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Self-management of physical activity in adults with type 1 diabetes[☆]

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1. Introduction

Adults with type 1 diabetes (T1D) make up <5% of the overall diabetes population (American Diabetes Association, 2016b), but the prevalence is increasing (Prime Group for JDRF, 2015). These adults have unique needs in managing their diabetes. Living with T1D is an endless challenge that requires constant attention (Prime Group for JDRF, 2015). Self-management of diabetes is complex and includes frequent monitoring of blood glucose, taking insulin, carbohydrate counting, being physically active, problem-solving (for blood glucose levels), reducing the risk of complications, and coping with the myriad of emotions and tasks associated with living with diabetes (Mulcahy et al., 2003). They are at risk for multiple diabetes-related complications such as cardiovascular disease (CVD), diabetic retinopathy, nephropathy, and neuropathy (Pambianco et al., 2006).

Although there is mixed evidence that physical activity may improve glycemic control, as measured by Hemoglobin A1c (HbA1c), there are known benefits for adults with T1D, including improvement of body weight, lipids, insulin sensitivity, self-confidence, psychological distress around diabetes, and most importantly, optimization of long-term protection against CVD (Galassetti & Riddell, 2013). The last two benefits of physical activity are important since individuals with T1D are three times more likely to report depressive symptoms compared to those without the disease (Roy & Lloyd, 2012). Moreover, the majority of adults with both T1D and T2D will die of some form of heart disease (Mozaffarian et al., 2016). The risk for CVD begins to develop in childhood (Snell-Bergeon & Nadeau, 2012) and increases with longer T1D duration (Secrest, Becker, Kelsey, Laporte, & Orchard, 2010). Thus, primary CVD prevention should be addressed early, particularly in young working-age adults who begin to experience a higher risk of CVD morbidity and mortality (deFerranti et al., 2014).

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Conflicts of interest

None.

Despite the many benefits, engaging in regular physical activity involves attention to a number of concerns, including insulin and food adjustment, and potential episodes of hypo- and/or hyperglycemia (Galassetti & Riddell, 2013). Regular physical activity is recommended as part of the American Diabetes Association's CVD risk reduction strategies and should be encouraged (American Diabetes Association, 2016a). Recommendations include 150 min of moderate-to-vigorous physical activity per week, spread over at least 3 days per week (Colberg et al., 2016). Furthermore, the rate of overweight and obesity in adults with T1D is troubling, with almost 60% being overweight or obese in a large national sample from the T1D Exchange Clinic registry (McCarthy, Whittemore, & Grey, 2016). Routine physical activity may help counteract this trend toward obesity.

Diabetes is a complex disease. Biological risk factors alone may not fully explain disease development and progression. Therefore, the biopsychosocial model was used to explore diabetes self-management from multiple dimensions. The model has been used to understand how psychological and environmental factors interact and contribute to health (Engel, 1977). Given the interrelationships among physical symptoms (hypo- and hyperglycemia, long-term complications) and psychosocial factors (depression, diabetes distress), there is a need for an integrated approach to understanding these phenomena (Wasserman & Trifonova, 2006).

Many factors may be associated with maintaining physical activity as a routine component of diabetes self-management for adults with T1D. The fear of hypoglycemia and work schedules have been noted as barriers (Brazeau, Rabasa-Lhoret, Strychar, & Mircescu, 2008). Higher depressive symptoms (McCarthy et al., 2016) and diabetes distress (Lloyd, Pambianco, & Orchard, 2010) have been associated with lower levels of physical activity. Unfortunately, there is a scarcity of research on physical activity in adults with T1D (Tielemans et al., 2013). Understanding what factors affect incorporating physical activity into daily self-management may provide insight into potential targets for intervention. Therefore, the purpose of this cross-sectional analysis in a sample of adults with T1D was:

1. To examine patterns of physical activity and to identify the biological (clinical and diabetes-related), and psychosocial (sociodemographics, barriers to physical activity, diabetes self-management, depressive symptoms, diabetes distress, fear of hypoglycemia) factors associated with physical activity;
2. To examine the self-management strategies (changes in diet intake and insulin administration) employed to engage in physical activity.

2. Methods

We employed a cross-sectional design with a community-based sample of adults with T1D who received care at the outpatient diabetes clinics in a large academic medical center. Inclusion criteria were age ≥ 18 years, diagnosed with T1D, English-speaking, and able to walk without assistance (to assure ability to provide physical activity data). A sample size of 120 subjects was identified a priori as sufficient to detect an effect size of 0.25 with power of 0.80 and $\alpha < 0.05$. Using G*Power program for statistical power analysis (Faul, Erdfelder,

Lang, & Buchner, 2007), our final sample of 83 participants allowed for detection of an effect size of 0.30, with a power of 0.80 and $\alpha < 0.05$.

2.1. Procedures

Following approval from the Yale institutional review board, potential participants were mailed a letter inviting them to participate. The letter included a link to the data collection site REDCap (Research Electronic Data Capture) (Harris et al., 2009). REDCap is a secure, web-based application designed to support data collection for research studies. The REDCap site included the consent, the surveys, and an invitation to wear a pedometer for 2 weeks. Participants received a gift card for survey completion and an additional gift card for wearing and returning a pedometer. The study researchers mailed the pedometer to participants with instructions and a paid envelope for the participant to return the pedometer after wearing it for 2 weeks.

Valid and reliable instruments were used to collect the quantitative data in addition to the pedometer data. The variables assessed including biological (blood pressure, body mass index, lipids, HbA1c, diabetes complications, medical comorbidities), psychological (depressive symptoms, diabetes distress, fear of hypoglycemia) and social (barriers to physical activity, diabetes self-management).

2.1.1. Biological—Data on blood pressure, lipids, HbA1c, medical comorbidities, and T1D-related complications that may impact physical activity (presence of peripheral neuropathy, foot ulcers, retinopathy) were collected from the medical records.

2.1.2. Sociodemographics—A sociodemographic questionnaire was used to collect sociodemographic data from the participants, as well as clinical, and diabetes-related data (height, weight, duration of diabetes, type of insulin used, number of blood-glucose checks performed daily, and changes to insulin or diet around exercise).

2.1.3. Psychosocial—The Patient Health Questionnaire (PHQ-8) is an 8-item self-report measure that assesses the severity of depressive symptoms experienced in the last 2 weeks. The PHQ-8 is highly correlated ($r = 0.998$) with the PHQ-9 (Corson, Gerrity, & Dobscha, 2004) which has excellent internal reliability ($\alpha = 0.86\text{--}0.89$) (Kroenke, Spitzer, & Williams, 2001). The Cronbach alpha in this study was satisfactory ($\alpha = 0.87$). The Diabetes Distress Scale (DDS) is a 17-item self-report measure with four subscales (emotional burden, physician-related distress, regimen-related distress, and diabetes-related interpersonal distress) that assess emotional burden in type 1 and type 2 patients (Polonsky et al., 2005). Items are on a 5-point (1 = “Not a Problem” to 5 = “A Very Serious Problem”) Likert scale. The scale has good internal consistency ($\alpha = 0.87$) (Polonsky et al., 2005). The Cronbach alpha for this study was 0.91. The Hypoglycemia Fear Survey-II (HFS-II) was used to measure the behavioral and affective dimensions of the fear of hypoglycemia and includes a 15-item Behavior subscale (assessing behaviors to avoid low blood sugar) and a 18-item Worry subscale (assessing concerns about low blood sugar) (Gonder-Frederick et al., 2011). Possible answers range from 0 (never) to 4 (almost always)). The survey has

demonstrated good internal and test-retest reliability (reliability = 0.74) in a sample of adults with T1D. The Cronbach alpha for this study was satisfactory ($\alpha = 0.95$).

The 12-item Barriers to Physical Activity in Type 1 Diabetes Scale (BAPAD-1) was used to assess the likelihood each of 12 items would keep them from physical activity with possible answers ranging from 1 (extremely unlikely) to 7 (extremely likely) (Brazeau et al., 2008; Brazeau et al., 2012). The BAPAD-1 has shown good internal validity and had significant negative correlations with peak volume of oxygen consumed (VO_2) and physical activity energy expenditure. The Cronbach alpha for this study was satisfactory ($\alpha = 0.83$). The Self-care Inventory Revised (SCI-R) is a 14-item self-report questionnaire, measuring the patients' perception of their adherence to diabetes self-care treatment and regimen in the last 1–2 months (Weinger, Butler, Welch, & La Greca, 2005). The measure was developed for both T1D and T2D. Items assess blood glucose, insulin and food regulation, exercise, and emergency precautions. SCI-R yields a global score. Responses are on a 5-point (1 = "Never" to 5 = "Always") Likert scale. Internal reliability is good ($\alpha = 0.87$) with acceptable concurrent reliability ($r = 0.63$) (Weinger et al., 2005). The Cronbach alpha for this study satisfactory ($\alpha = 0.71$).

2.1.4. Physical activity—The International Physical Activity Questionnaire (IPAQ) was used to obtain data on self-reported physical activity performed in the past 7 days and has satisfactory reliability (Craig et al., 2003). It can be scored on a continuous scale (as metabolic equivalent-minutes per week [MMW]) or categorically (low, moderate or high). In this study the IPAQ total MMW score had a low, but significant, correlation with weekly step counts ($r = 0.25$; $p = 0.04$). The Yamax digi-walker CW-701, which has the same system as the Yamax SW-701 validated in the literature (Schneider, Crouter, & Bassett, 2004), but upgraded with a 7-day memory for step counts, was used to collect step counts. Participants were also instructed to wear the pedometer daily, removed only for water-based activities and at bedtime. Researchers have found the reactivity (the change in behavior when one is being monitored) (Tudor-Locke, McClain, Hart, Sisson, & Washington, 2009) that occurs when subjects wear a pedometer for observation, wears off after approximately 1 week (Clemes & Deans, 2012). Therefore, subjects were asked to wear the pedometer daily for 2 weeks, but only step counts from the second week were used.

2.2. Data analysis

All data were exported directly from REDCap into Statistical Analysis Software (SAS) v. 9.3. Standard univariate statistics were used to describe the sample. Pearson correlations were used to examine the linear relationships among weekly step counts, total MMW, HbA1c, body mass index (BMI), barriers to physical activity, blood pressure, depressive symptoms, and fear of hypoglycemia. Chi-square and ANOVA were used to compare participants who achieved each category of weekly step counts: <35,000 (sedentary); 35,000–<70,000 (low to somewhat active); and 70,000 (active-highly active). These cut-points were based on previously established daily activity categories (Tudor-Locke, Hatano, Pangrazi, & Kang, 2008). Variables associated significantly with weekly step counts ($p < 0.05$) were entered into stepwise multivariate linear regression. Participants who were missing >2 days of valid step counts were excluded from these analyses, resulting in a total

of 67 participants with one week of step count data. The Charlson Comorbidity Index was calculated for each participant (Charlson, 1987) and categorized as low, moderate or high (Peterson, 2012).

3. Results

A total of 548 adults in the adult diabetes clinic were mailed an invitation to participate in the study, and 77 were enrolled. Forty-three adults age 18 and above from the children's diabetes clinic were invited to participate in the study and 6 were enrolled. The overall response rate from both clinics was 14%.

The majority were women (65%), and most identified as White (89%) and Non-Hispanic (92%). The mean age of the participants was 45 ± 17 years and 49% were employed full/part-time. The mean education was 15.4 ± 3.7 years, with the majority (56%) earning \$40,000 annually. The mean duration of T1D was 20 ± 15 years, and mean HbA1c level was $7.8 \pm 1.2\%$. Participants checked their blood glucose an average of 4.7 ± 1.7 times per day, and 16% ($n = 13$) used a continuous glucose monitor (CGM). Most participants used an insulin pump ($n = 53$; 64%). The majority were overweight (38%) or obese (25%). Most (63%) were in the low category on the Charlson Comorbidity Index (0–1), but 31% had at least one diabetes complication (peripheral neuropathy, retinopathy, nephropathy, or foot ulcer) (Table 1).

3.1. Physical activity

Weekly step counts were calculated for each participant. Participants took an average of $45,608 \pm 22,091$ steps/week. When step counts were categorized, 37% were sedentary ($<35,000$ steps/week), 48% were low-somewhat active ($35,000$ – $<70,000$ steps/week) and 15% were active ($>70,000$ steps/week) (Table 2). By self-report, participants spent 4.4 ± 2.1 days per week exercising at least 30 min. The mean IPAQ total MMW was 4892 ± 6114 and when the total MMW were categorized, 16% reported <600 MMW (low activity level), 39% reported 600 MMW but <3000 MMW (moderate activity level), and 46% reported 3000 MMW (high activity level). Weekly step counts were significantly associated with total MMW ($r = 0.25$; $p = 0.04$).

3.2. Factors associated with physical activity

Although there were no racial/ethnic differences in achievement of weekly step counts, there were significant differences between men and women. More women were in the sedentary category as compared to men (40% vs. 32%; $p = 0.02$). Individuals who worked full-time had higher mean weekly step counts as compared to other categories of employment (55,193 steps vs. 38,295 steps; $p = 0.001$). The mean Hypoglycemia Fear Survey total score was 36 ± 23.8 , but there was no significant association between Hypoglycemia Fear Survey total score and weekly step counts (see Table 3 Correlation Matrix). Twenty-two percent of the sample ($n = 16$) scored ≥ 10 on the PHQ-8, indicating high depressive symptoms, but there was no significant association between mean PHQ-8 scores and weekly step counts.

The BAPAD-1 scale assesses both diabetes-related and generic barriers to physical activity (ratings range from 1 = extremely unlikely to 7 = extremely likely). Risk of hypoglycemia

was the barrier with the highest rating (3.75 ± 1.87), followed by work schedule (3.75 ± 2.24), and weather conditions (3.54 ± 2.06). The total BAPAD-1 score was negatively correlated with weekly step counts, indicating a higher level of barriers was associated with lower weekly step counts. The total BAPAD-1 score was also significantly associated with HbA1c, BMI, the Hypoglycemia Fear Survey total and the PHQ-8. Some clinical variables were associated with weekly step counts. Weekly step counts were significantly correlated with systolic blood pressure and BMI, but not with HbA1c or diastolic blood pressure. For participants with diabetes-related complications, the majority were in the sedentary category (58%) vs. low-somewhat active (37%) or active (5%), but this result was not significant ($p = 0.07$).

In multivariate analysis, the only variable independently associated with weekly step counts was employment. Individuals who worked full-time walked an average of 11,612 more steps per week than all other categories of employment ($p = 0.03$) (Table 4).

Participants were asked about management of carbohydrate intake to prevent (before exercise) or raise (during exercise) low blood sugar levels. Only 8% ($n = 6$) of participants always ate or drank a carbohydrate before exercise, and only one participant always did so during exercise. They were also asked about any changes they made to their insulin doses. The majority did not make any changes in insulin either before or during exercise (56%). Similarly, the majority (69%) did not make any changes to insulin dosing after exercise.

4. Discussion

The purpose of our study was to describe the patterns of and factors associated with physical activity in a sample of adults with T1D, as well as how they managed their physical activity. We examined changes made in diet or insulin administration either before, during or after physical activity. Given the increased risk of diabetes complications, especially CVD, engaging in physical activity as part of overall diabetes self-management is a potential way to reduce this risk.

In this sample, few adults with T1D would be considered active by their step counts, although almost half reported enough activity on the IPAQ to categorize themselves as very active. Physical activity questionnaires can be inconsistent when relying on participant self-report (McCarthy & Grey, 2015). Participants in previous studies have self-reported more time in moderate-to-vigorous activity compared to that collected by accelerometer data (Cerin et al., 2016). This over-reporting of physical activity highlights the importance of collecting objective physical activity data using motion sensors. Additionally, use of feedback from a pedometer or accelerometer and setting goals may help motivate patients to improve their physical activity levels. In participants randomized to different levels of pedometer goals (control, “do your best”, easy, medium, difficult groups), changes in steps were significantly higher in those who were in the medium or difficult group vs. the “do your best” or control groups (Moon, Yun, & McNamee, 2016). These results suggest that individuals may respond to a specific step goal, even when the goal is challenging.

In our study, barriers to physical activity were significantly associated with weekly step-counts. Risk of hypoglycemia, weather conditions, and work schedules were the three top-rated barriers to physical activity. Risk of hypoglycemia and work schedule have been reported as important barriers to physical activity in a previous study of adults with T1D (Brazeau et al., 2008). In that study, barriers to physical activity was also positively correlated with HbA1c, but having someone to be physically active with was associated with fewer barriers. Suggesting an exercise partner may be an effective strategy to promote physical activity in this population.

Despite a risk of hypoglycemia being rated highly as a barrier to physical activity, the HFS-II score was not significantly associated with weekly step counts. Very few participants always ate or drank a carbohydrate before or during exercise to prevent or raise a low blood sugar, nor did they make changes to insulin doses. This appears to be inconsistent with risk of hypoglycemia being a top-rated barrier. It is unknown if this is a result of inadequate education and counseling regarding management of blood sugar when participating in physical activity, or that blood glucose levels were high when initiating physical activity. Current guidelines suggest additional carbohydrate intake and insulin reductions may be required during and after physical activity (Colberg et al., 2016). This finding is similar to a sample of adults with T1D where the majority (regardless of whether they performed self-monitoring of blood glucose (SMBG), used an insulin pump, a CGM, or both) only sometimes consumed extra carbohydrates before exercise (Pinsker et al., 2016). Only a minority of that sample made changes to insulin doses to prepare for exercise (SMBG = 10%; pump users = 19%; continuous glucose monitor = 25%; and use of both = 33%) as compared to 44% of our sample. Very few in our sample were using a CGM, but the majority was using an insulin pump. The HFS-II total score in our sample was lower than other larger samples (Gonder-Frederick et al., 2011) and did not vary by gender. However, fear of hypoglycemia remains a problem for many adults with T1D, as it impacts diabetes behaviors including insulin dosing, dietary choices, and physical activity (Martyn-Nemeth, Schwarz Farabi, Mihailescu, Nemeth, & Quinn, 2016). There is some evidence that the use of CGM may reduce the fear of hypoglycemia, along with providing tighter control of blood glucose (Halford & Harris, 2010). Further qualitative inquiry into self-management practices of insulin administration, monitoring of blood glucose, and dietary practices around physical activity may be warranted.

In our sample, those who worked full-time walked more steps than other categories of employment. This is in contrast to our recent analysis of data from adults with T1D in the Type 1 Diabetes Exchange Clinic registry ($n = 7153$; mean age 37.14 ± 17), where less than full-time employment was associated with higher odds of achieving optimal physical activity levels (McCarthy et al., 2016). It is also contrary to their high rating of work schedule as a barrier. It is possible that full-time employees are more physically active during the work day, but see their work schedule interfering with other types of planned physical activity. Other researchers have found work-related issues (“changing jobs” or “starting a first job”) interfered with performing physical activity (Thomas, Alder, & Leese, 2004). Long commutes and feeling exhausted at the end of the workday interfered with the ability of young working adults with T1D to exercise, even as they recognized it as an important part of diabetes self-management (Balfe et al., 2014). Weather was also cited as a reason for less

exercise, as adults with T1D were more likely to walk during the day or go to the gym in good weather. Providers can help these adults strategize how best to incorporate physical activity into their routine, regardless of employment status.

The majority of this sample was either overweight or obese, and higher step counts were associated with a lower BMI. These results are similar to the Type 1 Diabetes Exchange Clinic registry data, where 59% were overweight or obese, and higher BMI was significantly associated with increased odds of reporting no physical activity (McCarthy et al., 2016). A similar prevalence of overweight and obese was also seen in another large cohort ($n = 18,028$) of adults with T1D (Bohn et al., 2015). These trends are troubling since obesity in the presence of T1D increases the risk of CVD (Duca, Sippl, & Snell-Bergeon, 2013). The association of higher levels of physical activity with lower BMI suggest that promoting this aspect of diabetes self-management, along with healthy eating patterns, may be one approach to managing body weight and reducing CVD risk. Inquiring about usual dietary practices, insulin dosing, and physical activity may provide additional insight into the rising prevalence of obesity in individuals with T1D (Ashrafian et al., 2016).

HbA1c was not associated with weekly step counts in this study. These results are consistent with previous analyses where HbA1c was not independently associated with levels of self-reported physical activity (McCarthy et al., 2016). However, this result contrasts with a large cross sectional study of physical activity in adults with T1D in which an inverse association between self-reported physical activity and HbA1c was found (Bohn et al., 2015). The contrasting results, especially given the reliance on self-reported physical activity in previous research, highlight the need for longitudinal research examining the effect of well-documented objective physical activity data (including frequency, duration and intensity) on HbA1c. Additionally, despite checking their blood glucose an average of 5 times daily, HbA1c was still above optimal values in participants in this study.

4.1. Limitations and strengths

The small sample size was a limitation of this study. The cross-sectional nature of the data limited conclusions about causal relationships between the factors being analyzed. Furthermore, a more sophisticated accelerometer would have provided more data about the timing and intensity of the participants' physical activity. Despite this, we were able to collect one-week of objective physical activity data, a method more reliable than self-report, along with a comprehensive set of clinical-and diabetes-related factors on a sample of young adults with T1D, an understudied population.

5. Conclusion

This study highlighted the low levels of physical activity, and the high levels of overweight and obesity in a sample of adults with T1D, as well as some of the factors that were related to physical activity. Very little is known about the self-management practices of young adults with T1D, particularly how they routinely and safely incorporate physical activity. Moreover, this is also a population with high rates of depressive symptoms, which needs further exploration. A more thorough understanding these factors may guide clinicians in the promotion of optimal diabetes care, especially important in young adults.

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Table 1Sample Characteristics ($n = 83$).

Characteristic	Mean $\pm$ SD or n (%)
Sociodemographics	
Age (years)	45.2 $\pm$ 16.6
Gender	
Female	54 (65%)
Race	
White	73 (89%)
Black	3 (4%)
>1 race	5 (6%)
Ethnicity	
Not Hispanic or Latino	76 (92%)
Hispanic or Latino	5 (6%)
Not reported	2 (2%)
Marital status	
Single	37 (45%)
Married	34 (41%)
Divorced or separated	6 (7%)
Living with a domestic partner	5 (6%)
Employment	
Full-time/part-time	41 (49%)
Unemployed/sick leave or disability	14 (17%)
Retired	13 (16%)
Student	10 (12%)
Income level (dollars)	
\$0–\$40,000	44 (56%)
\$41,000–\$80,000	15 (19%)
\$81,000–\$100,000	9 (11%)
>\$100,000	11 (14%)
Education (years)	15.4 $\pm$ 3.7
Medical insurance	
Government	41 (50%)
Commercial	36 (44%)
Health maintenance organization	5 (6%)
Clinical characteristics	
Body mass index (kg/m ²)	28 $\pm$ 8
Body mass index (kg/m ²)	
Underweight (<18.5)	1 (1%)
Normal weight (18.5–24.9)	29 (36%)
Overweight (25–29.9)	30 (38%)
Obese (≥ 30)	20 (25%)

Characteristic	Mean $\pm$ SD or n (%)
Systolic blood pressure	122.4 $\pm$ 16.9
Diastolic blood pressure	74.3 $\pm$ 9.6
Total cholesterol (mg/dl)	175.5 $\pm$ 37.6
Low-density lipoprotein (mg/dl)	94.8 $\pm$ 35.2
High-density lipoprotein (mg/dl)	67.7 $\pm$ 20.8
Triglycerides (mg/dl)	78.1 $\pm$ 50
PHQ-8	5.5 $\pm$ 5
PHQ-8 10	16 (22%)
Diabetes-related characteristics	
Duration of type 1 diabetes (years)	20 $\pm$ 15
Hemoglobin A1c (%)	7.8 $\pm$ 1.2
(mmol/mol)	61
Blood glucose checks per day	
1–4 $\times$ /day	34 (41%)
5–8 $\times$ /day	30 (36%)
>8 $\times$ /day	6 (7%)
Continuous glucose monitor use	13 (16%)
Insulin delivery	
Pump	53 (64%)
Injectons	30 (36%)
Diabetes complications	
Peripheral neuropathy	12 (14%)
Autonomic neuropathy	0
Retinopathy	19 (23%)
Nephropathy	10 (12%)
Foot ulcer	4 (5%)

Note. mg/dl = milligrams/deciliter; mmol/mol = millimoles/mole.

Table 2

Exercise and diet/insulin management in adults with type 1 diabetes.

Characteristic	Mean $\pm$ SD or <i>n</i> (%)
Days spent exercising at least 30 min (self-report)	4.4 $\pm$ 2.1
Steps per week (pedometer)	45,608 $\pm$ 22,091
Weekly step categories	
<35,000 steps per week (<5000 steps/day)	25 (37%)
35,000–69,999 steps per week (5000/day–9999/day)	32 (48%)
70,000 steps per week (10,000 steps/day)	10 (15%)
Before exercise, how often eat/drink carbohydrate to prevent low blood sugar?	
Never	5 (7%)
Rarely	17 (22%)
Sometimes	28 (37%)
Most of the time	20 (26%)
Always	6 (8%)
During exercise, how often do you eat/drink carbohydrate to raise a low blood sugar	
Rarely	31 (40%)
Sometimes	37 (48%)
Most of the time	8 (10%)
Always	1 (1%)
Do you make changes in insulin before or during exercise?	
Yes	34 (44%)
No	43 (56%)
If yes, what changes do you usually make?	
Lower rapid insulin before exercise	19 (48%)
Suspend or lower basal rate on pump before or during exercise	21 (53%)
Do you make changes in insulin after exercise?	
Yes	23 (31%)
No	51 (69%)
If yes, what changes do you usually make?	
Lower dose of rapid insulin after exercise	16 (62%)
Suspend or lower basal rate on pump after exercise	10 (38%)

Table 3

Correlation matrix.

	Steps	MMW	SBP	DBP	BMI	BAPAD-1	HFS	PHQ-8	HbA1c	DDS	SCL-R	BG#
Steps												
		0.25	-0.26	0.03	-0.25	-0.25	-0.05	-0.23	-0.15	0.04	-0.03	0.05
MMW			0.04	0.03	0.05	0.05	0.70	0.08	0.22	0.72	0.83	0.68
				0.01	-0.04	0.17	0.11	0.23	0.10	0.13	-0.08	-0.03
				0.37	0.69	0.12	0.35	0.04	0.40	0.27	0.50	0.81
SBP					0.06	-0.14	-0.10	0.19	0.02	-0.03	-0.18	0.21
				0.53	0.61	0.22	0.38	0.10	0.85	0.80	0.16	0.05
				<0.0001	0.06	0.07	0.02	0.07	0.11	0.16	-0.27	-0.02
DBP					0.59	0.52	0.90	0.55	0.32	0.16	0.03	0.86
						0.30	-0.21	0.21	0.04	-0.01	-0.23	-0.07
BMI						0.01	0.07	0.07	0.70	0.90	0.07	0.56
							0.30	0.54	0.24	0.48	-0.25	-0.11
BAPAD-1							0.01	<0.0001	0.04	<0.0001	0.05	0.35
								0.35	0.24	0.62	-0.04	0.28
HFS								0.004	0.04	<0.0001	0.77	0.02
									0.25	0.53	-0.18	0.09
PHQ-8									0.03	<0.0001	0.17	0.47
										0.42	-0.34	-0.25
HbA1c										0.0001	0.006	0.02
											-0.30	0.02
DDS											0.02	0.89
												0.35
SCL-R												0.004

Note. Bold indicates significant correlation; MMW = metabolic minutes/week; SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index; BAPAD-1 = Barriers to Physical Activity in Type 1 Diabetes; HFS = Hypoglycemia Fear Survey-II; DDS = Diabetes Distress Scale; SCL-R = Self-care Inventory-Revised; BG# = number of blood glucose checks per day.

Table 4

Multivariate linear regression of step counts.

Parameter	Estimate	T-value	p-Value
Intercept	119,688.6226	5.22	<0.0001
Full-time (vs. other categories of employment)	11,612.9432	2.14	0.0372
Female (vs. Male)	−9440.4226	−1.49	0.1410
Body mass index (each 1-unit increase)	−387.9833	−1.14	0.2575
Systolic blood pressure (each 1-unit increase)	−311.5905	−1.81	0.0756
BAPAD-1 (each 1-unit increase)	−361.7067	−1.69	0.0966

Note. BAPAD-1 = Barriers to Physical Activity in Type 1 Diabetes.