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ORIGINAL PAPER

# Promoting physical activity among seniors in Abu Dhabi: an experimental test of the "forever fit" nudge

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**Abstract**
Physical inactivity is a leading cause globally of noncommunicable diseases such as diabetes, heart attacks, and strokes. Here, we present the results from a 4-week-long experimental test of a nudge designed to promote physical activity among 206 seniors in Abu Dhabi, United Arab Emirates—a population with one of the highest rates of physical inactivity in the world. We find that the "Forever Fit" nudge—a booklet containing a simple exercise program and information about the health benefits of physical activity—has a large positive effect on 93 previously inactive seniors. The nudge increases the time previously inactive participants spend being physically active from about 5 to about 15 minutes per day.

**Keywords:** Elderly; Experimental test; Health; Nudge; Physical activity

**JEL codes:** D04; I18; C93; D90

## 1. Introduction

Physical activity is associated with numerous health benefits (World Health Organization, 2021). Specifically, evidence from randomized controlled trials indicate that increases in physical activity lead to improvements in both physical (Valenzuela et al., 2023) and cognitive (Northey et al., 2018) function, as well as reductions in multiple health conditions (Powell et al., 2011; Warburton, 2006; Warburton & Bredin, 2017).[1] The Centers for Disease Control and Prevention in the United States considers regular physical activity as one of the most effective measures senior adults can take to prevent or delay various age-related health issues (Physical Activity Guidelines Advisory Committee, 2008). Despite this, many senior adults do not engage in sufficient physical activity (Thø gersen-Ntoumani et al., 2010).

This paper examines the impact of the Forever Fit Program (FFP)—a low-cost, scalable intervention designed to increase physical activity among senior adults in Abu Dhabi, United Arab

[1]The World Health Organization (2011) defines physical activity as any bodily movement produced by the skeletal muscles that requires energy expenditure. Regular physical activity helps prevent noncommunicable diseases such as heart disease, stroke, diabetes, and certain cancers, aids in weight management and maintaining healthy blood pressure, enhances mental health, and contributes to better sleep, bone and muscle health (World Health Organization, 2021; Xie et al., 2021).

Emirates (UAE). This population is interesting for two reasons. First, the rate of physical inactivity in this population is alarming: a recent UAE report revealed that 93.8% of individuals aged 60 and above do not meet the minimum standards for moderate-intensity physical activity of the World Health Organization (WHO) (Qawas et al., 2019). This figure is in stark contrast to the global age-standardized prevalence of insufficient physical activity, which stands at 27.5% (Guthold et al., 2018). Since the benefits of physical activity are especially pronounced among individuals aged 60 and above (Blake et al., 2009; Carlson et al., 2018; Rai et al., 2019) and those who are inactive (Moore et al., 2012), the potential health benefits of increasing physical activity in this population are substantial. Second, due to the hot climate in the region and the fact that our study was conducted during the COVID-19 pandemic, senior adults in Abu Dhabi have limited access to outdoor spaces, making it potentially more challenging to promote physical activity, as it must occur indoors, particularly at home.

The FFP is a booklet containing a simple exercise program and information about the health benefits of moderate physical activity (MPA), which the WHO defines as physical activity that requires moderate effort and makes individuals "breathe somewhat harder than normal" (World Health Organization, 2011). We focus on MPA because it offers more health benefits than milder forms of physical activity, such as normal walking (Nakagawa et al., 2020), while being suitable for the age of our target population. Guided by a diagnostic analysis of the underlying causes of inactivity among seniors in the UAE based on survey data, the FFP was designed to reduce the immediate costs of physical activity and enhance its perceived benefits. The FFP, therefore, is a "nudge" as it aims to improve individual well-being without affecting material incentives (Thaler & Sunstein, 2008). In designing the FFP, we consulted health experts to identify age-appropriate activities and collaborated with UAE nationals to ensure the cultural and contextual relevance of their description and presentation.

To test the effectiveness of the FFP in increasing MPA, we conducted a randomized control trial (RCT) over a four-week period. The RCT involved 206 senior adults aged 50 and above living in the Emirate of Abu Dhabi. Participants were randomly assigned either to a control group that did not receive the FFP or to a treatment group that received the booklet. We find that the FFP had a large positive effect on the MPA of senior adults identified as physically inactive before the start of the program. On average, inactive senior adults in the control group engaged in MPA for only 4.99 minutes per day, while those in the treatment group did so for 15.06 minutes per day. This result is consistent with the findings of a meta-analysis by Chase (2015), which reports that the average impact of interventions targeting physical activity in senior adults is around 10 minutes of increased physical activity.

Our study contributes to a literature exploring interventions for reducing physical inactivity (Clark et al., 2005; Chudyk & Petrella, 2011; Patnode et al., 2017; Anderson & Durstine, 2019). Given the health benefits of physical activity, the literature is extensive. In a review of 113 RCTs, Patnode et al. (2022) conclude that behavioral counseling interventions lead to improvements in physical activity and have a modest yet statistically significant impact on key health markers. The RCTs vary both in the type of intervention and the target population. Some interventions have specifically targeted senior adults, although these interventions tend to be more resource-intensive than the FFP (e.g., Hui & Rubenstein, 2006; Jancey et al., 2008; Morey et al., 2009a; Morey et al., 2009b; Lachman et al., 2018; for reviews, see Van der Bij et al., 2002; Chase, 2015; Lewis et al., 2017). We design and test a nudge tailored to the needs of senior adults in a population with high levels of physical inactivity. Compared to most interventions, our nudge is low-cost. Importantly, it involves no interaction aimed at promoting MPA, making it easier to scale than other more resource-intensive interventions.

The study most similar to ours is Burke et al. (2013). These authors explored the impact of a booklet-based intervention and found that it significantly increased exercise, walking, and improved nutritional behaviors in a sample of seniors in Perth, Australia. An important difference to our study is that the intervention also involved personal communication between the researchers and the seniors, which was aimed to encourage the latter to engage in physical activity. This implies that the intervention of Burke et al. (2013) is not easily scalable and that the RCT cannot identify the net effect of using

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a booklet.[2] With regards to the population, although our study also targets senior adults, there are important differences. For one, the climate in Perth is conducive to outdoor activities throughout the year. This may help explain why Australians are among the most physically active populations in the world (Guthold et al., 2018). Not only is our target population one of the least physically active globally, but also the intervention took place at a time of the year when temperatures in the UAE prohibit people from spending considerable amounts of time outdoors. Furthermore, the FFP test happened during the COVID-19 pandemic when seniors were not allowed to public indoor places such as malls due to their health. These factors combined make for a difficult test of a low-cost intervention.

## 2. The forever fit program

To increase the chances of designing an effective intervention to promote physical activity, we conducted an online survey with a sample of 422 individuals aged 55 and above residing in Abu Dhabi. The Abu Dhabi Department of Community Development recruited the participants via text messages. The survey included measures of physical activity and collected information on participants' backgrounds, living conditions, personality traits (like self-control), and perceptions of factors limiting their physical activity, such as hot weather, lack of money, lack of time, and health reasons (Schutzer, 2004).[3]

The analysis of the survey data revealed that lack of self-control and motivation are the primary drivers of physical inactivity among senior adults without severe mobility and health problems.[4] These findings suggest that a nudge targeting these factors can potentially increase physical activity in our population of interest. The survey also confirmed that senior adults in Abu Dhabi face high mobility costs due to extreme temperatures and COVID-19 exposure and highlighted a relatively high level of digital illiteracy among this demographic.

Based on our survey results, we decided to nudge seniors in their homes using a low-tech approach. Inspired by Burke et al. (2013), we designed a booklet describing a purpose-built physical activity program titled *Forever Fit*. The result is a compact 17-page booklet with colorful images and large fonts, making it easy for senior adults to read (see Figure 1a).

The booklet's design is informed by the theoretical literature on self-control. In particular, O'Donoghue & Rabin (1999, 2001) show that present-biased individuals will procrastinate on beneficial activities for them, such as exercising, when they involve immediate costs and the benefits accrue in the future. This theory was tested by Charness & Gneezy (2009), who found that lowering immediate costs through exogenous incentives effectively motivates students to engage in physical activity. Inspired by these insights, the FFP is designed to reduce the perceived immediate costs of physical activity and magnify its benefits. For example, to alleviate concerns and unease about exercising among senior adults, the booklet describes easy-to-do exercises with fun names to encourage participation. To ensure the exercises are age-appropriate, they were designed in collaboration with health experts from the Wellness Center of NYU Abu Dhabi. Recognizing the diversity in individual fitness levels, the booklet contains three fitness tiers of increasing intensity (see Figure 1b), allowing individuals to select exercises that neither overburden nor underwhelm them (see Figure 1c).

The booklet also provides customizable exercise plans to encourage goal setting, ideas on how to be physically active through everyday activities, and easily digestible information on the health benefits

[2]Testing an intervention with minimal personal contact as we do here may have the added benefit of limiting experimenter demand, and Hawthorne effects when measuring self-reported physical activity.

[3]Although this paper focuses on the FFP and not the diagnostic survey, for completeness, the complete survey can be found in Appendix A.

[4]For example, when answering the question "How much do the following factors limit your moderate physical activity?," the two most important factors for both men and women were 'lack of discipline' and 'lack of motivation.' The other options were: 'lack of personal time,' 'lack of appropriate space nearby,' 'lack of support from family and friends,' 'poor health (other than disability),' 'physical disability,' 'concern about being injured,' 'weather conditions,' and 'financial constraints.'

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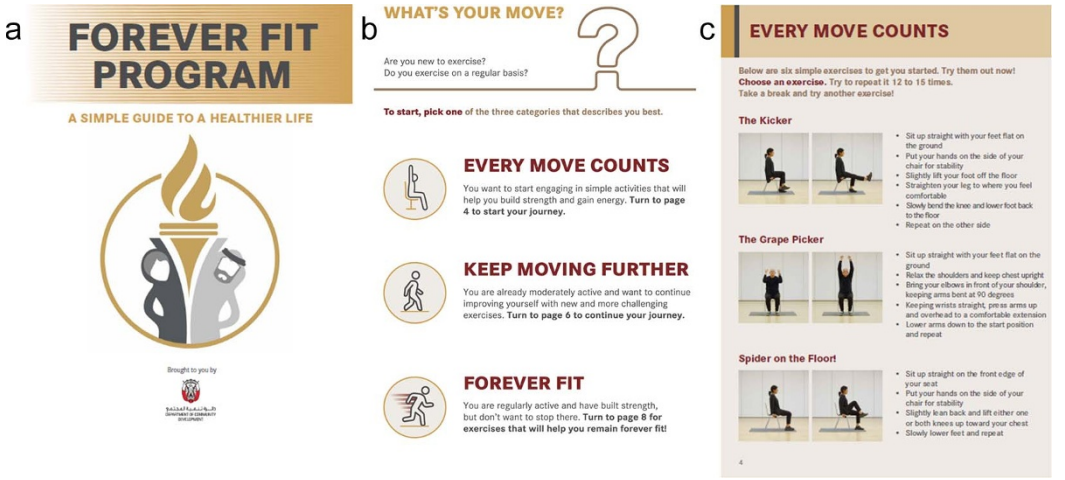


**Figure 1.** Excerpts from the forever fit booklet. (a) The booklet's cover (b) The three activity streams (c) Examples of exercises

of physical activity. Importantly, while the booklet mentions the long-term benefits of physical activity, it also emphasizes its immediate benefits, which should be more motivating for present-biased individuals. Additionally, the booklet includes a series of motivating messages identified as effective for this population (Notthoff & Carstensen, 2014). Lastly, the booklet includes links to a YouTube channel created to complement its exercise programs. The channel features a three-minute video explaining the FFP program and videos accessible through QR codes demonstrating each exercise.[5]

## 3. The randomized control trial

To evaluate the effectiveness of the FFP at increasing physical activity, we conducted a randomized control trial (RCT) during May and June 2021.[6] We recruited a sample of individuals aged 50 and above via text messages sent on our behalf by the Abu Dhabi Department of Community Development. In total, 206 senior adults residing in the Emirate of Abu Dhabi agreed to participate in the RCT.[7]

The low digital literacy of our sample and the COVID-19 restrictions at the time meant that the only viable option for measuring physical activity was through phone surveys. Specifically, we use questions from the International Physical Activity Questionnaire (IPAQ), a widely accepted survey instrument designed for this purpose (Craig et al., 2003). We measured the number of daily minutes spent on MPA, described to participants according to WTO guidelines as "activities that take moderate physical effort and make you breathe somewhat harder than normal, but you are still able to talk." We focus on MPA because our online survey indicated that senior adults in Abu Dhabi rarely engage in vigorous physical activity. In addition to physical activity, we measured time spent sitting, sleeping, and walking (see Appendix B for details). To reduce measurement error and mitigate recall bias, we modified the IPAQ to ask participants to report their behavior from the previous day, provided it was a typical day, rather than recalling their MPA over an entire week. The survey was administered over

[5]The video explaining the FFP can be found at https://www.youtube.com/watch?v=LWimE2XH2Bc. The exercise videos are also still available at https://www.youtube.com/@foreverfit3109/videos.

[6]The RCT evaluating the FFP was approved by the NYU Abu Dhabi IRB (protocol HRPP-2021-54).

[7]Of the 206 participants, 59% reported being 60 years old or older. Compared to the population in this age group, we have a higher fraction of men (78% vs. 59%), UAE citizens (42% vs. 30%), and residents of the city of Abu Dhabi (78% vs. 61%).

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the phone by trained independent enumerators, with real-time monitoring to ensure data quality.[8] To account for enumerator effects, participants were randomly assigned to a different enumerator each week. Moreover, participants were called on different weekdays to reduce the impact of day effects. Enumerators were blinded to our hypotheses and treatment assignment.

To establish baseline levels of MPA, all participants were surveyed once between May 16 and 18. Measuring initial MPA levels is essential because the benefits of increased physical activity appear to be much bigger for physically inactive individuals. For example, Moore et al., 2012 show that increasing daily physical activity from 0 to 10 minutes is associated with a similar improvement in life expectancy as increasing daily physical activity from 10 to 70 minutes. Hence, we would expect a smaller treatment effect on previously active participants.

After the initial survey, participants were randomly assigned to one of two groups. Those in the FFP treatment group received the FFP materials at home between May 19 and 20. To ensure delivery, we sent the materials via courier and required their signature. Participants in the control group did not receive any materials. We assigned 134 (65%) of participants to FFP treatment group and 72 (35%) to the control group.[9] By using a larger treatment group, we can examine whether the treatment effect varies based on initial MPA levels and specific participant characteristics such as gender and nationality.

We evaluated the impact of the FFP over a four-week period, from May 22 to June 17. During this time, participants were surveyed once a week to measure their MPA, providing up to four measures per participant. One of our primary concerns when designing the RCT was sample attrition. In particular, we worried that participants might drop out depending on their MPA levels. To reduce attrition, we incentivized participants to answer the phone surveys. Participants who completed a survey in a given week had a 1 in 10 chance of winning a prize (either a Fitbit smartwatch or a JBL wireless speaker). Additionally, those who answered all the RCT's surveys had a 1 in 10 chance of winning an iPad. The participation incentives had the desired effect, as participants answered an average of 3.9 out of 4 weekly calls in both the treatment and control groups. Moreover, 91% and 90% of participants in the treatment and control groups, respectively, answered all surveys. The very high participation rate and the fact that it is statistically indistinguishable across conditions means that our estimates are unlikely to be biased due to attrition.

## 4. Results

### 4.1. Baseline levels of physical activity

We begin by looking at the baseline levels of MPA. As shown in Figure 2, our sample exhibits high levels of physical inactivity. Specifically, 93 out of 206 senior adults were almost entirely inactive, engaging in 0 to 9 minutes of daily MPA.[10] From here on, we will refer to these participants as *inactive* senior adults and the rest as *active*. Overall, 45% of participants are classified as inactive (44% in the treatment group and 46% in the control group), while the remaining 55% are classified as active. Given that inactive senior adults account for nearly half of our sample and stand to gain the most from increased MPA, we consider the impact of the FFP separately for them. Note that the high fraction of physically inactive individuals in our sample is in line with the prevalence of physical inactivity among senior adults in other countries, underlining the significance of the problem (Al-Tannir et al., 2009; Mabry et al., 2012; Sibai et al., 2013).

[8] We included confederates in the call lists to ensure enumerators called at the scheduled times, followed the correct script, and accurately recorded data. Enumerators knew they would be monitored.

[9] Table A1 in Appendix C, presents the baseline means of our variables across both groups.

[10] Remarkably, 90% of inactive participants reported precisely zero minutes of MPA. For comparison, the WHO recommends that individuals engage in 150 minutes of MPA per week, implying around 21 minutes per day (World Health Organization, 2011).

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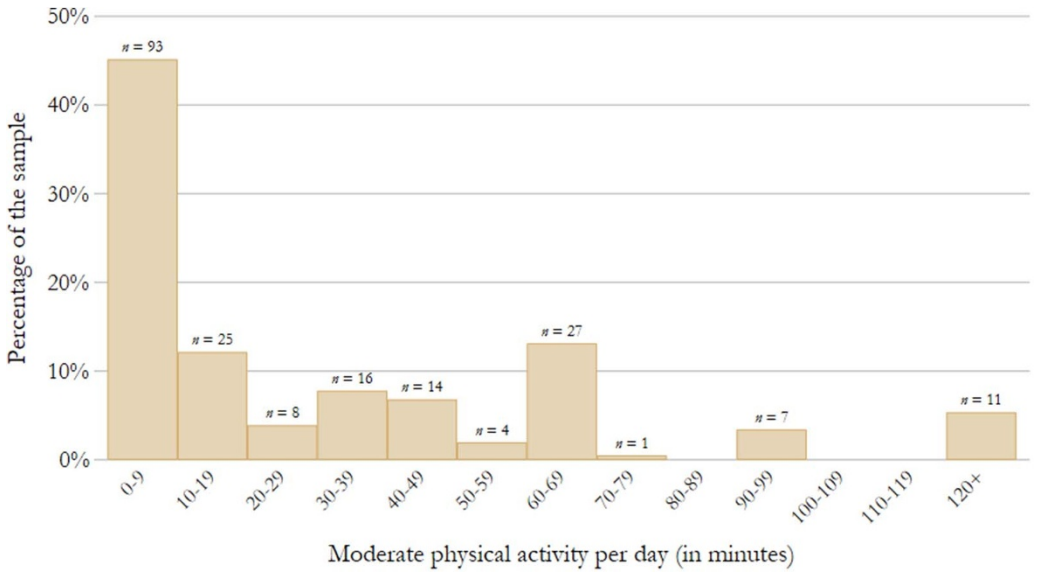


**Figure 2.** Distribution of baseline levels of moderate physical activity among senior adults

### 4.2. *Impact of the forever fit program*

Table 1 presents the estimated impact of the FFP on participants' MPA. Columns I through VI use the number of minutes of daily MPA as the dependent variable, while columns VII through IX use a binary variable indicating whether participants engaged in more than 10 minutes of daily MPA. Columns IV through IX include controls for individual characteristics, namely, gender, UAE citizenship, age, self-reported disabilities, region within the Emirate of Abu Dhabi, and the participants' baseline level of MPA. Panel A reports the estimated sample average treatment effect for initially inactive and active senior adults as well as the pooled sample. Panel B shows the estimated mean levels of MPA for participants in the FPP treatment and control groups. All estimates are based on linear regressions with robust standard errors clustered on individuals and include week, weekday, and enumerator fixed effects. We use post-stratification weights so that our sample is representative of the senior adult population in Abu Dhabi in terms of gender, citizenship (UAE nationals or expats), and regional distribution within the Emirate (Kalton & Flores-Cervantes, 2003). Applying post-stratification weights is common in the literature (Kulas et al., 2018). However, our results remain robust to using both non-clustered standard errors and unweighted estimates (see Table A2 in Appendix C).

The FFP had a noticeable and statistically significant positive effect on the MPA of inactive senior adults. Column I shows that, on average, inactive senior adults in the control group engaged in only 4.99 minutes of daily MPA. By contrast, inactive senior adults in the FFP treatment group engaged in 15.06 minutes of MPA per day, an increase of 10.07 minutes ($t = 3.36$, $p = 0.001$). This effect is comparable to the 10.43-minute average treatment effect reported by Chase (2015) in their meta-analysis. Column II shows that, as anticipated, the FFP had a much smaller effect on the MPA of active senior adults, with an estimated increase of only 0.69 minutes of daily MPA. This effect is far from being statistically significant ($t = 0.11$, $p = 0.917$), although we note that the standard error is fairly large. When pooling inactive and active participants, the FFP is estimated to increase daily MPA by 3.29 minutes (column III, $t = 0.70$, $p = 0.485$). The size of the overall effect is comparable to that in similar interventions. For example, Chase (2015) report that interventions that use only cognitive or behavioral components increase daily physical activity by 1.74 and 5.21 minutes,

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**Table 1.** Impact of the forever fit program on daily moderate physical activity for initially inactive and active senior adults

| | Daily MPA (no controls) | | | Daily MPA (controls) | | | MPA $>$ 10 min (controls) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inactive (I) | Active (II) | All (III) | Inactive (IV) | Active (V) | All (VI) | Inactive (VII) | Active (VIII) | All (IX) |
| Panel A: Sample average treatment effect | | | | | | | | | |
| FFP treatment | 10.07*** | 0.69 | 3.29 | 11.53*** | 2.77 | 5.24 | 0.23*** | 0.03 | 0.10* |
| | (3.00) | (6.59) | (4.70) | (2.96) | (6.37) | (4.38) | (0.07) | (0.06) | (0.06) |
| Panel B: Estimated means | | | | | | | | | |
| Control group | 4.99 | 34.40 | 22.80 | 3.98 | 33.07 | 21.51 | 0.19 | 0.66 | 0.47 |
| | (1.50) | (4.76) | (3.56) | (1.68) | (4.43) | (3.10) | (0.05) | (0.04) | (0.05) |
| FFP treatment | 15.06 | 35.09 | 26.09 | 15.51 | 35.84 | 26.75 | 0.42 | 0.69 | 0.57 |
| | (2.54) | (4.80) | (3.12) | (2.33) | (4.38) | (2.89) | (0.04) | (0.04) | (0.03) |
| Demographic controls | No | Yes | Yes | No | Yes | Yes | No | Yes | Yes |
| Control group observations | 124 | 156 | 280 | 124 | 156 | 280 | 124 | 156 | 280 |
| FFP treatment observations | 237 | 279 | 516 | 237 | 279 | 516 | 237 | 279 | 516 |
| Control group participants | 32 | 40 | 72 | 32 | 40 | 72 | 32 | 40 | 72 |
| FFP treatment participants | 61 | 73 | 134 | 61 | 73 | 134 | 61 | 73 | 134 |
| $R^2$ | 0.06 | 0.12 | 0.09 | 0.09 | 0.24 | 0.21 | 0.18 | 0.19 | 0.17 |

*Note:* Estimated sample average treatment effect (Panel A) and means for the FFP treatment and control groups (Panel B). The dependent variable is the number of minutes of daily MPA in columns I through VI, and a binary variable indicating whether participants engaged in more than 10 minutes of daily MPA in columns VII through IX. Inactive participants correspond to those who reported less than 10 minutes of daily MPA in the baseline survey, while active participants reported more than 10 minutes of daily MPA. Estimates are based on linear regressions. Robust standard errors clustered on individuals are in parentheses. All regressions use post-stratification weights so that our sample is representative of the senior adult population in Abu Dhabi in terms of gender, citizenship, and region within the Emirate. All regressions use week, weekday, and enumerator fixed effects. Demographic controls correspond to gender, UAE citizenship, age, self-reported disabilities, region within Abu Dhabi, and baseline level of MPA. ***, **, and * indicate statistical significance at 0.01, 0.05, and 0.10.

respectively—smaller effects than other more involved interventions.[11] When controlling for participants' demographic characteristics and baseline MPA levels (columns IV through VI), the estimated impact of the FFP increases slightly to 11.53 more minutes of daily MPA among inactive participants ($t = 3.89$, $p < 0.001$), 2.77 more minutes among active participants ($t = 0.43$, $p = 0.665$), and 5.24 more minutes for the pooled sample ($t = 1.20$, $p = 0.233$).

Columns VII through XI examine the prevalence of being physically active by looking at the fraction of participants who engaged in at least 10 minutes of daily MPA. Notably, the FFP's positive impact on MPA is not confined to a few overenthusiastic participants. While only 19% of inactive senior adults in the control group engaged in 10 minutes or more of MPA per day, this fraction more than doubled to 42% in the treatment group, an increase of 23 percentage points ($t = 3.37$, $p = 0.001$). For active senior adults, the effect was a much smaller increase of 3 percentage points ($t = 0.52$, $p = 0.604$). For the pooled sample, the FFP increased the fraction of seniors being physically active by 10 percentage points ($t = 1.70$, $p = 0.091$). For comparison, the closest study to ours,

[11]The fact that the overall treatment effect is not significant can be attributed to the observed variability in MPA between active and inactive participants. If we use the control group means and standard deviations to conduct a power analysis, we find that the minimum detectable effect size with a power of 80% is 15.51 minutes in the pooled sample, 7.42 minutes in the sample of inactive participants, and 24.33 minutes in the sample of active participants. Hence, while we are well-powered to detect the observed effect among inactive senior adults, this is not the case for the pooled sample.

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**Table 2.** Impact of the forever fit program on daily moderate physical activity for initially inactive senior adults depending on various demographic categories

| | Age | | Gender | | Citizenship | |
|---|---|---|---|---|---|---|
| | $< 60$ | $\geq 60$ | Male | Female | Emirati | Expat |
| Panel A: Sample average treatment effect | | | | | | |
| FFP treatment | 10.41* | 11.72*** | 10.84*** | 11.75** | 9.31** | 14.86*** |
| | (5.72) | (3.68) | (3.61) | (5.40) | (3.63) | (5.16) |
| Panel B: Estimated means | | | | | | |
| Control group | 4.87 | 4.15 | 5.43 | 2.50 | 4.38 | 4.67 |
| | (3.87) | (2.05) | (2.00) | (4.12) | (2.65) | (3.43) |
| FFP treatment | 15.28 | 15.87 | 16.27 | 14.25 | 13.68 | 19.53 |
| | (3.48) | (3.36) | (2.94) | (4.88) | (2.68) | (3.99) |
| Demographic controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 144 | 217 | 301 | 60 | 200 | 161 |
| Participants | 37 | 56 | 77 | 16 | 52 | 41 |

*Note:* Estimated sample average treatment effect (Panel A) and means for FFP and CONTROL (Panel B). Estimates are based on a linear regression with the number of minutes of daily MPA as the dependent variable. The sample is restricted to the 93 initially inactive senior adults. Treatment effects are estimated by interacting with the FFP treatment with age (above or below 60 years old), gender (male or female), and citizenship (UAE nationals or expats). Robust standard errors clustered on individuals are in parentheses. The regression uses post-stratification weights so that our sample is representative of the senior adult population in Abu Dhabi in terms of gender, citizenship, and region within the Emirate, and week, weekday, and enumerator fixed effects. Demographic controls correspond to self-reported disabilities, region within Abu Dhabi, baseline levels of MPA, and gender (in columns 1–2 and 5–6), UAE citizenship (in columns 1-4), and age (in columns 3-6). ***, **, and * indicate statistical significance at 0.01, 0.05, and 0.10.

Burke et al. (2013), reports that their intervention increased the fraction of seniors doing at least 10 minutes of MPA by 6.4 percentage points compared to their baseline treatment.[12]

Next, we decompose the impact of the FFP on different demographic categories. We focus on inactive senior adults as this sample showed a clearly positive response to the intervention. Specifically, we reran the regression in column II of Table 1, including interactions between the FFP treatment and age (whether a participant is older or younger than 60 years old), gender (male or female), and citizenship (UAE nationals or expats). These estimates are reported in Table 2. By and large, the FFP successfully increased the MPA of inactive senior adults regardless of their demographic category.

Lastly, we analyze the impact of the FFP over time. Figure 3 depicts the sample average treatment effect of the FFP for inactive senior adults, estimated separately for each week. As anticipated, there is no statistically significant difference in MPA prior to the program's initiation (Week 0). After that, we see that the effect of FFP is statistically significant and stable from the first to the last week of the intervention.

Although our primary focus was on MPA due to its health benefits, we also measured the time participants spent sitting, sleeping, and walking. For completeness, we explored the impact of the FFP on these variables, as seen in Table A3 of Appendix C. Consistent with our results for MPA, we find that the FFP increased the time spent walking for inactive senior adults ($t = 2.09$, $p = 0.040$) but not for active senior adults ($t = 0.07$, $p = 0.947$). Directionally, the FFP also decreased the time spent sitting by around 30 minutes and increased the time spent sleeping by around 10 minutes, but these effects are not statistically significant ($t < 1.05$, $p > 0.296$).

[12]To more accurately compare these estimates, it is important to consider that the fraction of initially inactive participants differed between the two studies (45% in ours vs. 29% in Burke et al., 2013). Assuming that the impact of both interventions is driven solely by initially inactive participants, we can adjust Burke et al.'s estimate to a population with 45% inactive individuals, yielding an increase of 9.6 percentage points in the fraction of moderately active participants. Unfortunately, Burke et al. (2013) do not report MPA in minutes, so a direct comparison of our other estimates is not possible.

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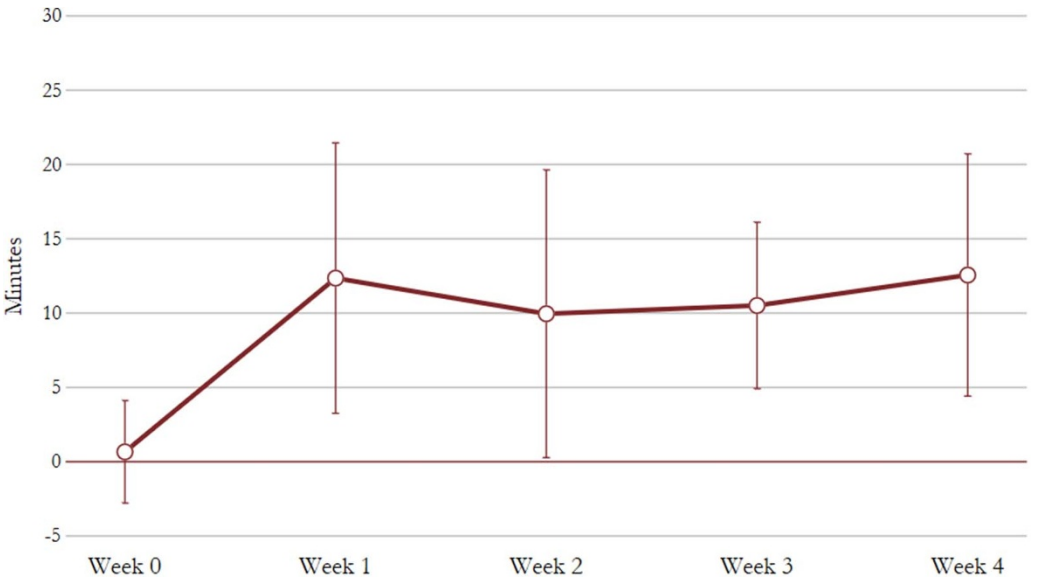


**Figure 3.** Impact of the FFP on daily MPA over time for inactive senior adults (in minutes)

## 5. Conclusion

This paper presents the evaluation of the Forever Fit Program, a nudge aimed at encouraging physical activity among senior adults in Abu Dhabi. The experimental results reveal that a booklet containing a simple, culturally and age-appropriate exercise program can effectively increase physical activity levels among previously inactive senior adults, even when confined to their homes. These findings are particularly encouraging for regions where outdoor activities are limited for extended periods due to environmental conditions.

Our findings underscore the potential of nudges to yield significant benefits, especially when the underlying causes of a problem are carefully diagnosed and addressed. That being said, we acknowledge the existence of limitations to our study that call for some caution when interpreting our results. First, due to COVID-19 restrictions at the time of the intervention, we measured physical activity using the International Physical Activity Questionnaire. This method is well-accepted, but since it is self-reported, it may be susceptible to experimenter demand and Hawthorne effects. Although we cannot completely rule out these biases, we believe they are unlikely to be the main drivers behind our results. Both treatment and control groups were aware of their participation in the study and received the same number of survey calls. Moreover, if participants in the treatment group felt compelled to report higher levels of MPA due to experimenter demand effects, we would expect to see significantly higher levels of MPA for both active and inactive senior adults.

Another limitation of our study is that due to cost considerations, we evaluated the FFP's impact over a relatively short time period. Although we did not observe a time trend in the program's impact during the four weeks of the intervention (see Figure 3), the long-term effects remain unknown. Despite this, the relatively low costs of the program and the immediate benefits of increased physical activity (such as better sleep) suggest that implementing this type of nudge can be welfare-enhancing, even if the increase in physical activity is short-lived.[13]

[13]The total cost of testing the FFP was $17,514.50 (AED 62,989), which included expenses for the booklet's graphical design ($9,226.00), printing ($1,150.00; $8.58 per unit), shipping ($364.50; $2.72 per unit) and incentives for the participants ($6,774.00). If the FFP was to be administered to the entire population of individuals aged 65 and above in the Abu Dhabi emirate, which according to the 2023 Census comprises of 69,540 individuals, the per-unit printing cost would drop to $4.36

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Lastly, while we tried to minimize selection into the sample during the recruitment process by providing incentives for participation, shipping all materials to people's homes, and using a very accessible, low-tech intervention, we cannot rule out that self-selection biases our estimated treatment effect. Our sample was recruited by the Abu Dhabi Department of Community Development from a proprietary database of phone numbers, which prevents us from testing whether our sample differs from the general population of senior adults in ways that would make the population average treatment effect differ from the sample average treatment effect (Imai et al., 2008). We do reweigh our estimates based on observable demographic characteristics to approximate representativeness in these dimensions. However, as in most studies of this kind, there can always be non-observable characteristics driving selection. Having said that, once recruited, participants were highly engaged, answering almost every survey call. Hence, we can rule out that self-selection biases our sample average treatment effect.

Based on the findings reported in this paper, the Abu Dhabi government decided to roll out the Forever Fit program across the entire Emirate of Abu Dhabi. This decision highlights the program's potential to make a significant impact on public health, particularly among senior adults who face barriers to outdoor physical activity.

**Supplementary material.** The supplementary material for this article can be found at https://doi.org/10.1017/esa.2024.5.

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