**Section:** Original Research

**Article Title:** Gender Differences in Physical Activity Levels of Older People With Type 2 Diabetes Mellitus

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## Abstract

**Background:** Physical activity (PA) is important in managing Type 2 Diabetes Mellitus (T2DM). This study aimed to determine (i) the number of daily steps taken by older people with T2DM, (ii) if T2DM is associated with taking fewer steps per day and less likelihood of meeting PA guidelines and (iii) whether these associations are modified by age or gender. **Methods:** PA was obtained by pedometer from two cohorts of older adults with and without T2DM. Multivariable regression was used to determine associations between T2DM, mean steps per day and meeting a guideline equivalent (7 100 steps per day). **Results:** There were 293 participants with T2DM (mean age 67.6 ± 6.8 years) and 336 without T2DM (mean age 72.1 ± 7.1 years). In women, T2DM was associated with fewer mean steps per day (β = -1306.4 95% CI -2052.5, -560.3, p=0.001) and not meeting the PA guidelines (OR 0.51 95% CI 0.28, 0.92, p=0.03). Associations were not significant in men (p>0.05). Only 29.7% of those with T2DM and 33.3% of those without T2DM met PA guidelines. **Conclusions:** Greater focus is needed on how to maintain and increase PA in older age with particular focus on women with T2DM.

**Key words**: Aging, steps per day, pedometer

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## Introduction

Populations are aging globally and the prevalence of Type 2 Diabetes Mellitus (T2DM) is increasing rapidly.[1] As T2DM and disease related complications are known to be associated with greater health care utilisation, reduced productivity, poorer quality of life and premature mortality, increasing prevalence is placing an enormous social and economic burden on individuals, families and health systems.[2-4] This is particularly relevant to older people with T2DM given complication rates are disproportionately high amongst this group.[2] It is well established that physical inactivity is an important modifiable risk factor for T2DM and related complications.[5,6] As such regular physical activity (PA) is recommended for prevention and management of T2DM[7] and has been shown to be effective in improving health outcomes in this population.[5]

To date, PA levels in community dwelling older people with T2DM are not well quantified. Many studies have relied on self-report tools, which are known to be subject to unreliable recall,[8] social desirability bias[9] and are inaccurate in determining absolute PA values.[8] Using such methods, cross-sectional studies have suggested that older people with T2DM perform less PA than their non-diabetic counterparts.[10-14] Recent reviews have summarised studies that objectively measured PA in people with T2DM in general, but the strength of these findings specific to older community dwelling people with T2DM are limited given large participant age variation, small sample sizes, reliance on clinic-based samples and use of volunteers in interventional research.[15-19] A further two population-based studies have objectively measured PA in community dwelling older people, but had small numbers of participants with diabetes and failed to distinguish between different types of diabetes in the analyses.[20,21] The effect of gender on ambulatory PA levels also remains uncertain in older age groups. It is plausible that gender may alter the relationship between T2DM and PA as women with T2DM have a greater number of cardiovascular risk factors.[22]

Current U.S. guidelines for aerobic PA in people with T2DM recommend accumulating 150 minutes of moderate intensity activity each week.[23] These are similar to those for older adults in general, which stipulate the completion of moderate intensity PA for 30 minutes, five days a week.[24] Despite the presence of well-established guidelines the compliance of older people with T2DM to these has not been well quantified. To address some of the limitations of studies mentioned above we used pedometers to measure PA in two large cohorts of community dwelling older people with and without T2DM with the aim to (i) describe the number of steps per day taken by older people with T2DM, (ii) investigate if a diagnosis of T2DM is associated with taking fewer steps per day and less likelihood of meeting PA guidelines and (iii) determine whether these associations are modified by age or gender. We hypothesised that those with T2DM would take fewer steps per day and have lower compliance with PA guidelines than those without T2DM.

## Methods

*Sample*

The sample was derived from participants recruited to two large cohort studies – the Cognition and Diabetes in Older Tasmanians study (CDOT) and the Tasmanian Study of Cognition and Gait (TASCOG). CDOT participants (the exposure group) were aged ≥55 years with a diagnosis of T2DM. Recruitment occurred between January 2008 and January 2010 via letters sent to people on the National Diabetes Service Scheme (NDSS) register whom had previously expressed a willingness to participate in research and resided in areas with postcodes between 7000-7199 in southern Tasmania, Australia. The NDSS is an organisation administered by Diabetes Australia that provides products, information and support to people with diabetes mellitus. Enrolment to the NDSS is performed on a voluntary basis and requires a diagnosis of T2DM based on standard criteria - fasting plasma glucose

≥7.0mmol/L, random plasma glucose ≥11.1mmol/L and 2 hour glucose ≥11.1 post oral glucose tolerance test[25] or $Hb_{A1C}$ ≥6.5%.[26]

The comparison group was derived from a sample of participants aged ≥60 years recruited into the previously described population-based TASCOG study.[27] This occurred via approach letters posted to eligible people randomly selected from the electoral roll residing in areas with the same postcodes to those in the exposure group between January 2005 and December 2008. Absence of T2DM was determined using the aforementioned fasting glucose criteria. Any participant diagnosed with T2DM was included in the above T2DM group. Exclusion criteria were identical in both CDOT and TASCOG studies and included residing in an aged care facility, poor command of English and contraindication to MRI, as this was the criteria for the larger study. Written consent was obtained from all participants and the Southern Tasmanian Health and Medical Human Research Ethics Committee and Monash University Human Research Ethics Committees provided approval for both the studies.

*Outcome measurements*

Steps taken per day were measured using unsealed Yamax Digiwalker® SW-200 pedometers (Yamax Corporation, Tokyo), which have been found to be valid and reliable for use by adults in free-living conditions.[28,29] Participants wore these at the waist of their dominant leg for a period of seven consecutive days. Participants were provided a pedometer log and written instructions outlining correct procedures for use and recording of daily pedometer display readings to be completed at the end of each day. Step count values were averaged across days where recording time was ≥8 hours for each participant. We determined that a cut off value for wear time of eight hours a day would result in 95% of mean steps/day being captured.

Standardised questionnaires were used to record demographic and clinical information including age, gender, education level, smoking history, onset and duration of

T2DM and medical history including vascular disease, hypertension, hyperlipidaemia and stroke. Mood was assessed using the 15-item Geriatric Depression Scale[30] and presence of pain using a subcomponent of the Assessment of Quality of Life instrument.[31] We used a battery of cognitive tests to assess a number of cognitive domains (executive function, processing speed, memory, language and visuospatial function) as described previously.[32] Participants were considered to be cognitively impaired if they were ≥1.5 standard deviations below the norm for age, gender and level of education in any one domain. Fasting plasma glucose was measured using a Roche Cobas 6000 analyser with hexokinase determination, $Hb_{A1C}$ with a Bio-Rad D10 analyser and waist and hip circumferences were measured to calculate waist-hip ratio (WHR). All recording and measurement of outlined variables were performed on both groups by trained individuals according to predetermined protocols. Participants were divided into four age groups: 55 - 59 years, 60 - 69 years, 70 – 79 years and 80 – 90 years to more clearly describe steps taken per day by age.

*Statistical Analysis*

Student's t-tests and Chi square tests were applied to compare mean values and proportions of demographic and clinical variables between groups. Multivariable linear regression was performed to determine the association between T2DM and mean number of steps per day adjusting initially for age and gender. Further potential confounding was examined for additional covariates and were included in the model if addition of these terms changed the coefficient for T2DM by >10%. Considered covariates included years of formal education, smoking history, ischaemic heart disease, stroke, cognitive impairment, depression, pain and WHR. Participant mean step per day values were compared against a 7 100 steps target to determine compliance with PA guidelines. This ambulatory target has been established as the equivalent of performing 150 minutes of moderate intensity PA accumulated over the period of a week in free living older adults with a diagnosed chronic

condition such as T2DM.[15,33] Univariable logistic regression was used to estimate the odds ratios between T2DM and meeting the 7 100 steps target. Statistical interaction between T2DM, age and gender were assessed for both overall mean steps and step per day target by a test of significance of the product terms in the model (T2DM × age, T2DM × gender). Data analyses were completed using Stata Data Analysis and Statistical Software (version 12, StataCorp LP, Texas).

## Results

In total 713 participants (350 participants with T2DM and 363 without T2DM) attended the clinic for assessment and completed the initial questionnaire. Of these, 293 with T2DM (mean age 67.6 ± 6.8 years) and 336 without T2DM (mean age 72.1 ± 7.1 years) participated in the pedometer component of the study. Those that did not participate in the pedometer component were significantly more likely to have T2DM ($p < 0.001$), lower mood ($p < 0.001$), cognitive impairment ($p < 0.001$), fewer years of formal education ($p = 0.04$) and higher reported levels of pain ($p = 0.01$). They did not differ by age ($p = 0.89$) or gender ($p = 0.18$).

Descriptive characteristics and intergroup comparisons of the sample are presented in Table 1. Participants with T2DM reported median disease duration of 8.9 ± 9.4 years and had significantly greater fasting blood glucose ($p < 0.001$) and $Hb_{A1C}$ levels ($p < 0.001$), greater WHR ($p < 0.001$) and were more likely to have a cognitive impairment ($p = 0.002$). Those with T2DM were also more likely to report a history of hypertension ($p < 0.001$) and hyperlipidaemia ($p < 0.001$).

*T2DM and mean number of steps per day*

Table 2 reports the mean (SD) steps per day by age group and gender. In unadjusted models mean steps per day were similar in those with and without T2DM at 6019.5 ± 3603.6

and 6106.0 ± 3185.3 respectively (β = -86.5 95%CI -618.1, 445.1, p = 0.75). However, after adjustment for age and gender, T2DM was associated with fewer mean steps per day (β = -907.3 95% CI -1431.5, -383.2, p = 0.001). The addition of cognitive impairment reduced the strength of the association by 11.1%, but the association between T2DM and steps per day remained significant (β = -806.8 95% CI -1330.7, -282.9, p = 0.003). Adjusting for WHR markedly reduced the magnitude of the T2DM coefficient (59.4%), but there was little change in the coefficient for WHR in the model with T2DM when compared to its value in the model without T2DM (1.1%). As we could not discount WHR as a mediator in the association between T2DM and PA it was not included in the model. None of the other considered covariates (years of formal education, smoking history, ischaemic heart disease, stroke, depression and pain) changed the co-efficient of T2DM by more than 10% and were therefore not included in the final analysis. As there was an interaction between T2DM and gender (p=0.05) we stratified by gender and found the association between T2DM and steps per day to be significant in females (β = -1306.4 95% CI -2052.5, -560.3, p = 0.001), but not males (β = -431.3 95% CI -1156.9, -294.2, p = 0.24). Finally, advancing age was associated with a smaller number of daily mean steps in men and women with and without T2DM (Table 2; p<0.001), however there was no interaction between T2DM and age in the full sample or when stratified by gender (p>0.05).

*T2DM and meeting PA guidelines*

The PA guideline equivalent of 7 100 steps per day was met by 29.7% (n = 76/256) of those with T2DM (≥ 60 years) and 33.3% (n = 112/336) of those without T2DM. In unadjusted analysis those with T2DM were less likely to meet the 7 100 step per day target (OR 0.61 95%CI 0.42, 0.89; p=0.01). Adjusting for age, gender and cognitive impairment made little change to the associations (OR 0.64 95%CI 0.44, 0.93; p=0.02). When stratified by gender, the association between T2DM and meeting the PA guideline remained significant

in females (OR 0.51 95%CI 0.28, 0.92; p=0.03), but not males (OR 0.75 95%CI 0.46, 1.22; p=0.25). In both those with and without T2DM there was significant association between greater age and not meeting the guideline (p<0.001). Figure 1 shows the percentage of participants meeting the guideline by T2DM status and gender.

## Discussion

This study provides novel data on the association between T2DM, objectively measured PA and the likelihood of meeting current PA guidelines in terms of step per day equivalents in older people. Our main finding was that in older women, but not men, T2DM was associated with taking fewer steps per day and less likelihood of meeting current PA guidelines. Advancing age was associated with taking fewer mean steps per day regardless of T2DM status or gender, and less than 35% of all older people (≥60 years) met PA guidelines. PA is recommended as part of first line and on-going treatment for T2DM[23] and plays an important role in the maintenance of health and effective functioning of older people in general.[34] These findings highlight the need for interventions that target older people and in particular women with T2DM to increase PA levels and hence reduce cardiovascular risk, disability and associated long-term costs.

This study has a number of strengths. Our sample comprised two large cohorts of community-dwelling older people with and without T2DM and as such is more likely to be representative of the general population when compared with previous studies, which have been limited by relatively small sample sizes of people with T2DM[20,21] or have relied upon clinic-based samples or volunteers in interventional research.[15,35] Our comparatively large sample size enabled multivariable regression modelling to adjust for a number of potentially important confounders and assessment of interaction between T2DM, age and gender. As such we were able to provide novel information on the association between T2DM, mean steps per day and compliance with PA guidelines including gender differences. Finally our

use of pedometers to objectively measure ambulatory activity is advantageous as pedometers have been shown to be more accurate than self-report in determining PA levels[36] and their use complies with the American College of Sports Medicine and American Diabetes Association recommendations for objective measurement.[23]

There are also a number of limitations to our study. Firstly, those with T2DM were recruited from individuals who had expressed willingness to participate in research on the NDSS register and consequently may have been a healthier representation in comparison to all people with T2DM. Furthermore, people who declined to participate in the pedometer component of both studies were found to be significantly more likely to have T2DM, lower mood, poorer cognition, fewer years of formal education and report higher levels of pain. As such it is plausible that our findings overestimate mean steps per day and compliance with PA guidelines in those with and without T2DM in the general population. Secondly, it has been shown that pedometers may be less sensitive when worn at the waist by overweight and obese people[37] and given that participants with T2DM in our study had significantly higher WHRs than those without T2DM it is possible that their step counts may have been underestimated. Our comparison to PA guidelines is limited in that we did not measure exercise intensity, instead relying on computed estimates based on total daily step counts. It is possible that participants in our study may not have been exercising at a moderate intensity despite meeting the recommended 7 100 step target and it is therefore possible that our results may overestimate compliance with PA guidelines in both groups. We also did not capture non-ambulatory forms of PA such as resistance-based exercise, cycling or swimming, although the effect of these are likely to be minimal given walking has been found to be one of the most common forms of exercise in older people with T2DM.[11] Finally, as our study design was cross-sectional, interpretation of results is limited to determining association between T2DM and levels of PA and cannot be used to establish causation.

We found that in women, T2DM was associated with fewer steps per day and reduced likelihood of meeting PA guidelines. To our knowledge there is a paucity of studies comparing objectively measured ambulation between community-dwelling older people with and without T2DM. The findings of the few studies[20,21] that have examined this have been conflicting. Harris and colleagues[21] reported fewer steps per day in those with T2DM over 65 years of age (n=15) compared with those without T2DM (n=220) recruited from one General Practice clinic in the United Kingdom. In contrast, a population-based study from Australia did not find a difference in steps per day between those with T2DM (n=75) and those without T2DM (n=562).[20] Differences may be due to the small number of participants with T2DM or the fact that gender differences were not examined. Our results are in agreement with one study that found women with T2DM self-reported less PA compared with women without T2DM.[14] We were unable to determine why gender differences were present. Women with T2DM may a greater number of cardiovascular risk factors compared with men,[22] and therefore it is possible that sub- or clinical disease not measured in this study may have prevented women from being as physically active. Other factors that were not measured in our study, but may contribute to lower PA levels in people with T2DM, although not necessarily specific to women include low levels of self-efficacy[38], motivation, mobility, general disability[38], peripheral neuropathy or peripheral arterial disease.

Despite regular PA being recommended for all older people regardless of disease status, less than 35% of older people with (29.7%) or without T2DM (33.3%) met the 7100 steps per day guideline equivalent. PA compliance in our study was slightly less than that reported by Ewald and colleagues[20] who used pedometers to measure PA levels in community dwelling older adults and found 42% met guidelines. This difference could be explained by the older age of our participants (mean age 71 ± 7 years compared with 65 ± 8 years). Similar to the findings of previous studies, examination of mean number of steps per

day stratified by age group in our study demonstrated that advancing age was associated with taking fewer steps per day in both those with T2DM and without T2DM.[20,38-40] Interestingly T2DM status did not modify this association. This was somewhat unexpected given that T2DM is associated with a number of conditions that can limit mobility and has been shown to contribute to more rapidly deteriorating mobility during the aging process.[41] Taken together with the findings discussed above, these results suggest that lower levels of PA in women with T2DM compared to those without T2DM may occur before the sixth decade of life. This highlights the importance of finding novel ways to assist people, particularly women with T2DM to carry out and maintain sufficient PA into older age.

## Summary/conclusions

Women with T2DM may be particularly at risk of cardiovascular complications taking fewer steps per day and being less likely to meet PA guidelines in comparison to their non-diabetic counterparts. The majority of community-dwelling older people with and without T2DM do not meet current recommendations for PA in terms of mean steps taken per day. Greater effort is needed to understand and assist people to maintain PA into older age in order to prevent, manage and reduce associated complications of T2DM, with particular attention to women with T2DM.

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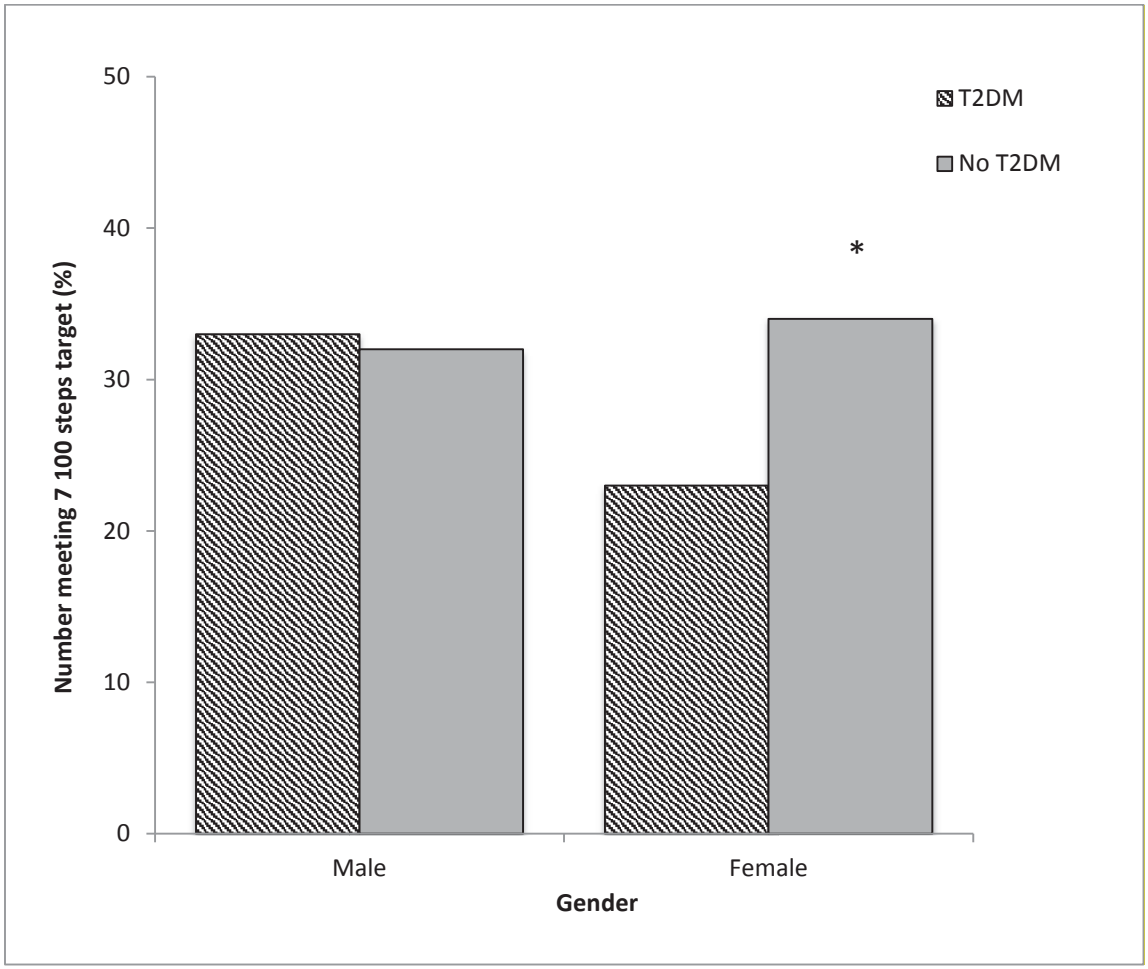
**Figure 1**. Percentage of participants meeting PA guideline by T2DM status and gender[+]




[+]55-59 year olds excluded for comparison; T2DM=Type 2 Diabetes Mellitus

* p = 0.03

**Table 1**. Sample characteristics

| | **T2DM Mean (SD) or n (%) n=293** | **No T2DM Mean (SD) or n (%) n=336** | ***p* value** |
|---|---|---|---|
| Age (years) | 67.6 (6.8) | 72.1 (7.1) | <0.001 |
| Female | 112 (38.2) | 154 (45.8) | 0.05 |
| Formal education (years) | 11.5 (3.5) | 10.9 (3.7) | 0.05 |
| *Self-reported medical history* | | | |
| History of hypertension | 211 (72.0) | 149 (44.4) | <0.001 |
| Ischemic heart disease | 41 (14.0) | 39 (11.6) | 0.37 |
| TIA or stroke | 27 (9.2) | 24 (7.2) | 0.35 |
| Hyperlipidaemia | 73 (25.0) | 28 (8.4) | <0.001 |
| Ever smoked | 161 (55.0) | 172 (51.2) | 0.35 |
| Pain (1-4)* | 1.71 (0.62) | 1.67 (0.61) | 0.38 |
| *Measured variables* | | | |
| Body mass index ($kg/m^2$) | 30.2 (5.0) | 27.1 (4.1) | <0.001 |
| Waist-hip ratio | 0.96 (0.1) | 0.90 (0.1) | <0.001 |
| Fasting blood glucose (mmol/L) | 7.7 (2.2) | 5.3 (0.6) | <0.001 |
| $HB_{A1c}$ (%) (mmol/mol) | 7.2 (1.2) | 5.6 (0.3) | <0.001 |
| Cognitively impaired | 130 (44.8) | 109 (32.5) | 0.002 |
| Geriatric Depression Score (1 – 15) | 2.2 (2.4) | 1.9 (2.2) | 0.14 |
| Median duration of T2DM (years) | 8.9 (9.4) | - | |

* Assessment of Quality of Life instrument subcomponent

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**Table 2**. Mean steps per day by age group, gender and T2DM status

| | Female | | | | Male | | | |
|---|---|---|---|---|---|---|---|---|
| **Age group (years)** | **n** | **T2DM Steps/day mean ± SD** | **n** | **No T2DM Steps/day mean ± SD** | **n** | **T2DM Steps/day mean ± SD** | **n** | **No T2DM Steps/day mean ± SD** |
| 55-59 | 18 | 6850.1 ± 3454.5 | | - | 19 | 8476.9 ± 3454.5 | | - |
| 60-69 | 59 | 5853.8 ± 2750.7 | 77 | 7501.0 ± 3419.8 | 102 | 6587.9 ± 3886.3 | 71 | 6971.1 ± 2639.0 |
| 70-79 | 29 | 4662.6 ± 3637.7 | 55 | 5739.1 ± 2459.7 | 49 | 5845.4 ± 3388.7 | 71 | 5873.8 ± 3156.1 |
| 80-90 | 6 | 3221.5 ± 1749.6 | 22 | 3826.8 ± 2287.0 | 11 | 1912.4 ± 1543.5 | 40 | 4055.7 ± 3172.6 |
| Trend | | -1168.1 | | -1818.5 | | -1650.7 | | -1416.5 |
| (95% CI) | | (-1912.5, -423.9)† | | (-2473.3, -1163.6)* | | (-2379.7, -921.7)* | | (-1985.5, -847.4)* |

T2DM = Type 2 Diabetes Mellitus; SD=standard deviation, n = number, CI = confidence interval; * p<.001; † p<.01; ‡ p<.05