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Physical activity and sedentary behaviour of Bahraini people with type 2 diabetes: A cross-sectional study

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Abstract

Objective: Study patterns of physical activity and sedentary behaviour and the influence of demographics and body mass index (BMI) on these behaviours amongst Bahraini adults with type 2 diabetes over 10 weeks using an activity tracker.

Method: This cross-sectional observational study was conducted at a Bahrain government health centre. Thirty-three Bahraini Arab adults, 30–60 years old, with controlled type 2 diabetes, wore a Fitbit Flex 2^{TM} activity tracker for 10 weeks. Data on age, sex, marital and employment status, education and BMI were collected at the start of the study.

Results: A total of $N = 32$ participants completed the study. The average steps per day were 7859 ± 4131, and there were no differences between baseline, week 5 and 10. A third of participants were sedentary, based on a threshold of 5000 steps/day. Females accumulated fewer average daily steps than males (6728 ± 2936 vs. 10,281 ± 4623, $p = 0.018$). Daily averages for physical activity intensity were as follows: sedentary (786 ± 109 min), light (250 ± 76 min), moderate (9 ± 10 min) and vigorous (12 ± 18 min). Males had higher daily averages versus females for moderate (13 ± 9 vs. 5 ± 9 min, $p = 0.018$) and vigorous physical activity (21 ± 23 vs. 5 ± 7 min, $p = 0.034$). 91% of participants wore the device ≥10 h/day. The adherence rate was 79% based on percentage of days the device was worn continuously over 10 weeks.

Conclusion: Future physical activity interventions should target sedentary and female participants with type 2 diabetes. In addition, we need to understand the facilitators and barriers to physical activity and the physical activity preferences of these two subgroups.

Keywords

Exercise, physical activity, behaviour, mHealth, type 2 diabetes mellitus

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Introduction

Type 2 diabetes (T2DM) is a diverse metabolic disorder characterised by persistent elevation of blood glucose that causes long-term vascular complications (cardiovascular disease, retinopathy, nephropathy and neuropathy) and premature mortality.[1] The number of people diagnosed with diabetes in Bahrain has risen from 9% in 2002 to 15% in 2022,[2,3] and it has been estimated that the direct costs of treatment consume 20% of the country's total health expenditure.[4]

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Dietary restriction, sleep hygiene, stress management, increased physical activity (PA) and reductions in sedentary behaviour (SB) are the fundamentals of intensive lifestyle management in T2DM.[5–7] The American College of Sports Medicine (ACSM) recommends that people with T2DM engage in regular PA and reduce sedentary time.[6] Recommended PA for adults is defined as ≥150 min of moderate-intensity (i.e., >3 metabolic equivalents [METs]) PA/week by the World Health Organisation (WHO).[8] Walking is the simplest form of PA; alternatively, it is recommended that adults aim for ≥4000 steps/day, and the more, the better.[9] Sedentary behaviour reduction is defined as limiting any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting, reclining or lying posture.[10] The benefits of adopting these changes in lifestyle behaviour include reduced HbA1C, triglycerides, blood pressure, insulin resistance and percentage of body fat[8,11,12] and lower risk of all-cause mortality in T2DM.[10,13]

Low adherence to the ACSM's PA guidelines remains a major behavioural challenge.[10,14] People with T2DM are more sedentary, do less PA, have lower cardiovascular fitness levels and are at higher risk for comorbid conditions that may affect mobility (e.g., sarcopenia and diabetic foot ulcers) compared to people without diabetes.[13,15,16] There are limited PA and SB data for people with T2DM in the Eastern Mediterranean Region, but it is estimated that at least 65% do not meet recommended PA guidelines, with very little data on SB.[17–20] Similarly, there are limited current data about the amount of PA currently done by adults with T2DM in Bahrain[21]; these data have been collected using self-reported measurements.

Understanding the PA and SB patterns in Bahraini adults with T2DM is an essential first step towards our long-term goal of planning and developing a 10-week PA intervention. Evidence suggests that adults overestimate their PA compared to objective measurements over seven days.[22] On the other hand, wearing tracker devices can increase PA in the short term.[23–25] Furthermore, hot and humid weather, environmental conditions and cultural events can impact PA in the Eastern Mediterranean Region.[26]

Our aim was to study patterns of PA and SB and the influence of demographics and body mass index (BMI) on these behaviours amongst Bahraini adults with T2DM over 10 weeks using an activity tracker.

Methods

Study design

The study was a cross-sectional observational design of 10 weeks duration (Figure 1), from January to April 2019.

Study sample

Participants were recruited at Mohammed Jassim Kanoo Health Centre, in the 5th health region, Kingdom of Bahrain.

Sample size

We estimated the sample size for our study based on the following calculations and assumptions. For a national study, we calculated the sample size required as 340 patients using an estimated 30% prevalence of meeting WHO PA recommendations, 95% confidence limits, a precision of 5% and a dropout rate of 5%. As a proportion of all Bahraini people with T2DM attending primary health care centres, Mohammed Jassim Kanoon Health Centre received 5.4%, based on data from 2021. Therefore, we estimated the sample size as $n = 18$. Due to the availability of participants and the protocol's demands, a sample of 33 Bahraini adults with T2DM was recruited. The number of participants in our study is typical for studies of this nature and duration.[27]

Inclusion criteria

- T2DM (i.e., HbA1c 6.5–9.0%) controlled with medication in the four months prior to participating in the study
- Age 30–60 years. This age range was chosen because (i) ∼6.6% under 44 years self-reported having diabetes in the most recent Bahrain National Health Survey[28]; (ii) adults over 60 years old had older models of mobile phones that often lacked Bluetooth technology, making it difficult to pair the Fitbit or track their data.
- No chronic disease apart from minor complications of T2DM
- Willingness to wear the fitness tracker wristband continuously (24 h/day) for 10 weeks
- Cognitive ability to give informed consent to participate

Exclusion criteria

- Taking insulin to control T2DM
- Female participants who were pregnant or breastfeeding
- Participants with any medical condition(s) which reduced their ability to stand or mobilise
- Presence of significant diagnosed disease unrelated to T2DM
- Inability to read and understand Arabic or English language

Recruitment

Whether a patient met the study criteria for inclusion was determined by the gatekeeper, a diabetologist at the health centre and not a part of the research team. In addition, a specialist nurse at the health centre confirmed whether each patient met the criteria during a regular visit and, if so, provided them with a leaflet summarising the study in English and Arabic. Those who were interested contacted one of the

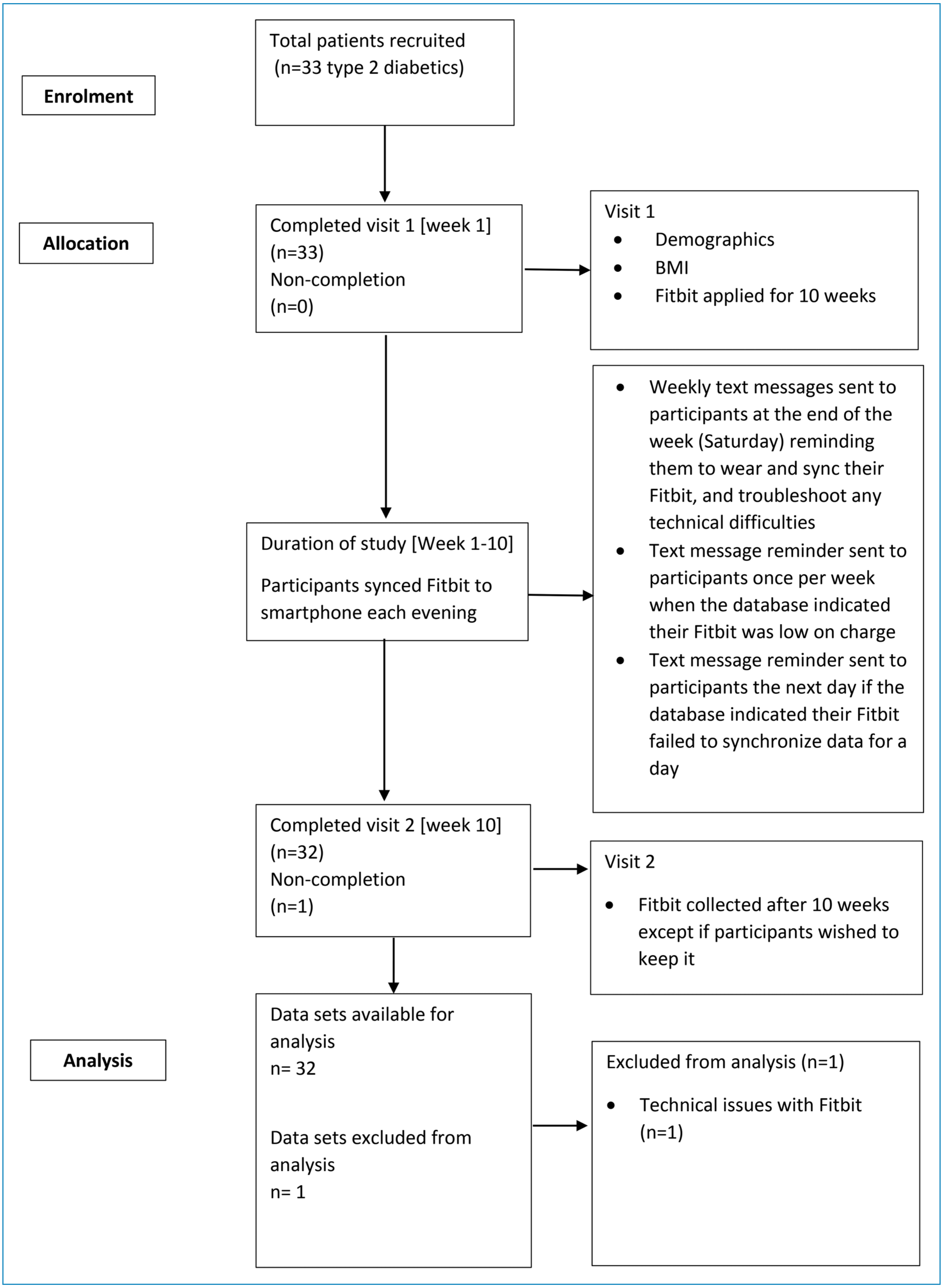

Figure 1. Overview of the study.

researchers to learn more about the study. An orientation session was organised for interested individuals, where they were shown a short video providing an overview of the study in English and Arabic and given a copy of the Participant Information Leaflet. Written informed consent was provided by all participants prior to the initiation of the study.

Demographics

Basic demographic information about age, sex, marital and employment status, and education were collected from each participant's electronic health records.

Body mass index

Height and weight measurements were conducted during visit 1 by PW using a combined stadiometer and weighing scale (Seca 700; Seca GmbH & Co. KG., Germany). The BMI was calculated as weight divided by the square of the height (kg/m^2). Standard categories of body weight status were applied (underweight: <18.50 kg/m^2; normal weight: 18.50–24.99 kg/m^2; overweight: 25.00–29.99 kg/m^2; obese: ≥30.00 kg/m^2).[29]

Physical activity tracker

Physical activity was measured using the Fitbit Flex 2$^{\text{TM}}$ device (Fitbit Inc.; San Francisco, CA), which has a three-axis accelerometer to count steps and has moderate to high validity with a tendency to undercount steps and underestimate moderate and vigorous PA.[30,31] The SmartTrack feature on Flex 2$^{\text{TM}}$ automatically recognises and records high movement activities such as running, aerobic exercises and cycling.[32]

Participants were provided with the device and instructed on using, charging and synchronising it's data to the Fitbit App. During visit 1, the Fitbit App was downloaded onto each participant's smartphone and synchronised with the device. Participants were instructed to wear the device throughout the study and remove it only when charging to obtain reliable and valid data for analysis.[33] No alarms or reminders were set up on the device. Continuous wear was necessary because we also collected data on sleep patterns; these are not reported in this article.

Participants' Fitbit accounts were added manually to the research project account assigned by Fitabase (https://www.fitabase.com/). Fitabase is a third-party data management company designated to remotely collect Fitbit data from all selected research Fitbit accounts on behalf of the study. Fitabase generates access to the data sets but does not process them *per se*. We accessed the data for two purposes. Firstly, we monitored participants' compliance with research study requirements (i.e., wearing the device continuously and regularly synchronising with the Fitbit server) (Figure 1). Participants were sent a text message once per week (on a Saturday), reminding them to wear and synchronise their Fitbit and troubleshoot any technical difficulties. A text message reminder was also sent to a participant when the Fitabase indicated their device was low on charge or if they had failed to synchronise their data for a day. Secondly, we downloaded a complete set of PA data (daily steps total, minutes of light, moderate and vigorous intensity exercise and minutes of sedentary time) for each participant after the study was completed for the analysis.

We categorised average daily step count for the entire 10 weeks as sedentary (<5000), low PA (5000–7499), somewhat active (7500–9999), active (10,000–12,500) and highly active (>12,500) according to Tudor-Locke and Bassett.[34] For PA intensity, active minutes of ≥10 min duration are calculated by Fitbit as metabolic equivalent of task (MET)[35] and accord with categories recognised by the WHO.[8] Briefly, sedentary was defined as any waking behaviour characterised by an energy expenditure of 1.5 METS or lower while sitting, reclining or lying. Light intensity PA is 1.5–3 METs. Moderate intensity was 3–6 METs, and vigorous was more than 6.0 METs. We expressed the data as PA intensity per day. We calculated the adherence rate as the percentage of days the Fitbit was worn continuously over the ten-week study period. We expressed wear time as the percentage of participants who wore the device for at least 10 h each day during waking hours.

At the end of the 10 weeks, each participant was sent their data, and then the study-assigned Fitbit accounts were deleted from the Fitabase service. Fitabase automatically deleted all data and backups related to these accounts 90 days after their removal from the Fitabase service. Finally, participants were instructed to create a new Fitbit account for their personal use if they wished to continue using the device.

Anonymity of participants

Each participant was assigned a unique identification code. This code was used when setting up each participant's research Fitbit account and replaced their name in the email address required for the account. Only one of the researchers had access to the information associated with each identification code, such as the unique email address assigned to the Fitbit device, their age, sex, height and weight. No other identifying information about the participant was included in the participants' research Fitbit accounts. Finally, a dedicated phone number was used in the study so that participants could contact one of the researchers for troubleshooting and queries.

Statistical analysis

Descriptive statistics were used to compute the frequency, percentages, mean and standard deviations. For PA data,

Table 1. Demographics and body mass index at baseline.

	DM2, $N = 32$		
Age [years] (mean, SD)		50.2	6.3
BMI [kg/m^2] (mean, SD)		32.8	6.1
Gender (*N*, %)	Male	14	43.8
	Female	18	56.3
BMI category (*N*, %)	Normal	2	6.3
	Overweight	10	31.3
	Obesity	20	62.5
Education (*N*, %)	No Education	2	6.3
	School	10	31.3
	High School	18	56.3
	University	2	6.3
Employment (*N*, %)	Unemployed	15	46.9
	Employed	9	28.1
	Retired	8	25.0
Smoking (*N*, %)	No	29	90.6
	Yes	3	9.4
Marital status (*N*, %)	Single	0	0
	Married	31	96.9
	Other	1	3.1

Demographic data expressed as number and percent; age and body mass index (BMI) data expressed as mean and standard deviation.
T2DM: people with type 2 diabetes.

we calculated weekly averages and the average over 10 weeks, including none wear periods during waking hours. The normality of data distribution was assessed by the Kolmogorov-Smirnov test. The Chi-square or Fisher's exact probability tests were used to assess the statistical differences in categorical data. Differences in the mean or median of continuous values were analysed using a *t*-test, Mann–Whitney test or Kruskal–Wallis test as appropriate. Analysis of variance (ANOVA) for repeated measurements (for normally distributed data) or Friedman test (for non-normally distributed data) were used to assess the differences in various parameters between different time points. For post-hoc comparisons between the time points, Bonferroni correction was applied to reduce the inflation of type I error. A general linear model was used to assess the effects of other confounding variables on the category of PA (Steps per day). All the tests were two-sided, and a p-value < 0.05 was considered statistically significant. All statistical analysis was performed using SPSS Statistics for Windows version 23.0 software (RRID: SCR_002865) (IBM Corp, Armonk, NY, USA).

Results

Thirty-two participants completed the study. One participant was excluded from the analysis because they did not have a suitable smartphone which could download the Fitbit app.

Demographics and BMI at baseline

Table 1 shows the basic demographic data of the study participants at baseline. There were more females ($n = 18$, 56%) than females ($n = 14$, 44%), although this difference was not statistically significant. Significantly more participants were obese ($p = 0.00$). There were more participants (56.3%) who completed their high school. About half of the participants were unemployed (46.9%). Most participants were married (96.9%) and non-smokers (90.6%).

Adherence rate and wear time

Over the 10 weeks of the study, 90.63% of participants achieved a wear time for the Fitbit of ≥10 h/day during waking hours. Based on the number of days the Fitbit device was worn continuously over 10 weeks, the mean adherence rate was 78.61 ± 35.41%. Non-parametric tests indicated that the adherence rates were not different for categories of gender, age groups, BMI, marital status, employment status and educational status.

Physical activity

Mean daily step count.

Over 10 weeks, the average steps per day were 7859 ± 4131 for the entire sample. There were no significant differences between step count at baseline (7495 ± 3797), week 5 (7981 ± 4125) and week 10 (8381 ± 4846) ($p = 0.115$). Non-parametric tests showed that average steps per day did not vary significantly across different categories of BMI, education, employment and marital status. However, females had significantly lower average steps per day than males (6728 ± 2936 vs. 10,281 ± 4623, $p = 0.018$) (Figure 2).

Frequency distribution for daily step count.

The largest category was sedentary lifestyle (<5000 steps/day), with 31.3% of the participants. Nineteen percent were low active (5000–7499 steps/day). However, only 16% had a highly active lifestyle (>12,500) (Figure 3).

A generalised linear model was performed to analyse variability in PA across the demographic variables. The variables gender, BMI category, education and employment

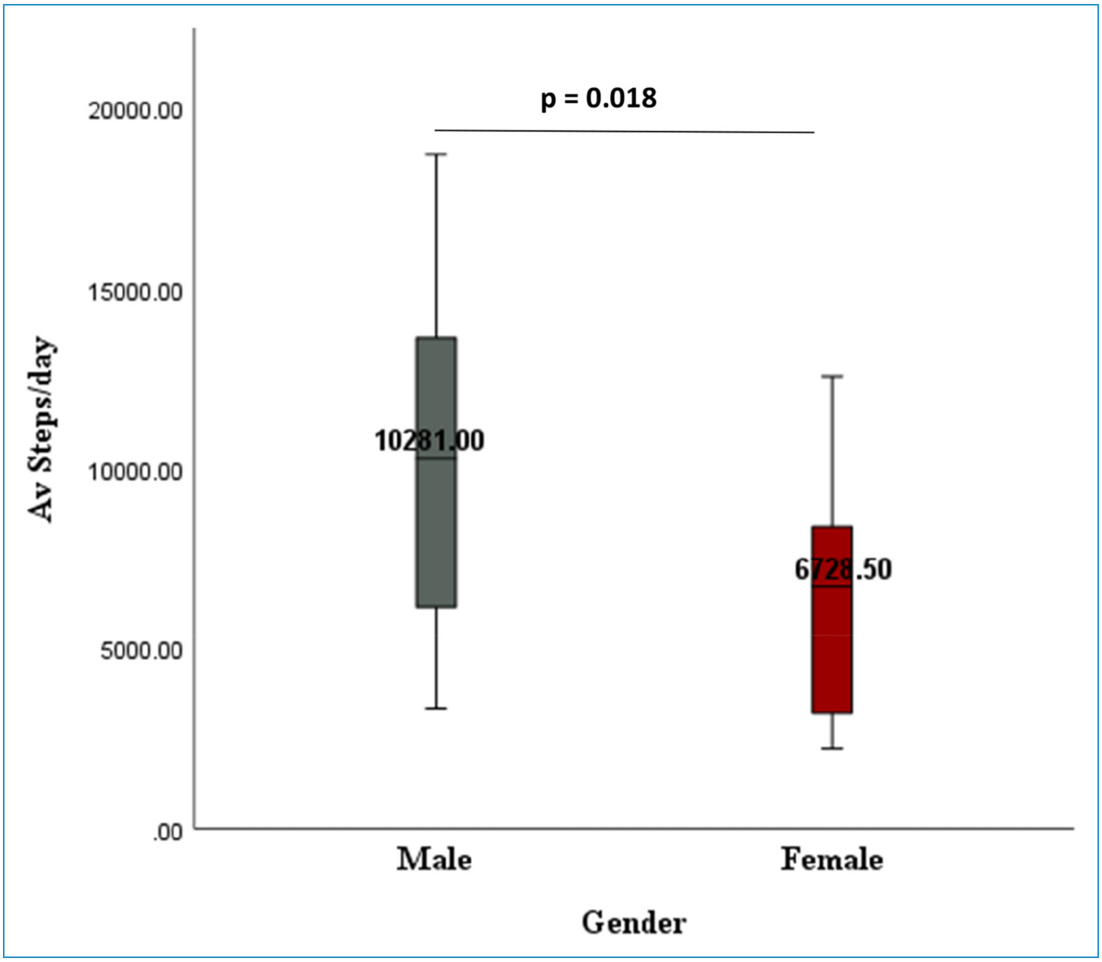

Figure 2. Comparison of daily step count between males and females.

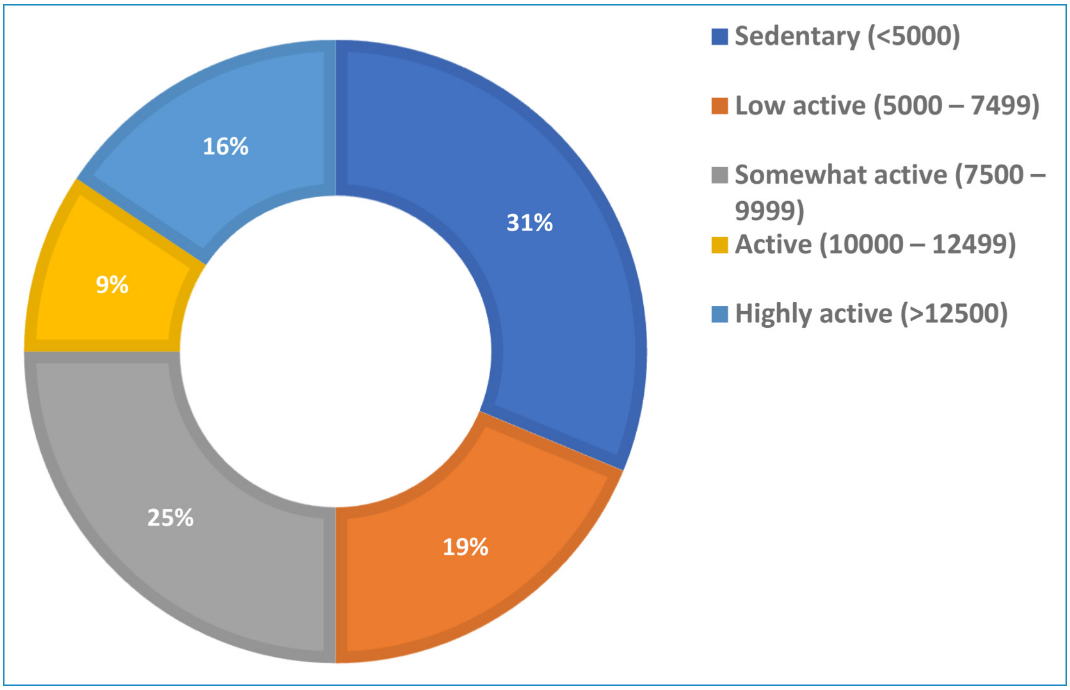

Figure 3. Frequency distribution for daily step count.

status were considered for analysis; however, education and employment status were later removed from the adjusted analysis. Gender and BMI categories were considered for the model for PA (Nagelkerke R^2 = 0.244, $p = 0.029$). Males had higher odds of being in the active to highly active PA category than females (OR: 6.91, 95% CI 1.56–30.54, $p = 0.01$). There was no significant impact of BMI categories on PA. Overall, participants spent more time sedentary per day and less time active (especially in moderate activities, especially in women) during the entire study.

Intensity of mean daily PA. The daily average sedentary time was 786 ± 109 min. Light PA time was 250 ± 76, moderate PA was 9 ± 10 and vigorous PA was 12 ± 18 min. Repeated measures ANOVA showed no significant differences between time points (baseline, mid-point and end of 10 weeks) in sedentary time, light activity time, moderate activity time or vigorous activity time. Non-parametric tests indicated that the intensity of daily PA did not vary significantly for demographic variables, including BMI, education, marital and employment status. However, males had a higher means of moderate (13 ± 9 vs. 5 ± 9, $p = 0.018$) and vigorous PA (21 ± 23 vs. 5 ± 7, $p = 0.034$) time (Figure 4).

Discussion

This is the first study to collect device-assessed PA data of Bahrain adults with T2DM. The mean daily step count was ∼7860, and there were no differences between baseline, week 5 and 10. Females accumulated fewer average daily steps than males (6728 vs. 10,281). Males had higher daily means of moderate and vigorous activity than females (13 vs. 5 min and 21 vs. 5 min, respectively). Aside from sex, none of the other demographic variables (BMI, education, employment or marital status) influenced PA. The average sedentary and light PA times were 786 and 250 min, respectively. The attrition rate was 3%, and 91% of participants wore the device for at least 10 h/day. The adherence rate was 79% based on the percentage of days the device was worn continuously over the 10 weeks.

Sample characteristics

In our study sample, there were more females ($n = 18$, 56%) than males ($n = 14$, 44%), although this difference was not statistically significant between the groups. Indeed, we did not power the study to compare differences between males and females. Anecdotally, females were more likely to consent to participation in the study. In 2019, the global prevalence of T2DM was slightly higher in males and increased with age up to 79 years.[36] Studies of this nature are scarce in the Gulf region and typically involve small sample sizes. However, data from Saudi Arabia have shown that diabetes prevalence is higher amongst females and may be associated with higher obesity prevalence and a sedentary lifestyle.[37]

Attrition, adherence rate and wear time

The attrition rate in our study was 3% ($n = 1$ participant), which is relatively low for a study of patients with chronic diseases using a fitness tracker.[28] The reason for discontinuation was that the participant did not have a suitable phone that could accommodate an authentic version of the Fitbit app.

In this study, we have provided the recommended minimum reporting (i.e., adherence data, validity period and PA data) for research studies.[38] As regards adherence, 90.63% of participants wore the Fitbit for ≥10 h/day during waking hours, and these data compare favourably with recommendations for the validity of wear time to estimate PA.[38] Based on the number of days the Fitbit device was worn continuously over 10 weeks (except when it was charging), the mean adherence rate was 78.61 ± 35.41%. However, few studies report adherence rate,[39] making conclusions difficult. Attrition, wear time and adherence data may have been influenced by the text messages we sent to participants reminding them to wear the Fitbit device, synchronise their data and troubleshoot any technical difficulties, although this would require further investigation. However, there was no evidence that text messages influenced the average daily step count over the 10 weeks of the study. Overall, our data suggest that developing a PA intervention for people with T2DM using a tracker device in Bahrain would be feasible.

Average steps per day

At baseline in our study, the average steps/day was 7859, which can be classified as 'somewhat active' [7500–9999 steps/day][34,40]; this is a positive and unexpected finding from our study. The average steps/day was higher than the previous ~5000 steps/day reported for the T2DM population[15] and exceeds the recommended daily thresholds of ~4000 steps for reducing all-cause mortality and 2337 steps for cardiovascular mortality irrespective of age, sex or climate.[9] However, 31% of our sample were sedentary, when defined as <5000 steps/day, supporting previous studies that people with T2DM tend to do less PA than those without.[13] Therefore, our future exercise intervention programme should support those Bahraini people with T2DM who are not achieving the minimum threshold for health benefits. Our results also show that females accumulated a lower average step count/day than males (6728 vs. 10,281, respectively). However, we did not explore the reason(s) (i.e., barriers and enablers) for the difference between males and females, and this is worthy of future study before designing any future exercise intervention programme.

Finally, in our study, PA (steps per day) and intensity of PA were not different between time points and therefore there was no evidence that wearing the Fitbit *per se* influenced PA. This finding contrasts with studies reporting that activity trackers alone have small-to-moderate effects on PA, typically increasing it by ~2500 steps/day or 1 h/day in people with T2DM.[28,41,42] The reasons for this difference are unclear and worthy of further investigation, but it is important to note the already higher average steps/day in our study compared to others.[15]

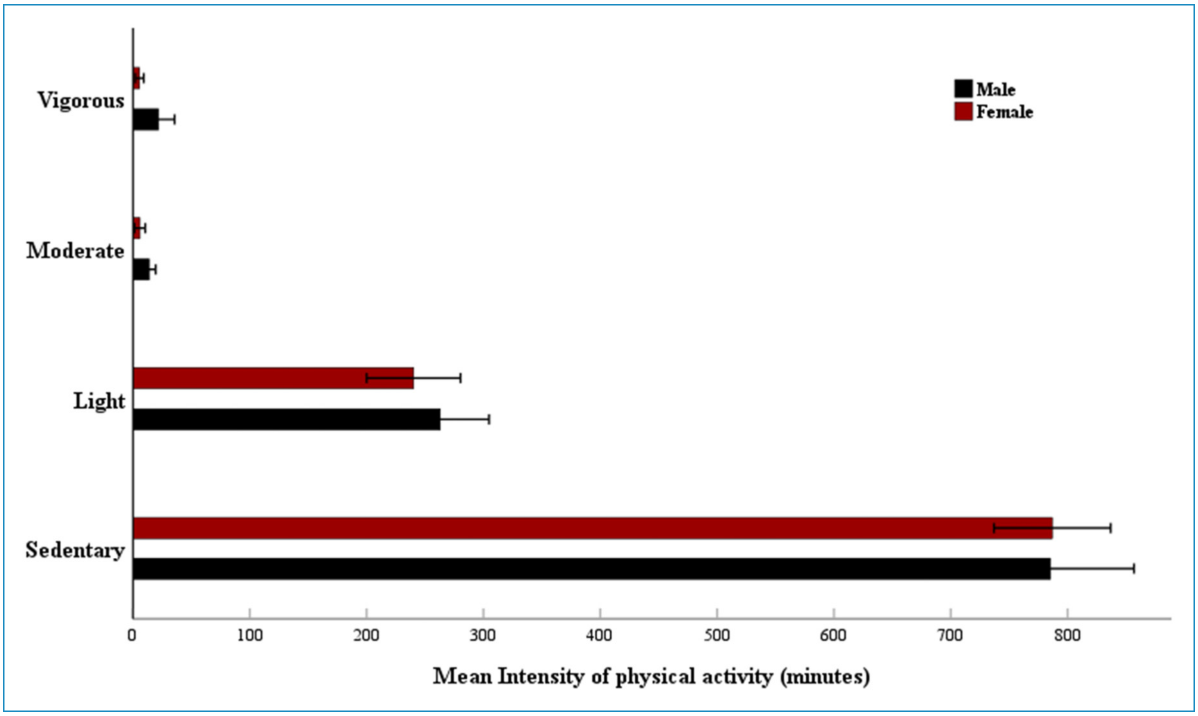

Figure 4. Comparison of average daily physical activity intensity between males and females.
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Intensity of PA

Current WHO guidelines are for adults to engage in ≥150 min/week of moderate-intensity PA (e.g., walking at a moderate or brisk pace on a level surface) or ≥75 min/week of vigorous-intensity PA (e.g., race walking, jogging or running),[43] or any combination of these, for health benefits, including improved blood glucose control in T2DM.[8,11] Public health campaigns often advise adults to achieve these PA goals in bouts of ≥30 min/day over five days of the week.[44] In our sample, males achieved these daily PA recommendations through 13 min of moderate- and 21 min of vigorous-intensity PA. These findings are similar (moderate PA: ~16 min/day; vigorous PA: 9 min/day) to those reported in a study of people with type T2DM using a Fitbit device in Saudi Arabia.[20] However, in our study, females only accumulated 5 min of each intensity per day and were well below the recommendations for PA. Similar findings have been reported for females with diabetes in a survey conducted in Saudi Arabia[18] and a large survey in the USA.[45] However, in contrast to the US survey, we did not find a relationship between low PA and other demographic variables.

In our study, participants accumulated most of their daily PA through light intensity PA (250 min/day). This PA data likely reflects activities of daily living or social activities that included walking. As regards a future exercise intervention, one approach to improving PA in our target population would be to capitalise on this preference for walking and focus on steps per day as a target based on the findings of Banach *et al.* that more steps are better irrespective of intensity, age, sex or climate.[9] Alternatively, we could focus on introducing short bouts of higher intensity ‘snacktivity’ throughout the day to achieve ≥150 min/week of moderate-to-vigorous intensity PA.[8,46] A survey of the target population would help identify which of these options males and females prefer and whether supervised PA would be realistic in light of any perceived barriers to PA.[47]

Sedentary time

In our study, the average sedentary time was ~786 min/day based on METs. A systematic review on SB in adults with T2DM reported objectively measured sedentary time of 11–15.4 h/day (or 660–924 min/day), higher than those without the condition.[15] Our data are concerning because sedentary times of ≥9.5 h/day or 570 min/day are associated with a significantly higher risk of death.[48] Adults are recommended to replace sedentary time with PA of any intensity (including light intensity) for health benefits; the public health message is simple, ‘sit less and move more’,[8] and this would need to be emphasised to patients in our planned future exercise intervention.

Limitations

Our study focuses on a single health centre and may not represent all people with T2DM in Bahrain. However, the results provide insight into objectively measured PA in adult Bahraini people with T2DM. Although we collected PA data over 10 weeks, we scheduled the study to avoid Ramadan (traditionally a month of significant changes in PA patterns) and the hotter summer months when we anticipated the participant dropout rate would be significant.[26] However, for our future intervention study, it would be important to know the dropout rate for our target population during Ramadan so that we could plan accordingly. Before the start of the study, we did not know how much and what intensity of PA our participants were currently undertaking. To reduce the risk of any hypo- or hyperglycaemic events, we excluded people on insulin therapy because we were not planning to monitor their blood glucose during the study. However, monitoring will be conducted during our future intervention study, and therefore, we will include people with T2DM on insulin therapy because the benefits of regular PA are known to outweigh this risk.[49]

The Fitbit Flex provides comparatively accurate estimates of sedentary time and has moderate validity for measuring PA with a tendency to undercount steps and underestimate moderate and vigorous PA, compared to the Actigraph GT3X + accelerometer.[30,31,50] This undercounting or underestimation may be partly due to the device having a preset walking and running stride length, although it can be adjusted in the Fitbit App if stride length is calculated for each user; we did not do this in our study.[32] A limitation of the SmartTrack feature for research purposes is that it is not entirely clear how Fitbit processes user data to detect higher movement activities. Although other newer devices may have been more suitable for tracking activity in our target population, we chose the Fitbit Flex 2 because of costs and also because it is waterproof, which meant it could be worn continuously, even during ablutions.

Wearing tracker devices increases PA in the short term, partly due to the continuous data they provide participants.[23,24] The Fitbit Flex 2 has an LED feature that allows the user to chart their progress towards a daily activity goal, and the user can also see their step count per day when they synchronise the Fitbit to their smartphone.[32] However, we did not observe a significant change in daily step count or intensity of PA across the 10 weeks of the study. The reason for this is unclear and worthy of further investigation, but it is important to note that we did not highlight or encourage participants to use these features.

Conclusions

We have studied patterns of PA and SB and the influence of demographics and BMI on these behaviours amongst Bahraini adults with T2DM over 10 weeks using an activity tracker.

The average steps/day were higher than reported in previous studies of people with T2DM. However, a third of participants were sedentary based on their step count and females accumulated fewer steps per day than males. Furthermore, although males achieved the WHO threshold recommendations for moderate-to-vigorous intensity PA, females did not. Our future planned intervention programme needs to target these two subgroups, but before that, we need to understand their facilitators and barriers to PA and whether they would prefer to focus on low-intensity PA and increase their steps per day or increase the amount of moderate-to-vigorous intensity PA. Both males and females had high sedentary times; therefore, the intervention study must include an educational component about the importance of sitting less and moving more.

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Author's note: Hani Malik is also affiliated at School of Medicine, Royal College of Surgeons in Ireland & Medical University Bahrain, Adliya, Bahrain.

Contributorship: FRD, ER, SD, DG, HM and WA designed the study. PW and HM were responsible for participant recruitment planning and logistics. FRD, PW, HM, AA and RA collected the data. FRD, SF and ER analysed the data. ER and FRD wrote the first draft of the manuscript. All authors reviewed the manuscript and approved the final submitted version. ER attests that all listed authors met the authorship criteria and that no others meeting the criteria have been omitted. ER acts as the guarantor.

Data availability: The data supporting this study's findings are available from the corresponding author, ER, upon reasonable request.

Declaration of conflicting interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval: This study was ethically approved by the Research Ethics Committees of RCSI Bahrain (Reference: 11th December 2018) and the Ministry of Health, Bahrain (reference: AURS/46/2019).

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References

1. American Diabetes Association. Classification and diagnosis of diabetes: standards of medical care in diabetes-2020. *Diabetes Care* 2020; 43: S14–S31.
2. Musaiger AO and Al-Mannai MA. Social and lifestyle factors associated with diabetes in the adult Bahraini population. *J Biosoc Sci* 2002; 34: 277–281.
3. Ministry of Health, Bahrain. Diabetes. [cited 16/03/2022] Available from: https://www.moh.gov.bh/Services/Diabetes?lang=en.
4. Elmusharaf K, Grafton D and Roberts E. *Prevention and control of non-communicable diseases in Bahrain: The case for investment.* Geneva: UNDP, WHO, UNIATF, GHC; 2021. Available from: https://bahrain.un.org/en/122828-case-investment-prevention-and-control-non-communicable-diseases-bahrain.
5. Pot GK, Battjes-Fries MC, Patijn ON, et al. Lifestyle medicine for type 2 diabetes: practice-based evidence for long-term efficacy of a multicomponent lifestyle intervention (reverse diabetes2 now). *BMJ Nutr Prev Health* 2020; 3: 188–195.
6. Kanaley JA, Colberg SR, Corcoran MH, et al. Exercise/physical activity in individuals with type 2 diabetes: a consensus statement from the American College of Sports Medicine. *Med Sci Sports Exerc* 2022; 54: 353–368.
7. Gregg EW, Lin J, Bardenheier B, et al. Impact of intensive lifestyle intervention on disability-free life expectancy: the Look AHEAD study. *Diabetes Care* 2018; 41: 1040–1048.
8. World Health Organisation. *WHO guidelines on physical activity and sedentary behaviour*. Geneva: World Health Organization, 2020. Licence: CC BY-NC-SA 3.0 IGO. Available from: https://www.who.int/publications/i/item/9789240015128.
9. Banach M, Lewek J, Surma S, et al. The association between daily step count and all-cause and cardiovascular mortality: a meta-analysis. *Eur J Prev Cardiol* 2023; 30: 1975–1985.
10. Tremblay MS, Aubert S, Barnes JD, et al. Sedentary behavior research network (SBRN) – terminology consensus project process and outcome. *Int J Behav Nutr Phys Act* 2017; 14: 75.
11. Colberg SR, Sigal RJ, Yardley JE, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016; 39: 2065–2079.
12. Leitner DR, Fruhbeck G, Yumuk V, et al. Obesity and type 2 diabetes: two diseases with a need for combined treatment strategies – EASO can lead the way. *Obes Facts* 2017; 10: 483–492.
13. Patterson R, McNamara E, Tainio M, et al. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol* 2018; 33: 811–829.
14. Das P and Horton R. Rethinking our approach to physical activity. *Lancet* 2012; 380: 189–190.
15. Kennerly A-M and Kirk A. Physical activity and sedentary behaviour of adults with type 2 diabetes: a systematic review. *Pract Diabetes* 2018; 35: 86–89. g.
16. Nowakowska M, Zghebi SS, Ashcroft DM, et al. The comorbidity burden of type 2 diabetes mellitus: patterns, clusters and predictions from a large English primary care cohort. *BMC Med* 2019; 17: 145.
17. Al-Kaabi J, Al-Maskari F, Saadi H, et al. Physical activity and reported barriers to activity among type 2 diabetic patients in the United Arab Emirates. *Rev Diabet Stud* 2009; 6: 271–278.

18. Mohamed BA, Mahfouz MS and Badr MF. Physical activity and its associated factors in females with type 2 diabetes in Riyadh, Saudi Arabia. *PLoS One* 2020; 15: e0239905.
19. Al-Qahtani AM. Frequency and factors associated with inadequate self-care behaviors in patients with type 2 diabetes mellitus in Najran, Saudi Arabia. Based on diabetes self-management questionnaire. *Saudi Med J* 2020; 41: 955–964.
20. Alghamdi AS, Alghamdi KA, Jenkins RO, et al. Impact of Ramadan on physical activity and sleeping patterns in individuals with type 2 diabetes: the first study using fitbit device. *Diabetes Ther* 2020; 11: 1331–1346.
21. Al-Mahroos F and Mckeigue P. Obesity, physical activity and prevalence of diabetes in Bahraini Arab native population. *Bahrain Med Bull* 1998; 20: 114–118.
22. Fukuoka Y, Haskell W and Vittinghoff E. New insights into discrepancies between self-reported and accelerometer-measured moderate to vigorous physical activity among women – the mPED trial. *BMC Public Health* 2016; 16: 761.
23. Tang MSS, Moore K, McGavigan A, et al. Effectiveness of wearable trackers on physical activity in healthy adults: systematic review and meta-analysis of randomized controlled trials. *JMIR Mhealth Uhealth* 2020; 8: e15576.
24. Laranjo L, Ding D, Heleno B, et al. Do smartphone applications and activity trackers increase physical activity in adults? Systematic review, meta-analysis and metaregression. *Br J Sports Med* 2021; 55: 422–432.
25. Scheers T, Philippaerts R and Lefevre J. Variability in physical activity patterns as measured by the SenseWear Armband: how many days are needed? *Eur J Appl Physiol* 2012; 112: 1653–1662.
26. Chaabane S, Chaabna K, Doraiswamy S, et al. Barriers and facilitators associated with physical activity in the Middle East and North Africa region: a systematic overview. *Int J Environ Res Public Health* 2021; 18: 1647.
27. Franssen WMA, Franssen G, Spaas J, et al. Can consumer wearable activity tracker-based interventions improve physical activity and cardiometabolic health in patients with chronic diseases? A systematic review and meta-analysis of randomised controlled trials. *Int J Behav Nutr Phys Act* 2020; 17: 57.
28. Ministry of Health, Bahrain. Bahrain National Health Survey 2018. Available from: https://www.iga.gov.bh/Media/Agencies/Bahrain%20National%20Health%20Survey%202018%20English.pdf.
29. World Health Organisation. WHO Expert Committee on Physical Status: the Use and Interpretation of Anthropometry (1993: Geneva, Switzerland) & World Health Organization. (1995). Available from: https://www.who.int/publications/i/item/9241208546.
30. Evenson KR, Goto MM and Furberg RD. Systematic review of the validity and reliability of consumer-wearable activity trackers. *Int J Behav Nutr Phys Act* 2015; 12: 159.
31. Sushames A, Edwards A, Thompson F, et al. Validity and reliability of fitbit flex for step count, moderate to vigorous physical activity and activity energy expenditure. *PLoS One* 2016; 11: e0161224.
32. Fitbit Inc. Fitbit Flex2. User Manual. Version 1.2. Available from: https://staticcs.fitbit.com/content/assets/help/manuals/manual_flex_2_en_US.pdf.
33. Wood WA and Basch E. From intuition to execution: realizing the potential of wearables in oncology. *J Oncol Pract* 2017; 13: 90–92.
34. Tudor-Locke C and Bassett DR Jr. How many steps/day are enough? Preliminary pedometer indices for public health. *Sports Med*. 2004;34:1–8.
35. Semanik P, Lee J, Pellegrini CA, et al. Comparison of physical activity measures derived from the fitbit flex and the ActiGraph GT3X+ in an employee population with chronic knee symptoms. *ACR Open Rheumatol* 2020; 2: 48–52.
36. Safiri S, Karamzad N, Kaufman JS, et al. Prevalence, deaths and disability-adjusted-life-years (DALYs) due to type 2 diabetes and its attributable risk factors in 204 countries and territories, 1990-2019: results from the global burden of disease study 2019. *Front Endocrinol (Lausanne)* 2022; 13: 838027.
37. AlQuaiz AM, Kazi A, Alodhayani AA, et al. Age and gender differences in the prevalence of chronic diseases and atherosclerotic cardiovascular disease risk scores in adults in Riyadh city, Saudi Arabia. *Saudi Med J* 2021; 42: 526–536.
38. Chan A, Chan D, Lee H, et al. Reporting adherence, validity and physical activity measures of wearable activity trackers in medical research: a systematic review. *Int J Med Inform* 2022; 160: 104696.
39. Semaan S, Dewland TA, Tison GH, et al. Physical activity and atrial fibrillation: data from wearable fitness trackers. *Heart Rhythm* 2020; 17: 842–846.
40. Tudor-Locke C, Craig CL, Brown WJ, et al. How many steps/day are enough? For adults. *Int J Behav Nutr Phys Act* 2011; 8: 79.
41. Baskerville R, Ricci-Cabello I, Roberts N, et al. Impact of accelerometer and pedometer use on physical activity and glycaemic control in people with type 2 diabetes: a systematic review and meta-analysis. *Diabet Med* 2017; 34: 612–620.
42. Hamasaki H. Efficacy of wearable devices to measure and promote physical activity in the management of diabetes. *EMJ Diabet* 2018; 6: 62–69.
43. Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exerc* 1993; 25: 71–80.
44. National Health Service, U.K. Physical Activity Guidelines for Adults (19-64 years). 2021. Available from: https://www.nhs.uk/live-well/exercise/physical-activity-guidelines-for-adults-aged-19-to-64/.
45. Mu L, Cohen AJ and Mukamal KJ. Resistance and aerobic exercise among adults with diabetes in the U.S. *Diabetes Care* 2014; 37: e175–e176.
46. Daley AJ, Griffin RA, Moakes CA, et al. Snacktivity to promote physical activity and reduce future risk of disease in the population: protocol for a feasibility randomised controlled trial and nested qualitative study. *Pilot Feasibility Stud* 2023; 9: 45.
47. Moghetti P, Balducci S, Guidetti L, et al. Walking for subjects with type 2 diabetes: a systematic review and joint AMD/SID/SISMES evidence-based practical guideline. *Nutr Metab Cardiovasc Dis* 2020; 30: 1882–1898.
48. Ekelund U, Tarp J, Steene-Johannessen J, et al. Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *Br Med J* 2019; 366: l4570.
49. Harrington D and Henson J. Physical activity and exercise in the management of type 2 diabetes: where to start? *Pract Diabetes* 2021; 38: 35–40.
50. Redenius N, Kim Y and Byun W. Concurrent validity of the fitbit for assessing sedentary behavior and moderate-to-vigorous physical activity. *BMC Med Res Methodol* 2019; 19: 29.