I wear a Fitbit™ therefore I am a Bitfit: Exploring the impact of a Fitbit™ device on exercise and work-related wellbeing

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I Wear a Fitbit™; Therefore, I Am a Bitfit: Exploring the Impact of a Fitbit™ Device on Exercise and Work-Related Wellbeing

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Abstract
Workplace wellbeing initiatives supporting mental health often utilise wearable activity trackers to promote physical activity. However, evidence regarding their efficacy is limited. The current study explored the potential for a Fitbit™ to increase engagement in exercise and to moderate the effect of exercise on work-related wellbeing in full-time workers. Participants recorded their work-related wellbeing and physical activity for two consecutive weeks, one wearing a Fitbit™. Results indicated that participants engaged in fewer minutes of exercise when wearing a Fitbit™, and that exercise alone was not associated with better work-related wellbeing. Participants were more frustrated when they exercised but were not wearing a Fitbit™. Participants also reported greater temporal demand when wearing a Fitbit™, which was exacerbated when not engaging in exercise. However, Fitbit™ wear was also associated with greater work-related satisfaction, regardless of whether they had engaged in exercise that day. Our findings imply that wearing a Fitbit™ can moderate the impact of exercise on work-related wellbeing, suggesting that it is not the activity tracker or exercise alone, but the interaction between the two which is key. The potential for wearable trackers to be effective in improving health and wellbeing is more complex than previously anticipated and warrants further investigation.

Keywords Exercise · Work-related wellbeing · Fitness trackers · Physical activity · Fitbit™

Introduction

In 2019–2020, 32.5 million workdays were lost due to work-related ill health in the UK. 17.9 million of these were lost to stress, depression, and anxiety (Health and Safety Executive, 2022). Consequently, the number of wellbeing initiatives in the workplace has grown amongst UK organisations. These initiatives often centre on the promotion of exercise with a focus on mental health (Statista, 2022). To facilitate engagement in exercise, activity trackers are often utilised. It may be no coincidence then that the global market for these is on an upward trajectory, rising from $36.34 billion in 2020 to an estimated $114.36 billion in 2028 (Fortune Business Insights, 2022).

Traditionally, activity trackers have taken the form of basic pedometers recording step count, but have evolved into wearable technology, such as the Fitbit™ and the Apple Watch, comprising a host of technological features. Wortley et al. (2017, p.12) defines wearable technology as "those technologies which are designed to be worn, attached to the body, and/or integrated into textiles and garments for the purpose of monitoring and/or influencing the health and well-being of the wearer." Therefore, we can make the distinction between mobile phone applications which can track activity and wearable activity trackers (WATs) such as the Fitbit™. The Fitbit™ has already shown some reliability in recording and reporting activity levels (Cadmus-Bertram et al., 2015; Diaz et al., 2015; Lee et al., 2014) making it a useful tool in free living studies.

WATs have shown some effectiveness in terms of increasing exercise (Lunney et al., 2016) and are preferable over traditional pedometers (Cadmus-Bertram et al., 2015). This is important as the benefits of exercise for physical health (Bauman, 2004) are widely documented. Indeed, research supports the idea that exercise not only improves physical health and prevents diseases (World Health Organisation, 2020) but is also beneficial for psychological wellbeing (Elkington et al., 2017), alleviating symptoms of both anxiety and depression (Anderson & Shivakumar, 2013; DeBoer

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et al., 2012; Guszkowska, 2004). This is supported by Roelofs and Du Bose (2018) who found that an eight-week exercise programme reduced anxiety and improved body image, regardless of change in weight. In addition, Xu et al. (2018) observed a strong negative correlation between the time spent engaging in exercise and depressive symptoms cementing the role of exercise in enhancing psychological wellbeing.

One manifestation of poor psychological wellbeing is work-related stress with many employees reporting stress at some point in their working lives (Elfering et al., 2017). There is some evidence that exercise can help alleviate (Gerber et al., 2020) or be seen as a moderator for work-related stress (Sliter et al., 2014). In a daily diary study, Sonnentag and Jelden (2009) found that participants believed that exercise was effective in relieving some of the work-related stress experienced. However, as their stress increased, participants were less likely to engage in exercise. Taken together, this evidence supports the potential for exercise as an intervention (Hansen et al., 2001; Yeung, 1996), and further, an intervention which utilises a WAT to maintain exercise, and subsequently, have a positive impact on psychological wellbeing.

Considering the importance of exercise for psychological wellbeing and the influence that WATs can have in increasing exercise, there is a potential for a moderating effect of WATs on the relationship between exercise and psychological wellbeing. Prior research has focussed primarily on the moderating effect of WATs to increase exercise with a goal to improve physical health. However, few studies have explored the potential moderating impact of WATs to increase exercise and subsequently improve psychological wellbeing. For example, Finkelstein et al. (2016) noted an increase in the amount of moderate to vigorous physical activity, when using a Fitbit™ Zip but did not measure the subsequent impact on wellbeing. Further, in a review of the effects of WATs on exercise and motivation for exercise, Nuss et al. (2021) concluded that although trackers were effective, their efficacy could depend on the characteristics of the user. The authors suggested that WATs may be more effective in those who were not currently meeting the recommended amount of exercise.

Some researchers have explored the moderating effect of WATs on wellbeing as part of a workplace intervention but did not specifically assess work-related wellbeing. Work-related wellbeing can be considered as a broad construct that encompasses a range of negative and positive aspects, including both burnout and ill-health but also happiness, flourishing, and thriving (Teoh et al., 2020). For example, in a Corporate Wellness Programme delivered by a major bank, Giddens et al. (2017) assessed the impact of a Fitbit™ on step count, subjective physical health, and psychological wellbeing. Step count increased, as did psychological wellbeing, which only improved with extended use of the device (for example, using other features such as recording sleep, food intake, etc.). In addition, Lennefer et al. (2020) explored work-related wellbeing but used a mobile phone application rather than a WAT as part of a randomised controlled trial technology-based intervention. Although the intervention successfully improved physical health, there was no improvement in work-related wellbeing. Since WATs have demonstrated some efficacy in promoting exercise (see Laranjo et al., 2020 for a review), it is important to consider the mechanisms underpinning their effectiveness. It is possible that WATs can provide a behavioural nudge, acting as a reminder to engage in a desired behaviour. This may centre on their potential role as extrinsic motivators, typically reward based (Hewett & Conway, 2016). The role of intrinsic and extrinsic motivators in behavioural change is reminiscent of Deci and Ryan's (1985) Self-Determination Theory (SDT), in which users see the device and are reminded that by engaging in exercise they will receive a reward. For example, this may be a notification or badge as confirmation of achieving a certain number of steps. The idea is that these extrinsic motivators encourage habit formation, and that over time, the user shifts from being extrinsically to intrinsically motivated. However, this also suggests that the removal of the activity tracker could, potentially, lead to disengagement (Renfree et al., 2016). Alternatively, WATs may contribute to self-regulation with regard to health behaviours, specifically, when engaging in exercise. Gowin et al. (2019) reported that participants viewed the self-regulatory aspects of wearing a WAT (such as being able to monitor and/or modify their behaviour to meet their goals) as being beneficial and boosted their confidence in meeting their exercise goals. Irrespective of the theoretical underpinning, this affirms the potential for WATs to have a positive effect on exercise and, consequently, wellbeing.

In summary, there is the potential for WATs to facilitate exercise which can subsequently improve psychological wellbeing, including work-related wellbeing, significant gaps in the literature remain. Given that WATs can increase exercise, it is surprising that the potential for these devices to further impact work-related wellbeing has not been exploited. In the present study, participants were asked to record their exercise in a daily diary containing measures of work-related wellbeing on two consecutive weeks, one week whilst wearing a Fitbit™ and one week without. The aim was to explore the potential for a WAT in the form of a Fitbit™ device to moderate the effect of exercise on work-related wellbeing in full-time workers. Further, we aim to demonstrate that taking part in exercise can reduce negative affect, increase positive affect, and improve measures of work-related wellbeing (work-related rumination and perceived workload) on days when exercise has occurred. It is also hypothesised that participants will engage in more exercise when wearing the Fitbit™, and that participants will report greater positive affect, lower negative affect, and more positive work-related wellbeing on those days where exercise has occurred.

Method

Participants

Thirty-one participants completed the study. Six participants were excluded due to missing data, either from withdrawal or incomplete diaries. There were no demographic differences between those who completed the study and those who did not. Further, there was no difference in terms of whether the participants commenced the study with the Fitbit™ versus without. Therefore, the final sample comprised 25 participants (21 females, 4 males) ranging from 23 to 63 years of age ($M=41.32$, SD = 11.16). Participants were recruited via social media (e.g., Facebook and Twitter) and posters distributed around campus. In addition, the study was advertised in a University of Chester Corporate Communication press release. Inclusion criteria were that participants were employed full-time and exercised at least once per week. In the recruitment materials, the term "exercise" was used in its broadest sense to be inclusive and flexible (i.e., any activity requiring physical effort). Furthermore, participant inclusion was not constrained by type and duration of weekly exercise normally undertaken, to increase ecological validity in a free-living study. Upon completion, participants were entered into a prize draw for a chance to win a Fitbit™. The study received ethical approval from the School of Psychology Ethics Committee at the University of Chester. All participants gave full informed consent. A summary of the sample demographics is presented in Table 1.

Measures

Background Demographics

To characterise, the sample, age, sex, occupation (including pattern of working and perceived work stressfulness), level of education, perceived healthiness, and exercise habits were recorded. In addition, height and weight were recorded to determine body mass index (BMI).

Daily Diary

Diaries are a rich source of within-subject level data (Nägel et al., 2015) and were utilised to permit daily assessment of exercise and psychological wellbeing (Kwan et al., 2011; Maher et al., 2014). Participants were asked to complete a paper-based daily diary at the end of each of the ten monitoring days. This was comprised of two five-day working weeks (five days with and five days without a Fitbit™). The following measures were included.

(i) Exercise engagement: Participants answered a set of questions to record and indirectly verify the total amount of exercise completed daily. These included (i) whether they had completed exercise, (ii) how many times, (iii) time of day, (iv) for how long, (v) type of exercise (e.g., running, walking, and gym session), (vi) level of effort for each exercise session ("How much effort would you say you have put into your exercise today?" from 1 (not much), to 10 (a lot)) and (vii) level of difficulty for each exercise session ("How difficult was your exercise session?" From 1 (not very) to 10 (very))

(ii) Work Rumination Questionnaire (WRQ, Cropley et al., 2006). The Work Rumination Questionnaire contains four items which centre on work-related rumination, for example, "Did you think about work in the last hour?". Participants respond using a seven-point Likert scale from 1 (not at all) to 7 (all the time)

(iii) NASA task load index (NASA-TLX) (Hart, 2006; Hart & Staveland, 1988). The NASA-TLX is a subjective, multidimensional measure assessing perceived workload across six subscales: (i) mental demand, (for example, *How much mental and perceptual activity was required?*); (ii) physical demand, (for example, *How much physical activity was required?*); (iii) temporal demand, (for example, *How much time pressure did you feel due to the pace at which the tasks or task elements occurred?*); (iv) performance, (for example, *How successful were you in performing the task?*); (v) effort, (for example, *How irritated, stressed, and annoyed versus content, relaxed, and complacent did you feel during the task?*); and (vi) frustration (for example, *How hard did you have to work (mentally and physically) to accomplish your level of performance?*). Since the original NASA-TLX focusses on a particular task, and because in the current study we were interested in the overall workload participants experienced each day, the question relating to the mental demands was changed from "How mentally demanding was the task?" to "How mentally demanding was your work today?" The response scale to each of the six subscales was adapted to a ten-point visual analogue scale. Unweighted responses to each of the subscales were analysed separately to permit a more detailed assessment of work-related demands (raw TLX) (Braarud, 2021; Hart, 2006)

Table 1 Sample characteristics ($N = 25$)

	N	Min	Max	Mean	Std. deviation
Age	25	23	63	41.32	11.16
BMI	25	21	39	26.42	4.45
Hours worked p/week	25	31	45	37.80	2.64
Perceived job stress	25	3	7	5.84	1.21
Number exercise sessions p/week	25	0	13	3.88	2.59
Perceived fitness	25	3	9	6.64	1.35
Perceived quality of diet	25	3	9	6.56	1.56
Units of alcohol p/week	24	0	30	9.83	9.97
Perceived quality of health	25	3	9	7.00	1.56
Highest qualification	25				
Master's degree (MA/MSc)	13				
Honour's degree/bachelor's degree/ordinary	4				
Diploma of higher education	2				
Certificate of higher education	1				
A/AS level	2				
HNC	1				
BTEC	1				
GCSE/O'Level	1				
Sex	25				
Male	4				
Female	21				
Smoker	25				
Yes	2				
No	23				
Employment status	25				
Employed full-time	25				
Employment type					
Administration	6				
Business and finance	3				
Civil service	8				
Health and support services	2				
IT	1				
Marketing	2				
Professional services	3				
Primary site of work					
Work on site	15				
Work from home once p/week	7				
Work from home more than once p/week	3				

(iv) Positive and negative affect schedule (PANAS) (Watson et al., 1988). The PANAS measures positive and negative affect by asking participants to rate the extent to which they experienced each of a list of 20 emotions (for example, *interested, irritable*) on a 5-point Likert Scale from 1 (*very slightly*) to 5 (*extremely*)

Fitbit™ Device

The Fitbit™ *Flex 1* was used as it has shown some reliability in recording and reporting activity levels (Cadmus-Bertram et al., 2015; Diaz et al., 2015; Lee et al., 2014). Although the number of steps was recorded in the current study, the data were not used as comparison step data from the non-Fitbit™

week was not available. The aim of the study was to assess the impact of the *presence* of the Fitbit™ device on exercise.

Procedure

Participants attended a face-to-face briefing session where they received information about the study and provided informed consent. They were then asked to complete background demographics questions and were measured (height) and weighed. As a precaution, participants were asked to refrain from wearing their own activity tracker for the duration of the study. However, only one participant declared they had previously used an activity tracker (and this was not a Fitbit™).

The study comprised two counterbalanced periods of monitoring (five consecutive working days), one with a Fitbit™ and one without. Participants were instructed to engage in exercise at least once per monitoring week and were provided with examples of the different types of exercise (for example, going to the gym, running, and bike riding). Although we were flexible in the type of exercise that they could engage in, we ensured that questions relating to exercise in the daily diary referred to "sessions" (e.g., number of sessions, difficulty of exercise session) to reaffirm that the exercise undertaken should be structured.

At the start of each period, participants were provided with a daily diary which required them to self-report the amount and type of exercise undertaken and to complete the WRQ, NASA-TLX, and PANAS. This was completed at the end of each monitoring day. This ensured that for each of the monitoring week (either a week with or without the Fitbit™), data from at least one exercise and no exercise days were recorded. Prior to using a Fitbit™, participants were guided through the setup and use of the device. They were asked to continually wear a Fitbit™ throughout the monitoring period. It was expected that there would be sufficient battery life for the duration of the monitoring period; however, a charger was provided in the event of battery failure. When completing the Fitbit™ condition, participants were also asked to record the time they hit (if at all) 10,000 steps that day (indicated by five flashing lights with vibration on the Fitbit™ device). As we were interested in the mere presence of the Fitbit™, this was the only feedback provided by the device during the monitoring period. Participants did not have access to the accompanying mobile phone application. Participants were asked to engage in exercise at least once per period of monitoring.

At the end of the first monitoring period, participants were asked to contact the researcher to arrange return of the equipment and the completed daily diary. They were then provided with the materials needed for the second monitoring period. At the end of both monitoring periods, participants were verbally debriefed and thanked for their time.

Data Analysis

Data from the daily diaries were entered into SPSS v26 for analysis. Differences in the amount of exercise undertaken (all types of exercise combined), perceived effort and job satisfaction between the Fitbit™ and No Fitbit™ periods were assessed using paired-samples *t*-tests. Data for WRQ, NASA-TLX, and PANAS were averaged across days with exercise and day without exercise. To explore differences in work-related wellbeing between exercise and no-exercise days (defined using the question of "have you exercised today") in the Fitbit™ and No Fitbit™ weeks and the potential for a Fitbit™ to moderate the effect of exercise on work-related wellbeing, a series of 2 (*exercise versus no exercise*) × 2 (*Fitbit™ versus No Fitbit™*) repeated measures ANOVAs were conducted. Significant interactions were followed up using two post hoc paired-samples *t*-tests with a Bonferroni correction that compared exercise versus no-exercise days (i) when a Fitbit™ was worn and (ii) when it was not.

Results

Prior to analysis, the internal reliability of each measure was assessed using Cronbach's alpha. As each measure was administered more than once (each day for two five-day working weeks), an average Cronbach's alpha was computed (Table 2).

Exercise During the Fitbit™ and No Fitbit™ Weeks

A series of paired samples *t*-tests were conducted to explore differences in the amount of exercise (number of sessions and total number of minutes exercised) and perceived effort when exercising when wearing a Fitbit™ compared to no Fitbit™. Means and standard deviations are shown in Table 3.

There was no significant difference in the number of exercise sessions between the Fitbit™ and the No Fitbit™ weeks (t (24) = -1.082, p = 0.290, d = 0.10), nor was there a difference in the perceived effort (t (20) = 0.038, p = 0.970, d = 0.01). Participants engaged in significantly *less* exercise

Table 2 Cronbach's alpha for WRQ, PANAS, and NASA-TLX

Measure		Cronbach's alpha Mean (SD)
WRQ		0.91 (0.04)
PANAS	Positive affect	0.90 (0.03)
	Negative affect	0.71 (0.11)
NASA-TLX		0.59 (0.07)

Table 3 Descriptive statistics for number of exercise sessions, number of minutes exercised, and perceived effort when using a Fitbit™ versus without ($N=25$)

	Fitbit™	No Fitbit™
Number of sessions	3.88 (4.35)	4.28 (3.57)
Total number of minutes	123.44 (96.74)	156.40 (84.82)**
Perceived effort	7.01 (1.92)	6.99 (1.68)

*$p<0.05$, **$p<0.01$

when wearing a Fitbit™ than when not (t (24) = -3.054, $p=0.005$), $d=0.36$), in terms of the total number of minutes exercised.

Exploring Differences in Work-Related Wellbeing Between Days Exercised and Days Without Exercise in the Fitbit™ and No Fitbit™ Weeks

A series of 2 × 2 repeated measures ANOVAs were conducted to explore differences in work-related wellbeing between exercise and no-exercise days in the Fitbit™ and No Fitbit™ weeks. Means and standard deviations for scores from the NASA TLX, work-related rumination, perceived control, and positive and negative affect are shown in Table 4.

NASA Task Load Index, Temporal Demand

There was a significant main effect of Fitbit™ use on temporal demand (F(1, 14) = 6.392, $p=0.024$, $\eta_p^2=0.31$). Participants perceived greater temporal demand when wearing a Fitbit™ ($M=5.71$, SD = 1.83) than when not wearing a Fitbit™ ($M=5.09$, SD = 1.62). However, there was no significant main effect of exercise on temporal demand (F(1, 14) = 0.569, $p=0.463$, $\eta_p^2=0.04$). Further, the interaction between Fitbit™ wear and exercise was also significant (F(1, 14) = 4.957, $p=0.050$, $\eta_p^2=0.25$). Post hoc analyses revealed that there was no significant difference in temporal demand on days exercised when wearing the Fitbit™ ($M=5.25$, SD = 2.06) compared to days exercised without a Fitbit™ ($M=5.48$, SD = 1.85) (t (20) = -0.583, $p=0.567$, $d=0.12$). However, on days with no exercise, participants reported greater temporal demand when wearing a Fitbit™ ($M=5.67$, SD = 1.48) than when not ($M=4.72$, SD = 1.34) (t (17) = 3.595, $p=0.002$, $d=0.67$).

NASA Task Load Index, Frustration

There were no significant main effects of Fitbit™ use (F(1, 14) = 0.092, $p=0.766$, $\eta_p^2=0.01$) or exercise (F(1, 14) = 4.066, $p=0.063$, $\eta_p^2=0.23$) on frustration. However, a crossover interaction between Fitbit™ wear and exercise was observed (F(1, 14) = 4.999, $p=0.042$, $\eta_p^2=0.26$). Post hoc analyses revealed that there was no significant difference in perceived frustration demand when wearing a Fitbit™ on days exercised ($M=3.72$, SD = 2.21) compared to days without exercise ($M=3.88$, SD = 2.07) (t(16) = -0.416, $p=0.683$, $d=0.07$). However, there was a significant difference in perceived frustration demand when not wearing a Fitbit™ on days exercised ($M=4.63$, SD = 1.96) compared to days without exercise ($M=3.36$, SD = 1.98) (t (18) = 3.541, $p=0.002$, $d=0.64$).

NASA Task Load Index, Performance

There was a significant main effect of Fitbit™ use on performance (F(1, 14) = 5.262, $p=0.038$, $\eta_p^2=0.27$). Participants reported greater satisfaction with their work-related performance when wearing a Fitbit™ ($M=6.96$, SD = 1.46) than when not ($M=6.60$, SD = 1.31). However, the main effect of exercise was not significant (F(1, 14) = 0.217, $p=0.648$, $\eta_p^2=0.02$) and neither was the interaction between Fitbit™ wear and exercise (F(1, 14) = 0.017, $p=0.898$, $\eta_p^2=0.00$).

Table 4 Descriptive statistics for work-related rumination, perceived control, positive and negative affect, and scores from the NASA TLX on exercise days versus no-exercise days when using a Fitbit™ versus without ($N=25$)

	Exercise day Fitbit™	Exercise day No Fitbit™	No-exercise day Fitbit™	No-exercise day No Fitbit™
NASA: mental demand	6.32 (1.78)	6.19 (1.78)	6.12 (1.73)	5.82 (1.48)
NASA: physical demand	2.02 (1.38)	2.02 (1.34)	2.01 (1.19)	2.36 (1.71)
NASA: temporal demand	5.59 (2.09)	5.46 (1.80)	5.83 (1.57)	4.72 (1.44)
NASA: performance	7.04 (1.38)	6.65 (1.36)	6.88 (1.54)	6.55 (1.26)
NASA: effort	6.48 (1.79)	6.25 (1.70)	6.26 (1.42)	5.76 (1.36)
NASA: frustration	3.99 (2.22)	4.77 (1.74)	4.17 (2.02)	3.50 (2.13)
Work-related rumination	2.87 (1.35)	3.06 (1.05)	2.97 (1.52)	3.02 (1.15)
Perceived control	5.16 (1.49)	5.77 (0.95)	5.62 (1.11)	5.63 (0.98)
Positive affect	26.91 (8.50)	26.61 (7.71)	25.99 (6.96)	23.97 (6.30)
Negative affect	12.70 (2.54)	12.98 (1.95)	12.52 (2.38)	12.01 (2.77)

NASA Task Load Index, Mental and Physical Demand and Effort

The main effects of Fitbit™ wear on mental demand ($F(1, 14) = 0.508$, $p = 0.488$, $\eta_p^2 = 0.04$), physical demand ($F(1, 14) = 1.133$, $p = 0.305$, $\eta_p^2 = 0.08$), or effort ($F(1, 14) = 1.359$, $p = 0.263$, $\eta_p^2 = 0.09$) were not significant. Additionally, the main effects of exercise on mental demand ($F(1, 14) = 1.901$, $p = 0.190$, $\eta_p^2 = 0.12$), physical demand ($F(1, 14) = 0.536$, $p = 0.476$, $\eta_p^2 = 0.04$), or effort ($F(1, 14) = 1.398$, $p = 0.257$, $\eta_p^2 = 0.09$) were also not significant. Further, the interactions between Fitbit™ wear and exercise and were not significant for mental demand ($F(1, 14) = 0.129$, $p = 0.725$, $\eta_p^2 = 0.01$), physical demand ($F(1, 14) = 0.624$, $p = 0.443$, $\eta_p^2 = 0.04$), or effort ($F(1, 14) = 0.358$, $p = 0.559$, $\eta_p^2 = 0.03$).

Work-Related Rumination and Perceived Control

The main effects of Fitbit™ wear ($F(1, 14) = 0.451$, $p = 0.513$, $\eta_p^2 = 0.031$), exercise ($F(1, 14) = 0.019$, $p = 0.892$, $\eta_p^2 = 0.001$), and interaction between Fitbit™ wear and exercise ($F(1, 14) = 0.177$, $p = 0.680$, $\eta_p^2 = 0.013$) on work-related rumination were not significant. In addition, the main effect of Fitbit™ wear ($F(1, 14) = 1.384$, $p = 0.259$, $\eta_p^2 = 0.09$), exercise ($F(1, 14) = 0.493$, $p = 0.494$, $\eta_p^2 = 0.03$), and interaction between Fitbit™ wear and exercise ($F(1, 14) = 2.120$, $p = 0.167$, $\eta_p^2 = 0.13$) on perceived control were also not significant.

Positive and Negative Affect

The main effects of Fitbit™ wear on positive affect ($F(1, 14) = 1.151$, $p = 0.301$, $\eta_p^2 = 0.08$) and negative affect ($F(1, 14) = 0.106$, $p = 0.749$, $\eta_p^2 = 0.01$) were not significant. Additionally, the main effects of exercise on positive affect ($F(1, 14) = 2.040$, $p = 0.175$, $\eta_p^2 = 0.13$) and negative affect ($F(1, 14) = 1.575$, $p = 0.230$, $\eta_p^2 = 0.10$) were not significant. Further, the interaction between Fitbit™ wear and exercise on positive affect ($F(1, 14) = 1.397$, $p = 0.257$, $\eta_p^2 = 0.09$) and negative affect ($F(1, 14) = 0.709$, $p = 0.414$, $\eta_p^2 = 0.05$) was also not significant.

Discussion

The aim of the current study was to explore the potential for a wearable activity tracker (WAT) in the form of a Fitbit™ to increase engagement in exercise and to moderate the effect of exercise on work-related wellbeing in full-time workers. The study also aimed to demonstrate that taking part in exercise could reduce negative affect and increase positive affect and improve measures of work-related wellbeing on days when exercise has occurred. The results indicated that, despite a similar number of sessions completed and amount of effort exerted, participants engaged in *fewer* minutes of exercise when wearing a Fitbit™. Furthermore, exercise alone was not associated with better work-related wellbeing, but appeared to be moderated by a Fitbit™ in terms of perceived workload. Participants reported significantly greater temporal demand when wearing a Fitbit™, which was even greater when wearing a Fitbit™ and *not* engaging in exercise on that day. Fitbit™ wear did not impact on perceived frustration and there was no difference in frustration on days with exercise compared to days without exercise. However, when *not* wearing a Fitbit™, participants reported greater frustration on days with exercise compared to days without exercise. Interestingly, participants were more satisfied with their work-related performance when wearing a Fitbit™, regardless of whether they had engaged in exercise that day. No other differences in wellbeing were observed.

We originally hypothesised that wearing a Fitbit™ would lead to an increase in exercise which would subsequently improve psychological wellbeing. However, our results suggest that the relationship between a WAT, exercise and psychological wellbeing is more complex than originally thought. This is especially true since participants reported exercising *less* when wearing a Fitbit™ and that exercise alone was *not* associated with improved psychological wellbeing. Any improvement in psychological wellbeing was contingent on both the presence or absence of exercise and the presence or absence of a WAT.

Although previous research has shown that engaging in exercise can improve psychological wellbeing (Anderson & Shivakumar, 2013; DeBoer et al., 2012; Guszkowska, 2004), few studies have explored *work-related* wellbeing specifically, which we would also expect to improve with exercise (Elkington et al., 2017; Gerber et al, 2020; Harris et al., 2006; Sliter et al, 2014). However, we found no evidence of this. Null effects of exercise on psychological wellbeing have been previously documented (Hamer & Stamatakis, 2010), but what was interesting in our results, was the observation that the use of a Fitbit™ appeared to moderate the effect of exercise on work-related wellbeing. This was evident when exploring perceived workload as determined by the NASA Task Load Index (NASA-TLX) (Hart, 2006; Hart & Staveland, 1988).

Surprisingly, our findings suggest that participants experienced *greater* temporal demand when wearing a Fitbit™. Furthermore, this was exacerbated when participants *did not* exercise, indicating that participants felt under greater time pressure when wearing a Fitbit™. To explain this, it is possible that the WAT acted as a reminder that the user should be exercising (Caraban et al., 2019). This then led to increased feelings of pressure when participants were not engaging in exercise when wearing a Fitbit™. We could speculate that the pressure would be increased further if participants intended to exercise but could not (for example, due to competing work commitments) but this was not assessed. Therefore, this suggests that the mere presence or sight of the WAT was sufficient to serve as a nudge to exercise. This is reminiscent of other behavioural change paradigms (Cadario & Chandon, 2019) but utilised much less so when assessing the impact exercise can have on wellbeing. It is also important to note that the WAT used in the current study had limited functionality. Therefore, the potential for it to motivate behaviour could reflect a more simplified version of nudge theory (Thaler & Sunstein, 2009).

Interestingly, when *not* wearing a Fitbit™, participants reported greater frustration on days when they *had* engaged in exercise. However, participants' frustration did not differ between days with and without exercise when wearing a Fitbit™. This is evidence of a possible moderating effect of a WAT on the relationship between exercise and psychological wellbeing. Perceived frustration was contingent on both the presence or absence of exercise and the presence or absence of a WAT. In this instance, frustration increased when exercising but *not* wearing a Fitbit™. Frustration may be higher as the required act of engaging in exercise was not being recorded. This is supported by what can be described as the potential "dark side" of WAT usage. Duus and Cooray (2015) noted that participants reported feeling "naked" without their device and felt that their activity was wasted as it was not recorded. Indeed, some studies have shown that negative feelings coincide with the removal of a WAT for those who typically wear one (Ryan et al., 2019). However, in our study, the order in which participants completed the two periods of monitoring (i.e., when they received the WAT) was counterbalanced to prevent such order effects.

The observation that perceived frustration was not contingent on exercise when wearing the WAT may reflect the possibility that participants feel that the act of merely *wearing* the device means that they are doing enough and are 'active'. This effect has been anecdotally reported with both the use of a WAT and also fitness wear or 'active wear' (Brice & Thorpe, 2021; Brown, 2015). Externally, the WAT enhances the perception by others that the person is 'active', regardless of whether they are or not. This effect may be explained by moral licencing theory. This theory proposes that displaying a moral action increases the probability of subsequent behaviour that is immoral, unethical, or otherwise problematic (Merritt et al., 2010). Applying this to our results, wearing a Fitbit™ projects or affirms the positive self-image of being an 'active' person. This may be a form of moral action which is consistent with the suggestion that people view exercise as being part of their social responsibility, to avoid burdening healthcare systems. Therefore, a person is responsible for taking care of their own health (Traina et al., 2019). If participants then choose *not* to engage in exercise, the consequences are minimised as it will not change the external perception that they are an 'active' person and, therefore, socially responsible. To the authors' knowledge, moral licencing has been applied to climate or eco behaviours (Burger et al., 2022) and not to the study of exercise promotion. However, clear parallels are evident in the application of this theory. Burger et al. (2022) found that when participants were reminded of past climate-friendly behaviour, their experience of discomfort triggered by ongoing problematic climate behaviour decreased. Similarly, the presence of the WAT reminds the user that they intend to exercise and, subsequently, reduces the discomfort of not doing so. This possibility raises more questions to be answered by future research in terms of determining the motives for using a WAT and engaging/or not in exercise.

Consistent with this is the finding that participants reported that they engaged in *fewer* minutes of exercise when wearing a Fitbit™. Although this was unexpected and opposite to what was hypothesised, it is also consistent with the idea of moral licencing. Indeed, the Fitbit™ and other similar devices are marketed as tools with the potential to increase exercise, with effects documented in previous research (for example, Finkelstein et al., 2016). However, our data suggest that their ability to do so may be influenced by other factors.

To more accurately assess the ability of a WAT to moderate the relationship between physical activity and wellbeing, we need to assess the motivation for using a WAT. Our findings show that wearing a WAT and not exercising increases temporal demand, but also that frustration increases when exercising and *not* wearing a WAT. Thus, exploring *why* a person is wearing a WAT is crucial for our understanding of the impact it can have on wellbeing. Previous studies have mainly focused on how a WAT can improve motivation for physical activity but have not explored the motivation for having a WAT in the first place. In a qualitative assessment of the impact of prior motivation on WAT usage, Jarrahi et al. (2018) found that a WAT alone was not capable of providing incentive for exercise. Prior motivation for use was needed to ensure their effectiveness. This supports the need for more information on *how* WATs are used rather than how many are sold. It is possible that high sales figures mask the potential for high abandonment (Clawson et al., 2015).

Limitations

One important aspect of the potential efficacy of a WAT is the degree to which participants can engage with the device. Giddens et al. (2017) found that a Fitbit™ could successfully increase step count and improve psychological wellbeing, but *only* when participants used additional features, such as recording sleep or food intake. In support of this, Kapteyn et al. (2021) compared the use of two versions of a WAT, one which provided feedback and one which did not. Exercise only increased when wearing the device which provided feedback to the user. The suggestion that feedback is important is consistent with Deci and Ryan's (1985) self-determination theory (SDT). The power of a WAT may be is in its ability to offer rewards for engaging in physical activity. This serves as an extrinsic motivator which may have been absent, or at least considerably reduced, in our study, as extremely limited feedback was given (only an indication of step count via flashing lights, one per 2 k steps to a maximum of 10 k steps). The Fitbit™ used here had limited functionality, and participants were not given access to any extended features, nor were they provided with any other form of additional support during the study. However, this explanation remains purely speculative as a device with feedback was not included as a comparison. Therefore, future research should explore the potential to interact with the WAT in more depth.

Some researchers have suggested that effective use of a WAT may depend on the sample studied. Research has shown that WATs can increase exercise in a variety of populations, for example, in children and adolescents (Creaser et al., 2021), older adults (Oliveira et al., 2020), clinical populations (Singh et al., 2022), and in healthy adults (Laranjo et al., 2020). Further, a review by Nuss et al. (2021) concluded that the effect of a WAT may be more pronounced in those not meeting the minimum requirements for exercise. The sample in our study was recruited on the basis that they exercised at least once per week which may have impacted on the effect of the device. However, consistent with our findings, some research has reported null effects of WATs on exercise (Cajita et al., 2020; Kim et al., 2018); therefore, it is difficult to draw any firm conclusions.

It is also evident that research exploring the effectiveness of a WAT in promoting exercise for psychological wellbeing should acknowledge prior use. This has implications for the assessment of (i) the effectiveness of the WAT in increasing exercise and (ii) its subsequent impact on psychological wellbeing. Advances in technology have meant that not only has the appearance of the WATs changed (resembling a traditional watch) but so has their functionality. This means that whether the user is wearing a WAT is less obvious. This then has implications for how this external view is constructed or maintained, should moral licencing apply. Consequently, the markers which label an 'active' person may be more subtle, which may impact on the amount of exercise the user engages in. It could be that their widespread use may centre on their more typical watch-related functions, rather than those designed to promote and record exercise. If the exercise-related functions are lost amongst the host of other features, the ability to 'nudge' behaviour could also be lost. The WAT used in the current study was primarily designed to track exercise; therefore, it would be of interest to assess a variant with greater functionality.

Conclusion

Previous research has used WATs such as Fitbit™ to quantify the amount of exercise undertaken as part of an intervention, but few studies have assessed the impact that this may have on psychological wellbeing. Our study shows that wearing a Fitbit™ can moderate the impact of exercise on work-related wellbeing, suggesting that it is not the activity tracker or the exercise alone, but the interaction between the two which is key. In addition, future research should consider the prior motivation for WAT usage.

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Data Availability The data that support the findings of this study are available from the corresponding author, NL, upon reasonable request.

Declarations

Conflict of Interest The authors declare no competing interests.

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