Objectively Measured Physical Activity in Older Adults With and Without Diabetes

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■ **IN BRIEF** People with known diabetes were found to be 20% less active than people without diabetes as measured by objective accelerometers. A threshold of 6,000 steps per day was associated with the lowest risk of prevalent diabetes. The study also emphasizes the use of objective techniques to measure physical activity in subjects with diabetes.

Insufficient physical activity (PA) is an important risk factor for obesity and noncommunicable diseases (NCDs) such as cardiovascular disease (CVD) and type 2 diabetes (1). For this reason, the World Health Organization (WHO) has issued recommendations for different age categories, stating that 150 minutes of moderate-intensity PA (or 75 minutes of vigorous PA) per week, performed in bouts of at least 10 minutes each, will provide significant health benefits for individuals aged 18–64 and ≥65 years (2). Moreover, reaching 300 minutes of moderate-intensity PA (or 150 minutes of vigorous PA) per week is suggested to confer additional health benefits. These recommendations are based on several extensive reviews (3–5) assessing the relation between predominantly self-reported PA and different aspects of health. However, the authors of these reviews also concluded that self-reported measures of PA constitute a limitation and that the recommendations for PA bout duration warrant further investigation.

Although the health benefits of regular PA on NCDs are well documented, the ideal intensity and duration of PA remain matters of debate (6), and the effects may differ among diseases (7). Thus, the establishment of a single recommendation for all NCDs may not be prudent.

Diabetes, a chronic condition that is one of the most common NCDs globally, is associated with increased risks of CVD and death (8,9). In a systematic review, moderate-intensity PA and brisk walking were associated with a 30% lower risk of type 2 diabetes compared to a sedentary lifestyle, although the optimal amount and duration of PA were not determined (10). Studies supporting longer bouts of activity are sparse, and PA performed in multiple shorter sessions was reported to generate lower blood glucose levels than a single, longer bout of PA in patients with type 2 diabetes (11). Furthermore, based on randomized intervention studies (12,13), the American College of Sports Medicine and the American Diabetes Association issued a joint recommendation for 150 minutes of moderate to vigorous PA (MVPA) per week, without bout restriction, for type 2 diabetes risk reduction (14), which further questions the relevance of bouted PA in relation to diabetes.

In the present study, we investigated objective and self-reported PA in a large cohort of 70-year-old individuals, with emphasis on PA patterns and amounts in individuals with and without diabetes (type 1 or type 2) in relation to the WHO guidelines.

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Methods

Participants

This cross-sectional investigation was part of the Healthy Ageing Initiative (HAI), an ongoing population-based study investigating risk factors for NCDs, including diabetes, in 70-year-old residents of Umeå municipality, Sweden. The investigated cohort comprised 1,872 participants with complete measurements of PA patterns, blood parameters, and body composition. Body composition was assessed by waist circumference and by visceral adipose tissue (VAT), quantified by dual-energy X-ray absorptiometry using a Lunar iDXA and the CoreScan application (GE Healthcare, Wauwatosa, Wisc.). No exclusion criteria were applied because the aim was to investigate a sample reflecting the general population. Data were collected between June 2012 and December 2015, and data analysis was conducted in 2016. The study procedure has been described in detail elsewhere (15). The study was approved by the Umeå Regional Research Ethics Committee (Dnr 07-031M with extensions).

Diabetes Criteria

Participants enrolled in the HAI were instructed to be in a fasting state, with no intake of food, calorie-containing beverage, or nicotine for 4 hours before the clinic visit. A capillary blood sample was analyzed on a HemoCue portable glucose analyzer (HemoCue AB, Ängelholm, Sweden) to determine the fasting blood glucose (FBG) concentration. In addition, participants' self-reported information on prior diabetes diagnosis was obtained. Information of self-reported diabetes had been shown to have very high specificity (99.7%) compared to medical records (16). Participants were divided into four groups based on FBG and prior diabetes diagnosis: no diabetes (group 1; FBG <6.1 mmol/L [<110 mg/dL] and no known diabetes, n = 1,396), prediabetes (group 2; FBG ≥6.1 to <7 mmol/L [≥110 to <125 mg/dL] and

no known diabetes, n = 266), diabetes detected in the study (group 3; FBG ≥7.0 mmol/L [≥125 mg/dL] and no known diabetes, n = 52), and known diabetes (group 4; regardless of blood glucose concentration, n = 158). For the majority of results presented, groups 1 and 2 and groups 3 and 4 were merged into "no diabetes" and "diabetes" groups.

PA Assessments

Self-reported PA data were obtained using the International Physical Activity Questionnaire–short form (IPAQ-SF) (17), which has been validated in several populations in different countries (18). Respondents were asked to recall the time spent (in at least 10-minute bouts) walking and engaging in moderate and vigorous PA during the past 7 days. Participants were also asked to report their adolescent PA levels on a scale from 1 to 5, in which 1 represented excluded from physical education and 5 represented training and competing at an elite level.

PA was measured objectively using triaxial accelerometers (GT3X+, Actigraph, Pensacola, Fla.) and subsequently filtered (normal frequency). Accelerometers are motion sensors that detect duration and intensity of PA by measuring accelerations in three dimensions. Sampled at 30 Hz, acceleration data were then transformed into counts representing activity. For this study, participants were asked to be normally active as they wore the accelerometers on their nondominant hip for 7 consecutive days, removing it only during water-based activities, including bathing, and nighttime sleep.

Upon participants' return, accelerometer data were downloaded with Actilife software 6.6.3 (Actigraph) into epoch lengths of 60 seconds, and wear-time was validated in accordance with Troiano et al. (19). Briefly, participants were required to accumulate at least 4 days of PA measurements, with a minimum of 10 hours/day, for the data to be considered valid

and eligible for further analysis. Non-wear time was defined as >60 minutes of inactivity, with a spike tolerance of no more than 2 minutes exceeding the cut point for sedentary time. PA patterns were investigated using predetermined cut points based on uniaxial counts as described by Freedson et al. (20), stating that tasks reaching a metabolic equivalent of ≥3 (e.g., walking, jogging, and cycling) are to be considered MVPA. A bout of MVPA was defined as at least 10 consecutive minutes, reaching the MVPA threshold of 1,952 counts per minute, with allowance for 1- to 2-minute interruptions (21). The total time per week in MVPA bouts and total time in MVPA without bout prerequisite were then recorded separately and used for further calculations. In addition, daily step-counts were also attained from accelerometers and retrieved by the ActiLife software. Finally, total registered counts from all three axes (with no bout limitation and no regard for intensity level) were combined and divided by total accelerometer wear time to form the total PA variable, which represents a measure of all PA conducted during the day and thus in addition to recorded MVPA also included light PA (e.g., lighter gardening and household work).

Statistical Analysis

Descriptive data are presented as means and SDs for continuous variables and absolute numbers and proportions of the total for dichotomous variables. Data processing and statistical analysis were carried out using the SPSS 23.0 software (IBM Corp., Armonk, N.Y.). Differences in descriptive data between adults with diabetes and adults without diabetes were examined using the independent-samples t test for continuous variables and the χ^2 test for dichotomous variables. To compare associations between self-reported and accelerometer-generated PA data, Pearson's correlation coefficients (r values) were calculated. Moreover, differences in step-counts between groups based on FBG

and diabetes diagnosis were assessed with an analysis of covariance adjusted for sex, smoking, and adolescent PA level. Normal distribution of data was assessed by visual inspection of histograms.

Associations between different measures of PA and diabetes prevalence were investigated using logistic regression adjusted for sex, smoking, adolescent PA level, and VAT mass. Additionally, statistical testing did not find an interaction effect between VAT mass and PA. To test whether the association between objectively measured PA and diabetes was nonlinear, PA squared was included into the model together with PA.

A logistic regression model adjusted for sex, smoking, adolescent PA level, and VAT mass was also used to test which cut point value for steps per day was associated with the lowest odds ratio (OR) for diabetes prevalence. For this model, we started with 2,000 steps/day and increased the cut point gradually in 500-step increments.

Finally, two sensitivity analyses were made. First, all individuals with either reported prior stroke or myocardial infarction were excluded. The fully adjusted regression model was then performed on the remaining sample to see if reduced physical capacity due to prior stroke or myocardial infarction would affect the impact of PA on diabetes prevalence.

The impact of the 6,000-step-per-day cut point was tested only against people with a prior diabetes diagnosis (not including people with diabetes based on a high FBG) due to the limitations of capillary FBG measurements (22). P values <0.05 were considered significant for all analyses.

Results

Study Cohort
Cohort characteristics are presented in Table 1. A total of 1,872 participants (49% women) aged 70 years and of Caucasian ethnicity were enrolled in the study. Of these, 210 participants (11%) had diabetes, based on a pre-

vious diabetes diagnosis (n = 158) or an FBG ≥7.0 mmol/L (≥125 mg/dL) (n = 52). The majority of the adults with diabetes (98.1%) had type 2 diabetes. Of the remaining 1,662 participants without diabetes, 16% (n = 266) were found to have prediabetes based on an impaired fasting glucose (≥6.1 to <7 mmol/L [≥110 to <125 mg/dL]). Waist circumference (P <0.001), VAT mass (P <0.001), and the prevalence of myocardial infarction (P <0.001) and stroke (P <0.01) were significantly greater in adults with diabetes than in those without diabetes. Systolic blood pressure and smoking prevalence did not differ between groups.

PA Characteristics
Based on objectively measured PA, 733 individuals of the study population reached the WHO's minimum PA requirement of 150 minutes MVPA/week in ≥10-minute bouts. The self-reported time per week spent engaging in MVPA in ≥10-minute bouts (not including walking) was more than double the corresponding objectively measured value (356 ± 394 vs. 146 ± 153 minutes/week; Table 1). Self-reported PA in bouts was not associated with bouted PA measured objectively by accelerometer (r = –0.01, P = 0.56). However, after disregarding the 10-min bout of consecutive PA criterion, a weak association was observed between self-reported and objectively measured MVPA (r = 0.06, P = 0.01). The time spent engaging in vigorous PA (self-reported, 94 ± 132 minutes/week; accelerometer-measured, 5 ± 27 minutes/week) constituted a minority of the total MVPA time. All measures of self-reported and accelerometer-derived PA levels were significantly higher in adults without diabetes than in those with diabetes (P <0.01 for all). Furthermore, a stratified analysis showed that the step-count per day was significantly higher among individuals without diabetes (7,375 ± 3,065 steps/day) than among those with diabetes detected in the study (6,359 ± 3,302 steps/day, P <0.05) and those with previously

diagnosed diabetes (5,754 ± 2,941 steps/day, P <0.001; Figure 1A).

Nonlinear Association Between Diabetes and Objective PA
The investigation of diabetes prevalence according to accelerometer-derived total PA quintiles revealed a higher prevalence of diabetes in the first two quintiles of total PA (20.6 and 13.6%, respectively) compared with the third to fifth quintiles (8.0, 8.3, and 5.6%, respectively), indicating a nonlinear relationship between diabetes prevalence and PA (Figure 1B), which was also confirmed by statistical testing (P <0.01). Quintiles of total PA were then plotted against the more understandable steps/day variable (Figure 1C). A total PA cut point of 6,000 steps/day discriminated best between subjects with and without diabetes at baseline (OR 0.36, 95% CI 0.26–0.48), in unadjusted as well as fully adjusted models (OR 0.50, 95% CI 0.36–0.69; Figure 1D and Table 2). In contrast, fulfillment of the WHO PA guideline (150 minutes MVPA/week in ≥10-minute bouts) could not discriminate between subjects with and without diabetes (OR 0.92, 95% CI 0.66–1.28) in fully adjusted models (Table 2). Also, the associations for different cut points of self-reported PA and diabetes were generally weaker than those for objective measures of PA (Table 2).

Finally, two sensitivity analyses were made. First, subjects with prior stroke or myocardial infarction were excluded, although this did not incur significant changes to the OR for prevalent diabetes in relation to the 6,000-steps-per-day cut point in the fully adjusted model (OR 0.46, 95% CI 0.32–0.66). Second, the impact of the 6,000-steps-per-day cut point was tested only on people with a prior diabetes diagnosis (not including people with a high FBG), which generated close to analogous results (OR 0.47, 95% CI 0.33–0.68).

TABLE 1. Characteristics of the Study Cohort				
Anthropometric Data	Adults Without Diabetes	Adults With Diabetes	P	Total
Subjects, n (%)	1,662 (89)	210 (11)		1,872
Age, years	70	70		70
Female, n (%)	844 (51)	72 (34)	**<0.001**	916 (49)
Weight, kg	75.7 ± 13.5	86.6 ± 17	**<0.001**	76.9 ± 14.3
Height, cm	170 ± 8.9	172 ± 9.3	**<0.01**	170 ± 9
BMI, kg/m²	26.2 ± 3.9	29.2 ± 5.2	**<0.001**	26.5 ± 4.1
Waist circumference, cm	93.8 ± 11.6	104 ± 13.5	**<0.001**	95 ± 12.3
Visceral adipose tissue, g	1,419 ± 887	2,305 ± 1,236	**<0.001**	1,519 ± 974
Systolic blood pressure, mmHg	141 ± 16.6	139 ± 17	**0.092**	140 ± 16.7
Diastolic blood pressure, mmHg	80.7 ± 8.8	78.2 ± 10	**<0.001**	80.4 ± 9
Fasting blood glucose, mmol/L	5.4 ± 0.6	7.5 ± 2	**<0.001**	5.6 ± 1.1
Cholesterol, mmol/L	5.5 ± 1.1	4.6 ± 1.1	**<0.001**	5.4 ± 1.2
Triglycerides, mmol/L	1.3 ± 0.7	1.7 ± 1	**<0.001**	1.4 ± 0.7
Myocardial infarction, n (%)	95 (5.7)	30 (14)	**<0.001**	125 (6.7)
Stroke, n (%)	55 (3.4)	15 (7.4)	**<0.01**	70 (3.9)
Current smokers, n (%)	99 (6)	13 (6.2)	0.90	112 (6)
Statin users, n (%)	476 (29)	140 (67)	**<0.001**	616 (33)
Hypertension medication, n (%)	864 (52)	173 (84)	**<0.001**	1,037 (56)
Level of PA, minutes/week				
Self-reported (IPAQ-SF)				
Total MVPA	366 ± 399	288 ± 346	**<0.01**	356 ± 394
Total MVPA + walking	732 ± 555	599 ± 482	**<0.001**	717 ± 549
Objective (accelerometry)				
Total MVPA	237 ± 184	168 ± 157	**<0.001**	229 ± 182
MVPA in at least 10-minute bouts	151 ± 155	107 ± 131	**<0.001**	146 ± 153
Step-count (steps/day)	7,355 ± 3,093	5,904 ± 3,038	**<0.001**	7,192 ± 3,119
Level of PA guideline fulfillment				
Self-reported				
300 minutes MVPA/week, n (%)	750 (45)	77 (37)	**<0.05**	827 (44)
150 minutes MVPA/week, n (%)	1,017 (61)	107 (51)	**<0.01**	1,124 (60)
Objective				
300 minutes MVPA/week, n (%)	500 (30)	38 (18)	**<0.001**	538 (29)
300 minutes MVPA/week (bout), n (%)	254 (15)	24 (11)	0.139	278 (15)
150 minutes MVPA/week, n (%)	1,046 (63)	90 (43)	**<0.001**	1,136 (61)
150 minutes MVPA/week (bout), n (%)	667 (40)	66 (31)	**<0.05**	733 (39)
≥6,000 steps/day, n (%)	1,077 (65)	83 (40)	**<0.001**	1,160 (62)

Data are presented as means ± SD or, for dichotomous variables, as absolute numbers and percentages. Bout indicates aggregated PA in bouts of at least 10 minutes. Bold type indicates statistical significance.

Visceral Adipose Tissue as a Mediator of Health Benefits From PA

In all statistical models, VAT mass was significantly associated with diabetes prevalence. Furthermore, the inclusion of VAT mass in statistical models weakened the association between PA and diabetes (Table 2). Moreover, all investigated PA measures were significantly correlated with VAT mass (P <0.001, Figure 2). However, associations with non-bouted and accelerometer-derived measures of PA were stronger than those with bouted
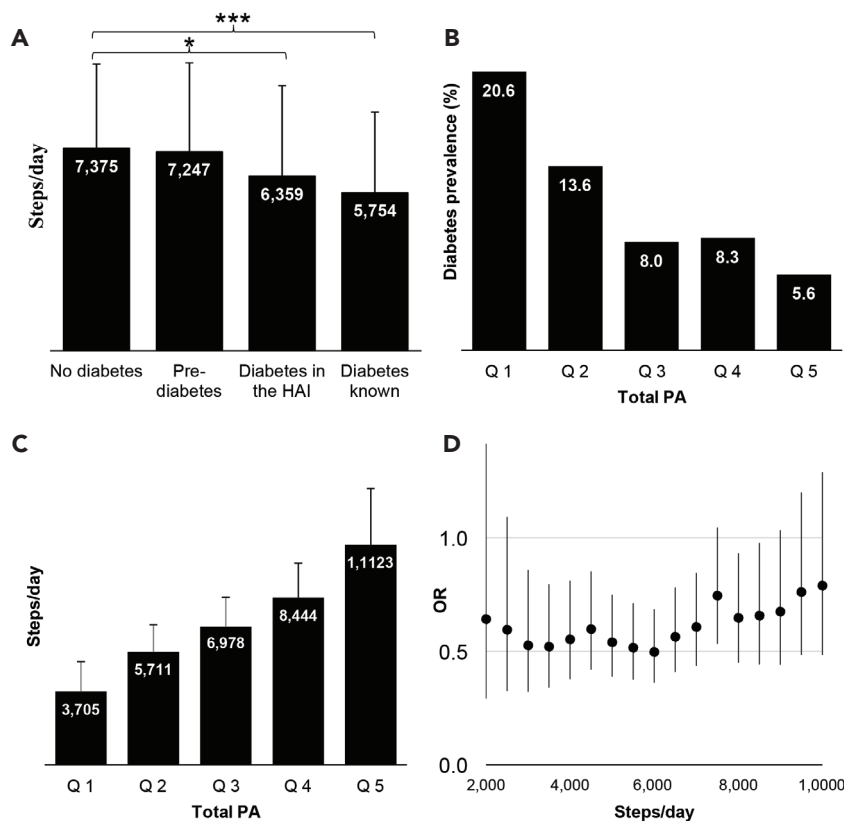
FIGURE 1. Prevalent diabetes is associated with lower levels of PA. *A*: Daily step-count for different groups based on FBG and diabetes diagnosis. Step-counts are generated from 7-day accelerometer measurement and presented as mean and SD for respective group. Groups were defined as no diabetes, prediabetes with an impaired fasting blood glucose, diabetes detected at the time of the study, and those with known diabetes. Differences between groups were investigated with analysis of covariance adjusted for sex, smoking, and adolescent PA level. *P<0.05. ***P<0.001. *B*: Total PA as defined by total count from accelerometer (7 days) divided into quintiles (Q 1–5). Diabetes prevalence was then investigated in each quintile. Diabetes prevalence was higher in the two first quintiles of PA, indicating a nonlinear relationship. *C*: Quintiles of total PA presented as mean and SD of daily step-count. *D*: Determination of the optimal cut point for daily step-counts in relation to prevalent diabetes. The risk of prevalent diabetes for different steps/day cut points presented as ORs and 95% CIs from logistic regression adjusted for sex, smoking, VAT mass, and adolescent PA level. The lowest OR, 0.50 (0.36–0.69), was found for the 6,000-steps-per-day cut point.

and self-reported PA measures. The strongest association for VAT mass was seen for the number of steps taken per day (β = 0.29, *P*<0.001).

Discussion

In this population-based study of men and women aged 70 years, participants with known diabetes at baseline had PA >20% lower than those without diabetes, as measured by objective accelerometers. A cut point of 6,000 steps/day discriminated best between subjects with and without diabetes. Number of steps per day also showed the strongest association with amount of VAT, a potential mediator of the effects of PA with respect to diabetes.

Increased PA is a general recommendation given to most individuals with type 2 diabetes, with a number of positive effects including increased insulin sensitivity, increased glucose control, and weight loss (3,10,12).

Therefore, it was quite surprising that individuals with known diabetes, who it is reasonable to assume have received such advice, had the lowest amount of PA.

We have found no previous studies in which objective measures of PA have been compared in elderly individuals with known diabetes and potential diabetes identified at baseline. However, Cichosz et al. (23) investigated 100 individuals with newly diagnosed diabetes and found, by use of accelerometers, that they had more time spent in sedentary activities during the day compared to a matched control group. These subjects with newly diagnosed diabetes may correspond to our group of individuals identified at baseline.

There may be several contributing factors for the low activity levels in individuals with diabetes. First, PA is largely determined by genetic factors, at least at younger ages. Thus, Joosen et al. (24) found that at least 70% of the variation in objectively measured habitual PA was controlled by genetic factors in twins aged 19–39 years. Another reason may be that the recommendations given are complicated and hard to monitor, which therefore results in poor compliance. It was previously demonstrated in a meta-analysis that PA advice alone was not associated with A1C changes in patients with diabetes (25).

It is also of interest that the WHO recommendation of at least 150 minutes of PA per week in at least 10-minute bouts did not discriminate between subjects with and without diabetes in this study. This cut point for objective PA also showed the lowest correlation with amount of VAT mass in the total cohort. This is of importance because VAT mass is of significance not only for diabetes but also for a number of other NCDs, including CVD (26).

The importance of PA bouts has been challenged previously, because objectively measured PA, with and without the 10-minute bout criterion, has been proven to be equally
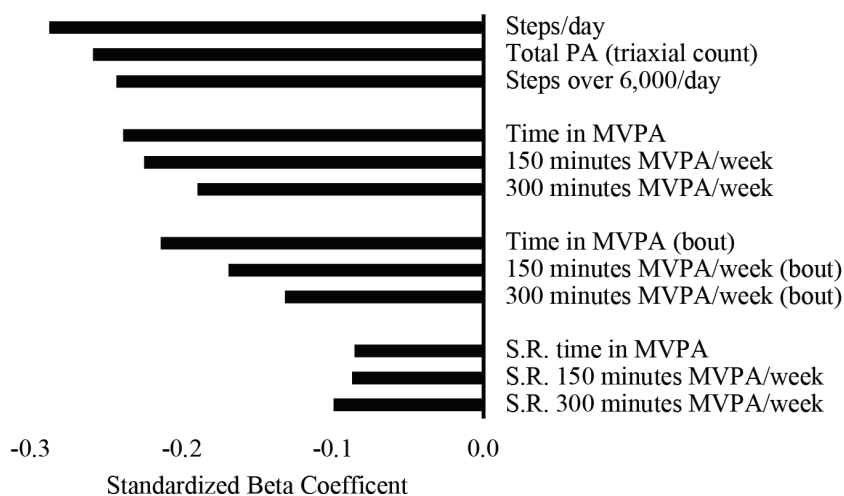
■ **FIGURE 2**. Association of objective and self-reported PA measurements and VAT mass. Linear regression adjusted for sex, smoking, and adolescent PA level revealed the investigated PA measurements to be significantly associated to VAT mass ($P <0.001$ for all), with a generally stronger association for non-bouted, objective measures of PA. Bout, aggregated PA in bouts of at least 10 minutes. S.R., self-reported data; all other data are based on 7-day accelerometer measurement.

associated with risk reductions for metabolic syndrome (27) and adiposity (28), and non-bouted PA has been associated with even larger risk reductions for unfavorable blood lipid profile and waist circumference (29) in adult and elderly populations.

In this study, we found a nonlinear relationship between PA and diabetes prevalence. After further elaboration, a cut point of 6,000 steps/day resulted in the best discrimination of subjects based on diabetes status. Identification of a specific cut point for older adults with respect to public health and exercise recommendations would be of interest. Pedometers are relatively affordable, and current step counters are integrated in most smartphone technology. Thus, tools for step-count documentation are widely accessible (30), and their effectiveness in weight loss interventions has been proven (31,32). Thus, the proposed cut point of 6,000 steps/day could be an understandable PA measure for older individuals. Given previous results in which activity advice alone has been found to be ineffective in subjects with diabetes (25), testing the value of this cut point in combination with the use of pedometers to promote compliance in a randomized

trial with activity-related outcomes would be of great interest.

Most guidelines concerning PA, including those issued by the WHO, are based mainly on self-reported PA. In this study, self-reported PA was more than twice objectively measured PA. Furthermore, the association between self-reported PA and objectively measured PA was weak or nonexistent. The importance of objective measures of PA has been shown previously by others (33,34). Our inference is that objective measures of PA should also be used more in the clinical situation, given that most people today have access to smartphones with free apps for measuring activity-related outcomes.

Exercise interventions for individuals with type 2 diabetes have been shown to reduce VAT mass without significant weight loss (i.e., change in BMI) (35). This points to the importance of using more accurate estimates of adiposity than weight or BMI when investigating the effects of interventions in relation to obesity and diabetes. In this study, we hypothesized that the association between PA and diabetes was mediated by the effects of VAT mass. Adjusting the association between

PA and diabetes for VAT mass weakened the diabetes OR reduction achieved by PA, indicating that the protective role of PA on diabetes is partially mediated by reduced VAT mass. This observation is supported by the results of a recent meta-analysis that produced similar findings when adjustments for adiposity were made (36). Moreover, we found that objectively measured steps per day had the strongest association with VAT mass, further strengthening the relevance of total non-bouted PA recommendations.

In this population-based cohort, all participants were 70 years of age at the time of investigation. Thus, although the study is limited by its cross-sectional design and inherent limitations in establishing causal relationships, the sample constitutes a representative reference group for the investigated age category. Furthermore, because diabetes is associated with an increased risk of CVD and that CVD in turn may affect physical capacity, a sensitivity analysis was made in which participants with prior stroke or myocardial infarction were excluded. The results of the sensitivity analysis did not significantly affect the results, suggesting that reverse causation due to reduced physical capacity in relation to diabetes is not evident.

An additional sensitivity analysis was also made in which only people with a prior diabetes diagnosis (not those with diabetes based on a high FBG, due to the limitations of capillary fasting blood glucose measurements [22]) were included, which generated close to analogous results. This indicates that the potential limitation of categorizing subjects as having diabetes based on capillary FBG does not influence the main findings of the study.

A limitation of the accelerometer is that it does not record aquatic PA, and it detects PA involving the legs more accurately than PA involving the arms. In addition, although participants were asked to adhere to their

TABLE 2. Association of Different PA Cut Points on Diabetes Prevalence

Physical Activity Cut Points	Model 1			Model 2			Model 3		
	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Self-reported (IPAQ-SF)									
300 minutes MVPA/week	0.70	0.52–0.95	**0.020**	0.66	0.49–0.89	**0.007**	0.74	0.54–1.02	0.068
150 minutes MVPA/week	0.66	0.49–0.88	**<0.001**	0.62	0.46–0.83	**<0.001**	0.71	0.52–0.96	**0.026**
Objective (accelerometry)									
WHO 300 minutes MVPA/week (bout)	0.72	0.46–1.12	0.141	0.72	0.46–1.13	0.153	1.00	0.63–1.60	0.990
300 minutes MVPA/week	0.51	0.36–0.74	**<0.001**	0.50	0.35–0.73	**<0.001**	0.71	0.48–1.04	0.079
WHO 150 minutes MVPA/week (bout)	0.68	0.50–0.93	**0.015**	0.67	0.49–0.92	**0.012**	0.92	0.66–1.28	0.631
150 minutes MVPA/week	0.44	0.33–0.59	**<0.001**	0.41	0.31–0.56	**<0.001**	0.60	0.44–0.83	**0.002**
6,000 steps/day	0.36	0.26–0.48	**<0.001**	0.34	0.25–0.46	**<0.001**	0.50	0.36–0.69	**<0.001**

Logistic regression of association between prevalent diabetes and PA cut points. Bout indicates aggregated PA in bouts of at least 10 minutes. Model 1 is unadjusted; model 2 is adjusted for sex, smoking, and adolescent PA level; and model 3 is adjusted for sex, smoking, adolescent PA level, and VAT mass. Bold type indicates statistical significance.

normal lifestyles during the 7 days of accelerometer measurement, they may have increased their activity. However, any change in activity is unlikely to be influenced by diabetes status at baseline. Furthermore, the results of this and previous studies suggest that accelerometer technology is the most reliable method of PA measurement (37) and that it avoids the risk of overestimation, which is otherwise inherent to self-reported PA (38).

Conclusion
In summary, compliance to PA recommendations for elderly people with diabetes seems challenging, given that individuals with known diabetes had the lowest PA level in this study. Notably, the WHO recommendation of PA in bouts discriminated poorly between subjects with and without diabetes. In contrast, a cut point of 6,000 steps/day revealed the strongest association with prevalent diabetes and showed the strongest inverse association with VAT mass, which may mediate the effects of PA. It would be of interest to test this cut point for compliance and effects on blood glucose and VAT mass in subjects at high risk for diabetes in a future intervention study.

Author Contributions
Conception and study design: P.N. and A.N. Data collection: J.J. Data interpretation

and analysis: A.H. and P.N. Drafting of the manuscript: A.H. and J.J. Revision of the manuscript and final approval: A.H., J.J., P.N., and A.N. A.N. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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