Physical activity and sedentary behaviour of adults with type 2 diabetes: a systematic review

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Abstract
Regular physical activity and low levels of prolonged sedentary behaviour are important lifestyle recommendations for the management of type 2 diabetes. This systematic review collates and summarises published research reporting on physical activity and sedentary behaviour of adults with type 2 diabetes.

Systematic searches with three databases were conducted (Medline; PubMed; SportDiscus). Intervention studies were excluded. Studies were eligible if they: (i) were published in English; (ii) were published between 1997 and January 2017; and (iii) objectively and/or subjectively measured physical activity and/or sedentary behaviour in adults with type 2 diabetes. Two reviewers independently cross-checked studies, conducted a quality assessment and extracted data. Data were analysed using descriptive statistics and a narrative synthesis.

The search identified 349 studies; 29 eligible studies were included. All studies measured physical activity and 15 studies measured sedentary behaviour. Twenty studies used subjective methods, six used objective methods and three used both subjective and objective methods. Most studies report low levels of physical activity and high levels of sedentary behaviour in adults with type 2 diabetes and note adults with type 2 diabetes to be less active and more sedentary than those without type 2 diabetes.

Regardless of measurement method or study location, adults with type 2 diabetes report low levels of physical activity and high levels of sedentary behaviour and are less active and more sedentary than those without type 2 diabetes. There is a need for large-scale interventions which support active lifestyles to be implemented into diabetes care. Copyright © 2018 John Wiley & Sons.

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Key words
physical activity; sedentary behaviour; type 2 diabetes

Background
There is substantial evidence documenting the wide-ranging benefits of frequent, regular physical activity (PA) for management of type 2 diabetes (T2D) with improvements in glycaemic control, cardiovascular risk factors and overall quality of life being reported.1 Independent of PA levels, time spent in sedentary behaviour (SB) has also been shown to be deleterious for health.2 Sedentary behaviour is characterised as any waking behaviour in a sitting or reclined posture with energy expenditure of less than 1.5 metabolic equivalents.3 A randomised crossover trial by Dempsey et al.4,5 concluded that interrupting prolonged SB with 3 minutes of light-intensity PA improves glucose metabolism in adults with T2D.

The American Diabetes Association recommends that adults with T2D should exercise daily or at least every other day taking part in both aerobic and anaerobic activities;1 the aim being to meet current PA guidelines of at least 150 minutes a week of moderate PA or 75 minutes of vigorous intensity exercise per week.6 Reducing the amount of time spent sedentary and breaking up prolonged SB of >30 minutes with light activity is also recommended for management of T2D.1

Surveys using self-report methods have found adults with T2D are less physically active than those without the condition.7 Recently, data exploring this topic have been reported using objective methods. Both methods have advantages and disadvantages. Objective methods can capture detailed information on the pattern, for example intensity and time of behaviour; however, they do not provide information about the type of activity and may not capture all physical activity such as water-based activity. Subjective methods provide information on the type of activity but are often criticised on issues related to robustness of self-report data.
The objective of this systematic review was to review published evidence exploring PA and SB levels in adults with T2D.

**Methods**

The protocol for this systematic review can be accessed via www.crd.york.ac.uk registration number: CRD42017053717. A literature search was conducted in January 2017 to identify eligible studies. A date restriction of 1997 was used to ensure findings were relevant to current practice. Only peer reviewed, published articles in English were included. Three databases were searched using a Boolean search strategy: Medline, PubMed and SportDiscus. Search terms were:
- Population – over 18 years of age with T2D.
- Intervention – no intervention.
- Comparison – no comparison or comparison with population with or without T2D or another relevant chronic disease.
- Outcomes – SB or PA/inactivity as an outcome.
- Study design – quantitative studies including cross-sectional and cohort design.

A Medical Subject Headings (MeSH) search of T2D was conducted to inform search terms. Definitions of PA and SB were used to describe outcomes – for example: exercise; exercise habits; physical inactivity; sedentary time; sitting. Additionally, reference lists and first authors of eligible studies were manually searched. Intervention studies were excluded as PA behaviour could be non-representative of participants’ usual patterns due to motivations during interventions. Exclusion and inclusion criteria were applied to the titles and abstracts of studies and 100% of the studies were cross-checked by an independent researcher (AK). Disagreements were discussed and agreed by consensus.

The quality of studies was assessed individually based on details reported by two reviewers (AMK and AK) using the National Institute for Health assessment tool for observational, cohort and cross-sectional studies. This assessment tool consists of 14 questions along with detailed guidance. Differences in quality assessment were resolved by discussion. Each question in the assessment tool was rated either yes, no or other (cannot determine [CD], not applicable [NA], not reported [NR]). One point was available for each question resulting in a possible 14-point total for a high-quality study. Studies which scored below six points were regarded to be of ‘poor’ quality, studies between 6–13 points were rated ‘fair’ and studies which scored 14 points were considered a ‘good’ quality study.

Alongside quality assessment, relevant data were extracted. The extracted information included: year and location of publication; sample characteristics and comparison group; measurement method; PA and/or SB results; and relevant conclusions. There was inconsistency across eligible studies regarding how PA and SB were measured, defined and analysed. Therefore, data were synthesised and presented narratively.

**Results**

**Study selection**

Figure 1 illustrates the process of article selection, including reasons for exclusion in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement.

**Study characteristics**

The study characteristics and quality assessment are summarised in Appendix I (available online at www.practicaldiabetes.com) and are grouped by methods of PA/SB measurement. The countries of included studies were: America (n=8), Nigeria (n=3), the UK (n=5), Australia (n=2), Canada (n=2), Belgium (n=1), Brazil (n=1), Croatia (n=1), Denmark (n=1), Finland (n=1), France (n=1), Nepal (n=1), Netherlands (n=1), Norway (n=1), and South Africa (n=1).
Poland (n=1), South Africa (n=1) and Turkey (n=1).

Three studies used both subjective and objective methods. None of these studies included a comparison sample.8–10 Only one study measured subjective and objective PA levels over the same time period.10

Six studies used objective methods with five of these studies including a comparison with an age appropriate non-diabetic sample.11–16

Two objective methods of measurement were used to assess PA and SB: accelerometers and pedometers. Twenty studies used solely subjective methods across a variety of subjective instruments to record participants’ activity data.5,17–35

The International Physical Activity Questionnaire (IPAQ) was the most common resource.17,18,25,26–33

Four studies used researcher-developed questionnaires.19,25,34,35 Seven studies using subjective methods included a comparison with an age appropriate non-diabetic group7,17–22 and three with a sample of people with type 1 diabetes23–25

All 29 studies included in the systematic review measured PA levels, with eight studies also recording SB.11,13,15–17,26,27,33

Four of the eight studies11,13,15,16 that measured SB used objective methods. Six studies received a ‘good’ quality assessment rating.8–10,13,15,16

For most studies (23/29) the quality assessment rating was either fair or poor (fair n=12, poor n=11).

Summary of study findings

Physical activity. Studies which objectively measure PA report variable outcomes including: average daily step count (range 4901–5659 steps/day);8,9

Actigraph accelerometer count (140 502 to 155 520);14

minutes of moderate to vigorous PA (range 24.2–34 minutes/day);9,11

percentage meeting 7100 steps/day (29.7%);12

percentage of waking day spent stepping (10.7%).13 All five studies which used objective methods of measurement and included a comparison group report people with T2D to be less active than age comparable people without diabetes.11–15

Studies which subjectively measured PA report variable outcomes even when using the same method of measurement. All seven studies which included an age appropriate comparison group of people without T2D report lower PA levels using a variety of subjective methods in people with T2D.7,17–22

Two of the three studies23,24 which report a comparison with people with type 1 diabetes report people with T2D to have lower levels of PA; however, people with type 1 diabetes are consistently younger across all three studies.

Sedentary behaviour. The four studies which objectively measured sedentary time report variable outcomes including: minutes per day sedentary (659.6–926 minutes);11,16

and proportion of waking day spent sedentary (64.5–75.1%).13,15,16 All three studies which included a comparison group report people with T2D to have higher levels of SB than those without T2D.11,13,15

Studies which subjectively measured SB report variable outcomes including: >3 hours/day watching TV (38.1%);17

mean sitting time/day (4.8–5.8 hours);27,33 and mean sitting time/week (302 minutes/week).26

Discussion

This study systematically reviews published research documenting PA and SB in adults with T2D. Results highlight that, regardless of measurement method, data reported or study location, adults with T2D report low levels of PA and high levels of SB and are less active and more sedentary than those without T2D. It is likely that multiple factors play a role in influencing PA and SB in people with T2D including chronic physical and mental health complications and age, in addition to societal influences.

Average step count was around 5000 steps/day and time spent stepping occupied approximately 10% of the waking day. Accelerometer-measured minutes of moderate to vigorous PA was around 30 minutes/day, occupying a small proportion (0.8%) of the waking day. The percentage of adults with diabetes meeting current PA recommendations of at least 150 minutes of moderate to vigorous PA per week varies, with objective data reporting approximately 9% meeting these recommendations while self-reported data vary between 15–61% from studies using the IPAQ with IPAQ scoring protocol and between 25–75% for other self-report measures. Regardless of the measurement method, adults with diabetes report lower levels of PA compared to adults without diabetes. Physical activity is higher during weekdays compared to weekend days and in spring/summer compared to autumn/winter.

One study which tracked changes in PA across five years reported no change in adults with diabetes over time, in comparison to a significant increase in people without diabetes. In comparison to adults without diabetes, those with diabetes have higher levels of SB, reporting around 5.5 hours of SB per day and approximately 70% of the waking day in sedentary behaviours.

Cassidy et al.17 explored self-reported PA and SB across cardiometabolic disease using a large population-based cohort (UK Biobank). Four groups were defined: no disease (103 993); cardiovascular disease (113 469); T2D (4074); CVD + T2D (11 574). Total PA declined across these groups and total SB (TV viewing) increased. The odds ratio of reporting low moderate PA (mins/day) was 1.18 (CVD), 1.35 (T2D) and 1.55 (CVD + T2D), and the odds ratio of reporting high SB was 1.42 (CVD), 1.59 (T2D) and 1.92 (CVD + T2D). The study demonstrates that those with more advanced cardiometabolic disease undertake too little PA and have high TV viewing times, yet report important positive dietary changes within the past five years. These behaviours are clustered, highlighting the importance of interventions focused on changing multiple lifestyle behaviours.

Although 29 studies were eligible for inclusion in this systematic review from a wide range of locations, only three studies were from the UK. Overall, the quality of most existing studies is low. Studies use different methods to process and report data across different recording time periods making comparison across studies difficult. Only three studies used objective and subjective methods of PA measurement; however, none of the eligible studies used both subjective and objective methods to measure PA and SB.
patterns simultaneously. Some standardisation of data collection methods and reporting is required to allow more accurate global comparisons to be conducted.

Overall, there is a need for large-scale interventions to be implemented into diabetes care which support people with T2D to initiate, maintain and achieve the substantial benefits of an active lifestyle.

**Declaration of interests**

There are no conflicts of interest declared.

**References**


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<td></td>
<td></td>
<td>No. + mean age (SD)</td>
<td>No. + mean age (SD)</td>
<td></td>
<td>Physical activity</td>
<td>Sedentary behaviour</td>
<td></td>
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<tr>
<td>Dasgupta (2010)</td>
<td>Canada</td>
<td>T2D (n=166), Mean (SD) age 62.4 (10.8)</td>
<td>–</td>
<td>Yamax SW-701 pedometer + IPAQ-SF (IPAQ scoring protocol used)</td>
<td>Average daily step count: Spring/Summer 5659 (2611); Fall/Winter 4901 (2464); SR MET-mins/week 1965</td>
<td>–</td>
<td>Daily step counts in T2D patients are low, dipping lower during fall/winter</td>
</tr>
<tr>
<td>De Greef (2011)</td>
<td>Belgium</td>
<td>T2D (n=133), Mean (SD) age 61.6 (8.4)</td>
<td>–</td>
<td>IPAQ-LF. Actigraph 7164 accelerometer. Yamax DigiWalker SW200 pedometer</td>
<td>IPAQ MVPA 80.9 (158.2) min/wk. AC MVPA 24.2 (28.3) min/day. Step counts 5365 (3070) steps/day</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mynarski (2012)</td>
<td>Poland</td>
<td>T2D (n=31), Mean (SD) age 54 (3.6)</td>
<td>–</td>
<td>IPAQ-SF. Caltrac accelerometer</td>
<td>IPAQ PA 2469±1326 MET-min/wk. CPA 4284±2146 cal/wk</td>
<td>–</td>
<td>No significant difference between self-reported and objective measured PA</td>
</tr>
<tr>
<td>Cichosz (2013)</td>
<td>Denmark</td>
<td>T2D (n=94), Mean (SD) age 58 (10) years</td>
<td>ND (n=85), Mean (SD) age 57 (10) years</td>
<td>Actiheart accelerometer. Accelerometer count classification: Sedentary &lt;20cpm MVPA &gt;20cpm</td>
<td>MVPA: ND 62min/day; T2D 34min/day</td>
<td>Min/day spent sedentary: ND 926min/day T2D 898min/day</td>
<td>People with T2D significantly less PA and more SB than ND</td>
</tr>
<tr>
<td>Kelly (2016)</td>
<td>Australia</td>
<td>T2D (n=293), Mean age (SD) 67.6 (6.8)</td>
<td>ND (n=336), Mean age (SD) 72.1 (7.1)</td>
<td>Yamax Digiwalker SW-200 pedometer</td>
<td>PA guideline of 7100 steps per day was met by: T2D 29.7% ND 33.3%</td>
<td>–</td>
<td>In women, but not men, T2D patients take fewer steps/day and less likely to meet current PA guidelines than ND</td>
</tr>
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</table>

Legend: SD = standard deviation; T2D = type 2 diabetes; ND = no diabetes; D = diabetes; MVPA = moderate to vigorous PA; PA = physical activity; IPAQ-SF = International PA Questionnaire-short form; IPAQ-LF = International PA Questionnaire-long form; LRCPA = lipid research clinics PA; CPM = counts per minute; CPA = Caltrac PA; SR = self-report; AC = accelerometer based; h/wk = hours per week; min/day = minutes per day; min/wk = minutes per week; MET= metabolic equivalents; MET-min/wk = metabolic equivalent minutes per week; kcal/wk = calories per week; GLTEQ = Godin Leisure Time Exercise Questionnaire; TAC = total activity counts; BRFSS = Behavioural Risk Factor Surveillance System; ADA = American Diabetes Association.

†The National Institute for Health tool for observational, cohort and cross-sectional studies was used.
*IPAQ scoring protocol: Low – failure to meet criteria for the ‘moderate’ or ‘high’ categories; Moderate – doing at least 150min/week of moderate-to-vigorous PA over at least 3 days; High – vigorous-intensity activity on at least 3 days and accumulating at least 1500 MET-min/week, or 7 or more days of any combination of walking moderate-intensity or vigorous-intensity activities, achieving a minimum of 3000 MET-min/week.
**Sport Index ranging from 1.0 = lowest PA to 5.0 = highest possible PA.

Appendix 1. Study characteristics and quality assessment of included research. (Continued on the next 6 pages)
## Objective method of PA/SB measurement (continued from previous page)

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<tr>
<td>Loprinzi (2014)</td>
<td>USA</td>
<td>D (n=407). Mean age 73.4</td>
<td>ND (n=1346). Mean age 74.3</td>
<td>ActiGraph 7164 accelerometer. Step count PA classification: Sedentary: 0–99cpm Light: 100–2019cpm Moderate: 2020–5998cpm Vigorous: ≥5999cpm</td>
<td>Light intensity PA: T2D 31.5% ND 34.6% MVPA: D 0.8% ND 1% Meeting PA guidelines: D 9.1% ND 13.1%</td>
<td>–</td>
<td>Good</td>
</tr>
<tr>
<td>Steeves (2015)</td>
<td>USA</td>
<td>T2D (n=270). Mean age (SD) 70.6 (0.5)</td>
<td>ND (n=302). Mean age (SD) 69.9 (0.6)</td>
<td>ActiGraph AM-7164 accelerometer</td>
<td>–</td>
<td>Adults with T2D accumulated less PA compared to ND</td>
<td>Fair</td>
</tr>
<tr>
<td>Van der Berg (2016)</td>
<td>Netherlands</td>
<td>T2D (n=714) Mean age (SD) 62.7 (7.7)</td>
<td>ND (n=1395) Mean age (SD) 58.1 (8.1)</td>
<td>ActivPAL3 accelerometer</td>
<td>Waking day spent stepping: T2D 10.7% ND 13.6%</td>
<td>Adults with T2D spent 26 minutes more per day sedentary than those with ND</td>
<td>Good</td>
</tr>
<tr>
<td>Hamer (2014)</td>
<td>United Kingdom</td>
<td>T2D (n=112). Mean (SD) age 63.9 (7)</td>
<td>--</td>
<td>Actigraph GT3X accelerometer. Step count PA classification: Sedentary: (&lt;1.5 MET) 0–199cpm. Light: (1.5–3 MET) 200–1998cpm. MVPA: (≥3 MET) ≥1999cpm</td>
<td>Light mean (SD): 186.9 (70.7) min/day. MVPA mean (SD) 32.1 (23.2) min/day Proportion of day spent in: Light activity 21.3%. MVPA 3.6%</td>
<td>–</td>
<td>Good</td>
</tr>
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Appendix 1. Study characteristics and quality assessment of included research. (Continued from previous page and continued on next 5 pages)
### Physical activity and sedentary behaviour of adults with type 2 diabetes

<table>
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<tr>
<td>Cassidy (2016)</td>
<td>United Kingdom</td>
<td>T2D (n=4074). 37–63 years of age</td>
<td>ND (n=103 993). 37–63 years of age</td>
<td>IPAQ-SF</td>
<td>Not meeting PA recommendations: ND 16.1% T2D 24.7%</td>
<td>Adults with T2D report less PA and more SB than those without T2D</td>
<td>Fair</td>
</tr>
<tr>
<td>Sibai (2013)</td>
<td>USA</td>
<td>T2D (n=187). ≥25 years of age</td>
<td>ND (n=2008). ≥25 years of age</td>
<td>IPAQ-LF (IPAQ scoring protocol used*)</td>
<td>Low: T2D 55.6% ND 45.9% Moderate: T2D 34.8% ND 30.7% High: T2D 9.6% ND 23.4%</td>
<td>–</td>
<td>Poor</td>
</tr>
<tr>
<td>Karjalainen (2008)</td>
<td>Finland</td>
<td>T2D (n=195). Mean (SD) age 64.3 (7)</td>
<td>ND (n=1750). Mean (SD) age 58.3 (8.2)</td>
<td>Self-administered questionnaire (researcher developed questions): Vigorous PA ≥2–3 times a week for 20–30 min Lifestyle PA ≥30 min/day</td>
<td>Vigorous PA: T2D 56% ND 63% Lifestyle PA ≥30 min/day: T2D 49% ND 57%</td>
<td>–</td>
<td>Women, but not men, with T2D self-report PA compared to those without T2D</td>
</tr>
<tr>
<td>Morrato (2007)</td>
<td>USA</td>
<td>Diabetes (n=1825). Age 18+ years (no upper age limit)</td>
<td>ND (n=21 401). Age 18+ years (no upper age limit)</td>
<td>The Medical Expenditure Panel Survey (MEPS) 'Physically active' defined as: ≥30 mins in MVPA ≥3 times a week</td>
<td>Physically active: D 39% of participants ND 58% of participants</td>
<td>–</td>
<td>Adults with diabetes significantly less PA than adults without diabetes. Data adjusted for sex, age, race/ethnicity, education and income level, region, BMI, cardiovascular risk factors, depression, physical limitation status. No differentiation between T1D and T2D</td>
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Appendix 1. Study characteristics and quality assessment of included research. (Continued from previous page and continued on next 4 pages)
## Subjective methods of PA/SB measurement (continued from previous page)

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<tr>
<td>Zhao (2008)20</td>
<td>USA</td>
<td>D: 2001 (n=5869); 2003 (n=8888); 2005 (n=13 608) Age 18+ years (no upper age limit)</td>
<td>ND: 2001 (n=116 984); 2003 (n=144 533); 2005 (n=191 369) Age 18+ years (no upper age limit)</td>
<td>BRFSS Survey PA based on ADA 2007 guidelines</td>
<td>Participants meeting PA guidelines mean (SD). Diabetes: 2001: 38.5 (1.5)% 2003: 39 (1.5)% 2005: 41.7 (1.6)% No diabetes: 2001: 46.6 (0.2)% 2003: 47.7 (0.2)% 2005: 49.8 (0.2)%</td>
<td>People with diabetes were less likely to meet either national or ADA recommendations for PA than people without diabetes. The percentage of people with diabetes who participated in PA in the past 10 years or met PA recommendations in the past 5 years did not vary, whereas significantly increasing trends were observed in people without diabetes. Multivariate adjustment made for age, sex, BMI, race/ethnicity, education, income, smoking and employment/work status. No differentiation between T1D and T2D</td>
<td>Poor</td>
</tr>
<tr>
<td>Zhao (2011)21</td>
<td>USA</td>
<td>D: (n=18 370) 19.8% of total sample Mean age of total sample 74.3 years</td>
<td>ND: (n=80 802)</td>
<td>BRFSS Survey PA based on ADA 2007 guidelines</td>
<td>Meeting PA guidelines: Diabetes 25% ND 34%</td>
<td>Adults with diabetes significantly less PA than adults without diabetes. Data stratified according to age, sex, and race or ethnicity. No differentiation between T1D and T2D</td>
<td>Poor</td>
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Appendix 1. Study characteristics and quality assessment of included research. *(Continued from previous page and continued on next 3 pages)*
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<tr>
<td>Babić (2004)22</td>
<td>Croatia</td>
<td>T2D (n=76). 20–65 years of age. Mean (SD) age 52 (10)</td>
<td>ND (n=60). 20–65 years of age. Mean (SD) age 52 (10)</td>
<td>Baecke’s questionnaire and LRCPA questionnaire</td>
<td>Sport Index:** ND 2.05 T2D 1.86</td>
<td>–</td>
<td>Poor</td>
</tr>
<tr>
<td>Duarte (2012)23</td>
<td>Brazil</td>
<td>T2D (n=118). Mean (SD) age 62 (11)</td>
<td>T1D (n=107). Mean (SD) age 37 (11)</td>
<td>IPAQ-LF (IPAQ scoring protocol used*)</td>
<td>T2D: Low 30.7% Moderate 60.6% High 8.7% T1D: Low 10.3% Moderate 64.7% High 25% 29.7% of adults with T2D reported exercising regularly compared with 46.7% of adults with T1D</td>
<td>–</td>
<td>Larger percentage of T2D classified as poorly active and a lower percentage classified as highly active compared with T1D</td>
</tr>
<tr>
<td>Plotnikoff (2006)24</td>
<td>Canada</td>
<td>T2D (n=1614). Mean age (SD) 62.9 (12.1)</td>
<td>T1D (n=697). Mean age (SD) 51.1 (17.1)</td>
<td>GLTEQ &lt;600 MET-min/wk = ‘inadequately active’</td>
<td>MVPA in MET-min/wk, mean (SD): T1D 677.6 (1136.3) T2D 523.3 (1197.3) Inadequately active: T1D 63.7% T2D 71.9%</td>
<td>–</td>
<td>Adults with T2D report lower levels of PA compared to adults with T1D</td>
</tr>
<tr>
<td>Thomas (2004)25</td>
<td>United Kingdom</td>
<td>T2D (n=329). Mean age (SD) 60.5 (11.9)</td>
<td>T1D (n=77). Mean age (SD) 33.9 (8.4)</td>
<td>Questionnaire (researcher developed questions)</td>
<td>Physically active participants: T2D 32% T1D 39%</td>
<td>–</td>
<td>No direct comparison between T2D and T1D reported</td>
</tr>
<tr>
<td>Çolak (2016)26</td>
<td>Turkey</td>
<td>T2D (n=129). 20–79 years of age. Mean (SD) age 56.4 (11.1)</td>
<td>–</td>
<td>IPAQ-SF (IPAQ scoring protocol used)</td>
<td>Low 39.5% Moderate 51.9% High 8.5%</td>
<td>Mean sitting duration: 302min/wk</td>
<td>–</td>
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Appendix 1. Study characteristics and quality assessment of included research. (Continued from previous page and continued on next 2 pages)
Subjective methods of PA/SB measurement (continued from previous page)

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<tr>
<td>Cooper (2015)²²</td>
<td>USA</td>
<td>T2D (n=253). Mean (SD) age 57.93 (11.52)</td>
<td>–</td>
<td>IPAQ-SF + Summary of Diabetes Self-Care Activities Measure (IPAQ scoring protocol used)</td>
<td>Low 62.9% Moderate 15% High 22.1%</td>
<td>Mean (SD) sitting hours per day 5.82 (4.53)</td>
<td>–</td>
</tr>
<tr>
<td>Nolan (2016)²⁶</td>
<td>Australia</td>
<td>T2D (n=408). Mean age (SD) 62.7 (6.6)</td>
<td>–</td>
<td>IPAQ-SF</td>
<td>57% PA recommendations</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Oguntibeju (2012)²⁹</td>
<td>Nigeria</td>
<td>T2D (n=100). Between 40–85 years of age</td>
<td>–</td>
<td>IPAQ-SF (IPAQ scoring protocol used*)</td>
<td>Low 62% Moderate 34% High 4%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Ojoowo (2012)³⁰</td>
<td>Nigeria</td>
<td>T2D (n=100). Between 40–85 years of age</td>
<td>–</td>
<td>IPAQ-SF (IPAQ scoring protocol used*)</td>
<td>Low 26% Moderate 41% High 33%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Cloix (2015)³¹</td>
<td>France</td>
<td>T2D (n=724). Mean (SD) age 62 (10) years</td>
<td>–</td>
<td>IPAQ-LF (IPAQ scoring protocol used*)</td>
<td>Low 15.1% Moderate 51.3% High 33.6%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Kabanda (2011)²²</td>
<td>South Africa</td>
<td>Participants with DM (n=156). Mean age 48.7 years</td>
<td>–</td>
<td>IPAQ-LF Participants who accumulated &lt;599 MET-min/ wk were classified as inactive</td>
<td>39.7% of participants were inactive</td>
<td>–</td>
<td>No differentiation between T1D and T2D</td>
</tr>
<tr>
<td>Oyewole (2014)³²</td>
<td>Nigeria</td>
<td>T2D (n=119). Mean age (SD) 61.8 (11.8)</td>
<td>–</td>
<td>IPAQ-LF Participants who accumulated &lt;599 MET-min/ wk were classified as inactive</td>
<td>31.1% of participants were inactive</td>
<td>Mean sitting time: 288min/day</td>
<td>–</td>
</tr>
</tbody>
</table>

Appendix 1. Study characteristics and quality assessment of included research. (Continued from previous page and continued on next page)
<table>
<thead>
<tr>
<th>First author, year</th>
<th>Country</th>
<th>Type 2 diabetes sample</th>
<th>Comparison sample</th>
<th>Method of measurement</th>
<th>Results: mean/median (SD)</th>
<th>Relevant conclusions</th>
<th>Quality assessment rating†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hays (1999)⁵⁴</td>
<td>USA</td>
<td>T2D (n=260). Mean age 67 years</td>
<td>–</td>
<td>Interviewer administered survey (researcher developed questions)</td>
<td>Weekly PA reported: 1–60 minutes 22%; &gt;60 minutes 23%; 55% of participants reported 0 minutes of PA per week</td>
<td>–</td>
<td>Poor</td>
</tr>
<tr>
<td>Parajuli (2014)³⁵</td>
<td>Nepal</td>
<td>T2D (n=385). Mean age (SD) 54.4 (11.5)</td>
<td>–</td>
<td>3-day recall questionnaire (researcher developed questions using compendium of PA)</td>
<td>Poor adherence to PA 36%; Good adherence to PA 21%. 42.1% of participants were inactive</td>
<td>–</td>
<td>Poor</td>
</tr>
</tbody>
</table>

Subjective methods of PA/SB measurement (continued from previous page)

Appendix 1. Study characteristics and quality assessment of included research. (Continued from previous pages)