional health outcome is now influenced by the increased physical activity associated with the campaign. The diabetes indicator is less prevalent among those with the campaign caused increase physical activity. The remainder of the health outcomes continue to show no influence.

We next split our sample by age. This split is potentially important as obesity is known to increase with age. This reflects an increasingly sedentary lifestyle on average and changes in metabolism (NIHR, 2024). We split our sample roughly in the middle at age 45 and reran the estimates within each of the two subsamples. The difference in differences show a highly significant increase in both the probability of activity and the hours of activity. These make instruments that are not weak in each of the first stages. The final instrumental variable estimates are shown in Table 8.

There is clear difference in the magnitude of the influence by age group. None of the IV measures of activity are statistically significant for those under 45. The same IV activity measures are associated with significant decreases in BMI and obesity for those over 45. Importantly, the coefficients for those over 45 are two to three times larger in absolute magnitude. Thus, the reductions in obesity happen in older respondents where it is more common.

7. Conclusions

This research examined two related questions. Did the government campaign *This Girl Can* causally increase women's physical activity? If so, does that increase in physical activity improve women's health.

Our first contribution has been evidence that the government campaign, indeed, caused increased physical activity among women. As the success of such campaigns has been doubted, this provides evidence that a relatively inexpensive intervention can change behaviour in a way that is associated with improved public health.

Second, this finding provides a first stage identifying a plausibly exogenous increase in activity. In turn, this allowed us to estimate the influence of activity on health outcomes avoiding the likely confounding bias. We found evidence that activity reduced BMI which has direct and indirect influences of health. We also found evidence that within our prime age adult sample, there was an increase in self-reported health. These results can help inform the design of policy interventions aimed at increasing physical activity.

We did not find influences of physical activity on the wide range of other health outcomes. This may be because of our relatively short window of observation. A longer window may have brought about better health outcomes. Despite this possibility, the evidence cautions strongly against believing simple contemporaneous correlations that likely do reflect confounding bias.

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Table 1. Descriptive Statistics

	Overall		Male		Female	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
Active	0.584	0.493	0.629	0.483	0.549	0.498
# hours	7.401	11.155	9.067	12.501	6.069	9.747
Self-assessed health	0.260	0.439	0.258	0.438	0.262	0.440
Fatigue	27.518	5.503	27.714	4.908	27.355	5.948
Diabetes	0.316	0.465	0.302	0.459	0.326	0.469
Total Chol	0.085	0.278	0.103	0.303	0.069	0.254
HDLChol	5.188	1.120	5.074	1.127	5.285	1.104
Endocrine & metabolic	1.531	0.460	1.360	0.390	1.676	0.465
Mental disorders	0.095	0.294	0.091	0.287	0.099	0.299
Heart & circulatory	0.063	0.243	0.054	0.226	0.071	0.256
Respiratory system	0.124	0.329	0.140	0.347	0.111	0.314
Digestive system	0.076	0.265	0.073	0.260	0.079	0.269
Musculoskeletal s	0.051	0.219	0.045	0.208	0.055	0.228
Female	0.554	0.497				
Single	0.190	0.392	0.201	0.401	0.180	0.384
Married	0.526	0.499	0.557	0.497	0.501	0.500
Separated	0.021	0.144	0.017	0.130	0.024	0.154
Divorced	0.072	0.259	0.058	0.234	0.084	0.277
Widowed	0.071	0.257	0.041	0.198	0.096	0.295
Cohabitees	0.120	0.324	0.125	0.331	0.115	0.319
NVQ4/NVQ5/Degree	0.261	0.439	0.266	0.442	0.257	0.437
Higher ed below degree	0.108	0.311	0.127	0.333	0.093	0.291
NVQ3/GCE A Level e	0.151	0.358	0.145	0.352	0.157	0.363
NVQ2/GCE O Level	0.203	0.402	0.188	0.391	0.215	0.411
NVQ1/CSE other	0.040	0.196	0.051	0.221	0.031	0.172
Foreign/other	0.015	0.121	0.003	0.053	0.025	0.155
No qualification	0.221	0.415	0.219	0.414	0.223	0.416
Age 16-24	0.090	0.287	0.092	0.290	0.089	0.285
Age 25-34	0.145	0.352	0.135	0.341	0.153	0.360
Age 35-44	0.165	0.371	0.157	0.364	0.171	0.376
Age 45-54	0.180	0.384	0.180	0.384	0.180	0.384
Age 55-64	0.157	0.364	0.162	0.368	0.154	0.361
Age 65-74	0.149	0.356	0.159	0.366	0.141	0.348
Age >75	0.114	0.317	0.115	0.319	0.113	0.316
Income Q1	0.143	0.350	0.132	0.338	0.152	0.359
Income Q2	0.145	0.352	0.137	0.343	0.152	0.359
Income Q3	0.162	0.369	0.163	0.369	0.162	0.368
Income Q4	0.170	0.376	0.180	0.384	0.163	0.369
Income Q5	0.175	0.380	0.192	0.394	0.161	0.368

Manager	0.041	0.198	0.044	0.206	0.038	0.191
Supervisor	0.122	0.327	0.126	0.332	0.119	0.324
Employee	0.268	0.443	0.257	0.437	0.277	0.448
White	0.437	0.496	0.438	0.496	0.435	0.496
Black	0.012	0.109	0.010	0.101	0.013	0.115
Asian	0.030	0.169	0.030	0.169	0.030	0.170
Other ethnicity	0.011	0.106	0.011	0.105	0.011	0.106
Observations	28,341		12,593		15,748	

Table 2. Exercise and Health Outcomes of Women, OLS Estimate, HSE 2013-2016

	(1) BMI	(2) Obese	(3) Self-assessed health	(4) Fatigue	(5) Diabetes	(6) Total Chol	(7) HDL Chol	(8) Endocrine	(9) Mental disorders	(10) Heart & circulatory	(11) Respiratory	(12) Digestive	(13) Muscular
OLS													
Active	-0.914***	-0.097***	-0.170***	-0.135***	-0.046***	0.058***	0.088***	-0.026***	-0.038***	-0.046***	-0.026***	-0.017***	-0.079***
	(0.072)	(0.006)	(0.005)	(0.009)	(0.005)	(0.019)	(0.007)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.005)
N	24,561	28,282	28,275	12,056	14,320	14,451	14,455	28,270	28,270	28,270	28,270	28,270	28,270
R^2	0.073	0.046	0.157	0.050	0.069	0.109	0.162	0.056	0.046	0.126	0.017	0.015	0.104
OLS													
# hours	-0.032***	-0.003***	-0.005***	-0.004***	-0.001***	0.002**	0.004***	-0.001***	-0.001***	-0.002***	-0.001***	-0.001***	-0.002***
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	24,595	28,331	28,324	12,075	14,349	14,480	14,484	28,319	28,319	28,319	28,319	28,319	28,319
R^2	0.071	0.042	0.137	0.038	0.065	0.109	0.161	0.055	0.044	0.125	0.016	0.015	0.098

Notes: Robust standard errors are estimated ***significant at the 1 percent level; **significant at the 5 percent level; *significant at the ten percent level. All models include controls for year fixed-effects, year trend, year trend interacted with treatment, gender, ethnicity, marital status, education, age, quartile and occupation dummies.

Table 3. This Girl Can and Exercise Activity, Difference in Differences Estimates, HSE 2013-2016

	(1) Simple	(2) Full Covariates	(3) Full Covariates with differential trends
		Active	
dd	0.093***	0.091***	0.149***
	(0.012)	(0.011)	(0.026)
Female	-0.129***	-0.121***	-0.080***
	(0.008)	(0.008)	(0.019)
Trend			0.002
			(0.004)
Trend x Female			-0.028**
			(0.011)
Observations	28,341	28,282	28,282
R-squared	0.009	0.082	0.082
		# hours	
dd	3.550***	3.539***	2.630***
	(0.252)	(0.249)	(0.573)
Female	-4.818***	-4.811***	-5.457***
	(0.181)	(0.181)	(0.410)
Trend			-3.294***
			(0.088)
TrendxFemale			0.439*
			(0.249)
Observations	28,391	28,331	28,331
R-squared	0.105	0.133	0.134

***significant at the 1 percent level. Column 1 includes treatment and year fixed effects. Column 2 adds to Column 1 controls for ethnicity, marital status, education, age, quartile and occupation and year dummies. Column 3 allows for trends to differ between treatment and control groups.

Table 4. This Girl Can and Exercise Activity, Difference in Differences Estimates, Heterogeneity

	(1)	(2)	(3)	(4)	(5)
			INCOME		
	INC1	INC2	INC3	INC4	INC5
Active	0.135*	0.141**	0.201***	0.143**	0.146***
	(0.074)	(0.072)	(0.062)	(0.060)	(0.056)
Observations	3,890	4,091	4,698	4,997	5,213
R-squared	0.080	0.097	0.071	0.051	0.049
# hours	0.612	6.643***	2.939**	3.179**	2.461**
	(1.602)	(1.587)	(1.424)	(1.375)	(1.191)
Observations	3,898	4,098	4,704	5,006	5,222
R-squared	0.137	0.176	0.171	0.125	0.088
		EDUCATION			
	ED1	ED2	ED3		
Active	0.100**	0.216***	0.144***		
	(0.041)	(0.044)	(0.053)		
Observations	10,856	10,254	7,172		
R-squared	0.033	0.040	0.095		
# hours	1.523*	3.274***	4.389***		
	(0.873)	(1.010)	(1.129)		
Observations	10,876	10,270	7,185		
R-squared	0.100	0.149	0.162		

Notes: Robust standard errors are estimated, and the full set of explanatory variables are included in each estimation. These are the estimates with differential trends. ***significant at the 1 percent level

Table 5. Health Outcomes for Women, Instrumental Variable Estimation

	(1) BMI	(2) Obese	(3) Self-assessed health	(4) Fatigue	(5) Diabetes	(6) Total Chol	(7) HDL Chol	(8) Endocrine	(9) Mental disorders	(10) Heart & circulatory	(11) Respiratory	(12) Digestive	(13) Muscular
IV													
Active	-3.853**	-0.304*	-0.089	0.145	0.060	0.399	0.047	-0.045	0.087	-0.027	0.144	0.008	-0.003
	(1.905)	(0.178)	(0.148)	(0.272)	(0.140)	(0.523)	(0.207)	(0.105)	(0.090)	(0.112)	(0.102)	(0.080)	(0.134)
N	24,561	28,282	28,275	12,056	14,320	14,451	14,455	28,270	28,270	28,270	28,270	28,270	28,270
R^2	0.010	0.006	0.150	-0.032	0.036	0.089	0.160	0.055	-0.013	0.125	-0.073	0.012	0.095
F	37.33	32.59	32.74	13.29	16.85	18.80	18.79	32.87	32.87	32.87	32.87	32.87	32.87
IV													
# **hours**	-0.239*	-0.017*	-0.005	0.008	0.003	0.020	0.002	-0.003	0.005	-0.002	0.008	0.000	-0.000
	(0.124)	(0.010)	(0.008)	(0.016)	(0.007)	(0.027)	(0.011)	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)	(0.008)
N	24,595	28,331	28,324	12,075	14,349	14,480	14,484	28,319	28,319	28,319	28,319	28,319	28,319
R^2	-0.087	-0.052	0.137	-0.028	0.040	0.078	0.160	0.052	-0.027	0.124	-0.099	0.012	0.095
F	19.13	21.04	21.27	9.300	13.39	14.08	14.27	21.37	21.37	21.37	21.37	21.37	21.37

Notes: Robust standard errors are estimated, and the full set of explanatory variables are included in each estimation. ***significant at the 1 percent level; **significant at the 5 percent level; *significant at the ten percent level. All models include controls for year fixed-effects, year trend, year trend interacted with treatment, gender, ethnicity, marital status, education, age, quartile and occupation dummies.

Table 6. Comparing Married/Cohabiting Males to Single Males

Panel A – D in D

	(1) dd	(2) ddcovs	(3) ddtcovs
Active	0.032*	0.029	0.029
	(0.019)	(0.018)	(0.018)
Observations	12,593	12,563	12,563
R-squared	0.005	0.091	0.091
# hours	-0.529	-0.701	-0.701
	(0.454)	(0.445)	(0.445)
Observations	12,614	12,584	12,584
R-squared	0.107	0.156	0.156

Panel B – Health Outcomes

	(1) BMI	(3) Obese	(2) Diabetes
IV			
Active	-12.275	-1.057	-1.590
	(11.233)	(0.857)	(2.368)
Observations	11,150	12,563	6,562
R squared	-1.101	-0.816	-5.413
IV			
# hours	0.412	0.045	0.060
	(0.367)	(0.040)	(0.096)
Observations	11,166	12,584	6,574
R squared	-0.990	-1.278	-5.843

Table 7. Comparing Women to Single Men

Panel A – D in D

	(1) dd	(2) ddcovs	(3) ddtcovs
Active	0.115***	0.114***	0.201***
	(0.018)	(0.017)	(0.039)
Observations	19,684	19,643	19,643
R-squared	0.005	0.083	0.083
# hours	3.210***	3.216***	3.401***
	(0.355)	(0.351)	(0.811)
Observations	19,721	19,679	19,679
R-squared	0.084	0.112	0.112

Panel B – Health Outcomes

	(1) BMI	(3) Obese	(2) Diabetes
IV			
Active	-5.819**	-0.619***	-0.289*
	(2.493)	(0.218)	(0.161)
Observations	16,838	19,643	9,684
R^2	-0.071	-0.205	-0.123
IV			
# hours	-0.347**	-0.036***	-0.013*
	(0.157)	(0.014)	(0.007)
Observations	16,861	19,679	9,706
R-squared	-0.195	-0.397	-0.119

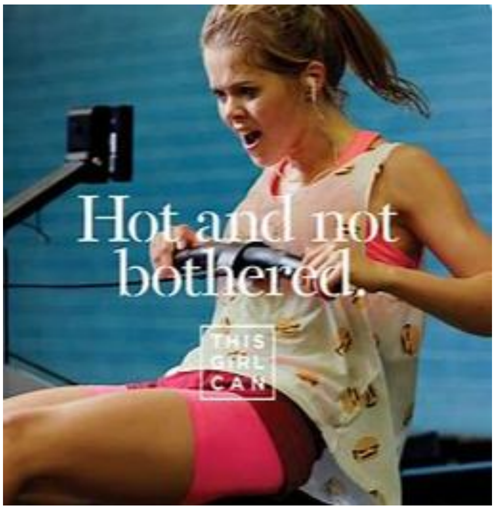
Table 8. Results by Age, IV estimates

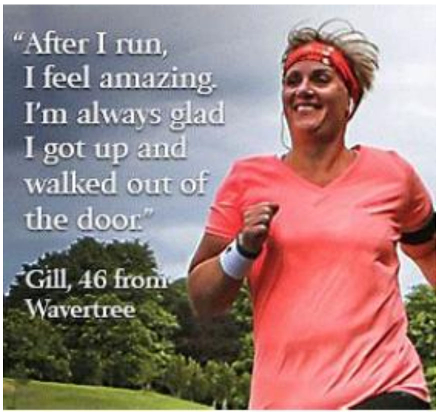
Under 45	(1)	(2)	(3)
VARIABLES	BMI	Obese	Diabetes
Active	-2.766	-0.131	-0.056
	(2.962)	(0.262)	(0.097)
Observations	10,083	11,481	4,974
R-squared	0.032	0.033	-0.006
# hours	-0.205	-0.009	-0.004
	(0.230)	(0.018)	(0.006)
Observations	10,090	11,496	4,981
R-squared	-0.065	0.008	-0.053

Over 45	(1)	(2)	(3)
VARIABLES	BMI	Obese	Diabetes
Active	-4.602*	-0.422*	0.115
	(2.417)	(0.235)	(0.224)
Observations	14,478	16,801	9,346
R-squared	-0.060	-0.047	-0.017
# hours	-0.256*	-0.022*	0.005
	(0.140)	(0.013)	(0.010)
Observations	14,505	16,835	9,368
R-squared	-0.140	-0.107	-0.001

Notes, the full difference in differences estimates and the separate first stage estimates are available upon request.

Appendix 1: Examples of Announcements





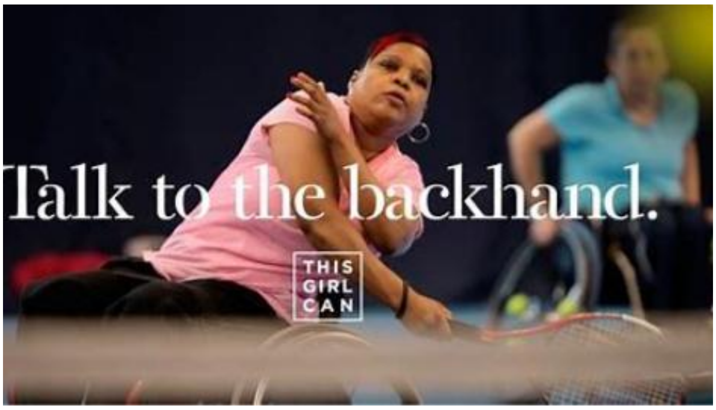


Table A1. Activity and Health Variable descriptions

Active	1 if the individual exercises for 150 mins or more on a regular basis, and 0 otherwise
# hours	number of hours and minutes per week that the individual engages in moderate/vigorous physical activities for 10 mins or more
Obese	BMI>=30
BMI	Valid/corrected measure of Body Mass Index
Self-assessed health	Dummy 0 if health is very good or good 1 if fair, bad or very bad
Fatigue	Whether conditions or illnesses affect: Stamina, breathing or fatigue
Diabetes	Doctor diagnosed diabetes and/or hemoglobin A1c
Total Chol	Total Cholesterol level
HDLChol	HDL Cholesterol level
Endocrine & metabolic	1 if any endocrine or metabolic condition is present, 0 otherwise
Mental disorders	1 if mental disorders are present, 0 otherwise
Heart & circulatory	1 if any heart or circulatory condition is present, 0 otherwise
Respiratory system	1 if any condition from the respiratory system is present, 0 otherwise
Digestive system	1 if any condition from the digestive system is present, 0 otherwise
Musculoskeletal	1 if any conditions from the musculoskeletal system is present, 0 otherwise