Objectively measured light-intensity physical activity is independently associated with 2-hr plasma glucose

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Running title: Objectively measured activity & blood glucose

Genevieve N Healy MPH¹
David W Dunstan PhD²
Jo Salmon, PhD³
Ester Cerin PhD⁴
Jonathan E Shaw MD²
Paul Z Zimmet MD²
Neville Owen PhD¹

¹ Cancer Prevention Research Centre, School of Population Health, The University of Queensland, Brisbane, Australia
² International Diabetes Institute, Melbourne, Australia
³ Deakin University, Melbourne, Australia
⁴ The University of Hong Kong, Hong Kong

Corresponding Author
Genevieve Healy, MPH
Cancer Prevention Research Centre
School of Population Health, The University of Queensland
Herston, Queensland, Australia 4006
Email: g.healy@uq.edu.au
ABSTRACT

OBJECTIVE: We examined the associations of objectively-measured sedentary time, light-intensity physical activity, and moderate-to-vigorous intensity activity with fasting and 2-hr post-challenge plasma glucose in Australian adults.

RESEARCH DESIGN AND METHODS: 67 men and 106 women (mean age 53.3, SD 11.9 years) without diagnosed diabetes were recruited from the 2004-2005 AusDiab study. Physical activity was measured by Actigraph accelerometers worn during waking hours for seven consecutive days, and summarised as sedentary time (accelerometer counts/minute <100; average hours/day), light-intensity (counts/minute 100-1951), and moderate-to-vigorous intensity (counts/minute ≥1952). An oral glucose tolerance test was used to ascertain 2-hr plasma glucose and fasting plasma glucose.

RESULTS: After adjustment for confounders (including waist circumference), sedentary time was positively associated with 2-hr plasma glucose (b=0.29, 95% CI 0.11 to 0.48, p=0.002); light-intensity time (b=-0.25, -0.45 to -0.06, p=0.012) and moderate-to-vigorous intensity activity time (b=-1.07, -1.77 to -0.37, p=0.003) were negatively associated. Light intensity activity remained significantly associated with 2-hr plasma glucose following further adjustment for moderate-to-vigorous intensity activity (b=-0.22, -0.42 to -0.03, p=0.023). Associations of all activity measures with fasting plasma glucose were non-significant (p>0.05).

CONCLUSIONS: These data provide the first objective evidence that light-intensity physical activity is beneficially associated with blood glucose, and that sedentary time is unfavourably associated with blood glucose. These objective data support previous findings from studies using self-report measures, and suggest that substituting light intensity activity for television viewing or other sedentary time may be a practical and achievable preventive strategy to reduce the risk of type 2 diabetes and cardiovascular disease.
Chronic high blood glucose concentrations (hyperglycaemia) are both a characteristic and a precursor of type 2 diabetes (1). Hyperglycaemia is also associated with an increased risk of cardiovascular disease and premature mortality, and this association persists below the categorical cut-offs for diabetes and impaired glucose tolerance (2-5). Understanding the association of modifiable type 2 diabetes risk factors with blood glucose, across the glucose range, can inform the development of population strategies for reducing the risk of diabetes and other cardiovascular diseases.

Physical activity is one of the key modifiable risk factors for hyperglycaemia. Evidence from population-based cross-sectional studies indicates that both physical activity and sedentary behaviour (particularly television viewing time) are independently associated with blood glucose in adults without known diabetes (6-8). However, the physical activity and sedentary time variables in these studies have typically been derived from self-report measures, generally 1-week recall. In addition to the imprecision associated with such measures, it is also difficult to accurately capture light intensity physical activity or total sedentary behaviour (rather than components of leisure-time sedentary behaviour) by questionnaire (9). Light-intensity activity, which includes activities such as washing dishes, ironing, and other routine domestic or occupational tasks (10), is the predominant determinant of variability in total daily energy expenditure (11). Clinical studies have demonstrated associations between non-exercise activities (‘nonexercise activity thermogenesis’; NEAT) and obesity risk (12); however, there is limited evidence on the extent to which such light-intensity activities are associated with other health outcomes (13; 14).

Given the challenge of assessing physical activity across the continuum of varying intensities, accurate measures of free-living physical activities (sedentary, light, moderate, and vigorous) are required. Using accelerometers, we examined the associations of objectively-measured sedentary time, light intensity activity, and moderate-to-vigorous intensity activity with fasting and 2-hr post-challenge plasma glucose, in Australian adults without diagnosed diabetes.

**RESEARCH DESIGN AND METHODS**

Participants for this cross-sectional, observational study were recruited between October and December 2005 from attendees at five Queensland testing sites of the population-based Australian Diabetes, Obesity and Lifestyle (AusDiab) Study (15-17). Recruitment for the present study was contingent on accelerometer availability and the timing of examination procedures of the main study; those with known diabetes, with visible limitations to mobility, and pregnant women were not approached. Of those available and eligible, all were approached, with the recruitment rate exceeding 80% at each site. Each participant gave informed consent to participate and ethics approval was obtained from the International Diabetes Institute, and from the University of Queensland.

On the day of recruitment to this study, participants underwent biochemical, anthropometric and behavioural assessments as part of the larger set of AusDiab survey procedures. The detailed methods of this protocol have been previously published (16-18). In brief, following an overnight fast (minimum of 9 hours), an oral glucose tolerance test was performed using World Health Organization specifications (19). The outcome variables of fasting plasma glucose (FPG) and 2-hr plasma glucose (2-hr PG) levels were determined by a spectrophotometric-hexokinase method (Roche Modular, Roche Diagnostics, Indianapolis, USA). Demographic and behavioural attributes were assessed using interviewer-administered questionnaires; height, weight, and waist circumference were measured.

Uniaxial Actigraph accelerometers (formerly known as the CSA activity monitor model WAM 7164, [http://www.theactigraph.com/]), fitted firmly around the participant’s trunk and placed on the right anterior axillary line, were
used to measure physical activity. Participants were instructed to wear the accelerometer during all waking hours for a continuous period of seven days, and to provide details on activity duration, type, and intensity during non-wearing/non-sleep periods. Physical activity diaries supplemented the accelerometer data by recording non-ambulatory activities, as well as on/off times of the accelerometer.

Statistical Analysis
In line with previous research reporting the reliability and validity of the International Physical Activity Questionnaire (20), a pragmatic cut-off of <100 counts/minute was chosen to categorise sedentary time, which includes activities such as sitting, or working quietly (e.g. reading, typing). The widely utilised Freedson’s cut-offs (21) were then used to differentiate moderate-to-vigorous intensity activity (counts/min ≥1952) from light intensity activity (100-1951 counts per minute). A criterion of at least 20 minutes of continuous zero counts, as well as diary information, identified non-wearing periods. Average daily time (hours) was used to summarize the time spent in moderate-to-vigorous, light-intensity, and sedentary activity.

To be included in the analysis, participants were required to wear the accelerometer for at least five valid days, including at least one weekend day, where a valid day was at least 10 hours of recorded activity (using both accelerometer and diary data). Of the 204 originally recruited, there were nine withdrawals, six cases where the accelerometer download was faulty, and 11 cases where the participant did not meet the compliance criteria, leaving a total of 178 (70 men, 108 women) who met the inclusion criteria. Blood glucose measures were available for 173 of these participants (67 men, 106 women). Data were complete for all other variables. Of the 173, six (3.5%) had five days of valid physical activity data, with the majority (80.3%) having seven days of valid data.

Univariate analyses were used to compare sex differences for descriptive and physical activity characteristics of the sample. Forced-entry linear regression models then examined the associations of physical activity with blood glucose measures. Models were initially adjusted for the potential confounders of age (years), sex, and time accelerometer worn (hours), with further adjustment for height (cm), waist circumference (cm), accelerometer unit number, alcohol intake (self-reported as none, light, and moderate-to-heavy), education (attended university or further education yes/no), income (household income ≥$1500/week yes/no), smoking status (current or ex/non-smoker), and family history of diabetes (8). Sex and age (<60, 60+ years) differences in the associations between the physical activity and blood glucose measures were tested for by adding interaction terms to the model. Statistical significance was set at p<0.05 for the main effects, and p<0.1 for the interaction effects. Analyses were conducted using Stata Statistical Software Release 9.0 (22).

RESULTS
The age of the participants ranged from 30-87 years (mean 53.3 years), and the majority (86%) had blood glucose readings within the ‘normal’ range (<6.1mmol/l for FPG and <7.8mmol/l for 2-hr PG); 47.4% were overweight (BMI 25.0-29.9 kg.m$^2$) and 21.4% were obese (BMI ≥ 30). The majority (98.8%) spoke English at home, while 38 women (35.5%) had either gone through, or were now going through menopause. Socio-demographic and behavioural characteristics are listed in Table 1.

Consistent with previous findings, (1; 7; 8) men had significantly higher FPG readings and waist circumference, and spent more time in moderate-to-vigorous intensity activity compared to women. Additionally, a higher proportion of men worked full-time compared to women. Compared to the broader AusDiab study population, participants in this sub-study were slightly younger (53.0 vs. 56.6 years, p<0.001), but had a similar mean BMI (27.2 vs. 27.7kg.m$^2$, p=0.683), self-reported physical activity (5.2 vs. 4.8 hours per week, p=0.372), and self-reported television viewing time (13.3 vs. 13.7 hours per week, p=0.628).
Table 2 shows that after adjustment for potential confounders, higher sedentary time was associated with significantly higher 2-hr PG, while higher moderate-to-vigorous intensity and increased light-intensity physical activity time were associated with significantly lower 2-hr PG. Although attenuated, these significant associations persisted after adjusting for other physical activity measures. Figure 1 highlights these significant adjusted associations with 2-hr PG across sex-specific quartiles of sedentary time, light intensity, and moderate-to-vigorous intensity.

The significant association of moderate-to-vigorous physical activity with 2-hr PG persisted when the diary data were excluded from the analysis (b=-1.07, 95%CI -1.86 to -0.28, p=0.008). Additionally, although attenuated, the direction of the effect remained the same when only those with seven days of complete data were analysed (N=139), with unstandardised regression coefficients of 0.17 (p=0.088), -0.14 (p=0.162), and -0.42 (p=0.271) for sedentary time, light-intensity activity, and moderate-to-vigorous intensity activity respectively. A similar pattern is also observed when a more generalised measure of obesity, body mass index, is included in the models instead of waist circumference, with unstandardised regression coefficients of 0.31 (p=0.001), -0.27 (p=0.006), and -1.09 (p=0.002) for the three intensity levels (sedentary time, light, and moderate-to-vigorous respectively). Similarly, when the data were reanalysed for full-time workers only (n=95), the unstandardised regression coefficients were 0.32 (p=0.018), -0.28 (p=0.064), and -1.09 (p=0.014) for sedentary time, light-intensity activity, and moderate-to-vigorous intensity activity respectively.

For FPG, Table 3 shows that the only significant association observed was with sedentary time, adjusted for age, sex, and time accelerometer worn. However, the association became non-significant following further adjustment for potential confounders, including waist circumference. There were no statistically-significant sex or age interactions observed for the associations between the physical activity measures and blood glucose (p>0.1).

**CONCLUSIONS**

Previous research in this study population has reported significant dose-response associations of sedentary behaviour (television viewing time) and moderate-to-vigorous physical activity with 2-hr PG, but not FPG, using self-report measures (6; 8). Our study extends these findings, and is the first to examine the associations of objectively-measured intensity of physical activity and sedentary time with blood glucose measures in adults. Following adjustment for potential confounders, including waist circumference, significant dose-response associations of sedentary time and moderate-to-vigorous physical activity were observed with 2-hr PG, but not FPG, with the magnitude of the associations greater than that previously reported (6; 8; 23). Given that the characteristics of our sample are similar to the participant characteristics of the overall AusDiab sample, these results increase our confidence in earlier findings that were based on self-reported physical activity and sedentary behaviour (6; 8; 18).

A major finding of this study is the significant association of light-intensity physical activity with 2-hr PG, independent of moderate-to-vigorous intensity physical activity time. Light-intensity physical activities are reported to be the most prevalent form of activity in the general North American population; however, this intensity level is particularly difficult to detect and assess (9). Consequently, there is limited epidemiological evidence on the association between light-intensity physical activity and health outcomes (13; 14). The majority of participants in our study had normal glucose tolerance, and therefore would be considered to have a lower risk for hyperglycaemia-induced complications compared to those with impaired glucose tolerance. However, a recent meta-analysis of 38 prospective studies reported a continuous linear association between increasing 2-hr PG and risk of all-cause and cardiovascular disease mortality, with no apparent risk threshold (4).
Thus, even apparently small shifts in 2-hr PG may have important clinical implications.

On average, participants spent only a small proportion of waking hours in moderate-to-vigorous intensity activity (4%). Most activity during waking hours can thus be categorised broadly into two distinct modes: light-intensity physical activity and sedentary time. Those who spend more time in light-intensity activity must therefore spend less time in sedentary behaviours. The beneficial association of light intensity physical activity with 2-hr PG, as opposed to the detrimental association of sedentary time with 2-hr PG, has important implications for lifestyle interventions. Although moderate-to-vigorous intensity physical activity is an important component of the healthy lifestyle message, practically, intervention studies that target reducing sedentary behaviour by the substitution of light-intensity activities may have a higher success rate, particularly given that more than half of the population fail to participate in adequate amounts of physical activity to benefit their health (6). Light-intensity physical activity interventions may also be more likely to succeed across a variety of settings, including the workplace.

The only significant association observed for FPG was for sedentary time, unadjusted for waist circumference. This concurs with previous population-based research using self-reported television time, as an estimate of sedentary behaviour (7; 8; 24). These findings emphasise the important physiological differences between FPG and 2-hr PG in their relationship with physical activity, and highlight that lifestyle interventions addressing increasing physical activity, and reducing sedentary time, need to measure 2-hr PG, rather than FPG, as the primary outcome.

This is the first study to examine associations of objectively-assessed intensity of free-living physical activity and sedentary time with standard blood glucose measures. The study was conducted in a non-clinical population that was representative of the broader AusDiab study population. Additional strengths of the study include the detailed socio-demographic, medical and behavioural data obtained. There was high compliance with the study protocol, and the study followed recommendations for best practice for the use of accelerometers in field work (25). Measurement of physical activity and sedentary time was not limited to leisure-time activities, while the combined use of accelerometers and physical activity diaries ensured that a broad range of physical activities could be captured and analysed.

There are some potential limitations of our findings. The cross-sectional nature of the data limits inference about causality, though considering that those with known diabetes were excluded from the study, it is unlikely that the blood glucose levels of our participants could have influenced their physical activity behaviour. The 7-day collection of physical activity data occurred after the blood glucose measure was taken. Given that there are acute effects of physical activity on blood glucose, the results of this study are therefore reliant on the extent to which participants engaged in a typical week of free-living physical activity behaviour. Additionally, the beneficial association of moderate-to-vigorous physical activity on 2-hr PG may have been underestimated, as collapsing moderate-to-vigorous intensity physical activity into a single category does not take into account the strong influence on insulin action of vigorous-intensity activity compared to moderate-intensity activity (26). Limitations are inherent in all cut-points used to summarise accelerometer data (27). Freedson’s cut-points were used in this study, and although they are one of the more commonly reported cut-points used in accelerometer studies of physical activity, they were originally derived using a young adult population (21), and the intensity values that represent light and moderate-to-vigorous may not reflect the self-reported intensity level in this older adult population. Similarly, in line with previous research (20), a relatively high cut-point of <100 counts per minute was chosen for sedentary time. Although it is unlikely to change the direction of the findings, a lower cut-point for sedentary time may be more appropriate, given the recent
evidence that non-ambulatory standing activities, such as the filing of paperwork, can register a quite low average of 60 counts per minute (28). Also, there is some evidence that the relationship between accelerometer counts and physical activity intensity varies across individuals (29). Future research, using shorter epoch lengths, should utilise recently published regression equations that more accurately capture free-living physical activity (28).

Our study adds to the broader evidence base on not only the importance of increasing moderate-to-vigorous physical activity, but also reducing sedentary behaviour in adult populations where the prevalence of type 2 diabetes is increasing. Our data provide the first objective evidence that light-intensity physical activity is beneficially associated with blood glucose, and sedentary time is unfavourably associated with blood glucose. Substituting light intensity activity for television viewing or other sedentary time may be a practical and achievable preventive strategy.

Acknowledgements

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REFERENCES


2. DECODE study group: Is the current definition for diabetes relevant to mortality risk from all causes and cardiovascular and noncardiovascular diseases? Diabetes Care 26:688-696, 2003


22. Stata Corp: Statistical Software: Release 8.0. College Station, TX, Stata Corporation, 2003


<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Men (n=67)</th>
<th>Women (n=106)</th>
<th>Total (n=173)</th>
<th>P for sex difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (95% confidence intervals, CI), y</td>
<td>52.7 (49.7-55.7)</td>
<td>53.6 (51.4-55.9)</td>
<td>53.3 (51.5-55.1)</td>
<td>0.628</td>
</tr>
<tr>
<td>BMI, mean (95% CI), kg.m²</td>
<td>27.8 (26.8-28.7)</td>
<td>26.8 (25.9-27.8)</td>
<td>27.2 (26.5-27.9)</td>
<td>0.187</td>
</tr>
<tr>
<td>Waist circumference, mean (95% CI), cm</td>
<td>98.2 (95.6-100.9)</td>
<td>87.0 (84.8-89.2)</td>
<td>91.4 (89.5-93.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Height, mean (95% CI), cm</td>
<td>176.3 (175.0-177.6)</td>
<td>163.4 (162.1-164.6)</td>
<td>168.4 (167.1-169.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>FPG, mean (95% CI), mmol/l</td>
<td>5.4 (5.2-5.5)</td>
<td>5.1 (5.0-5.2)</td>
<td>5.2 (5.1-5.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2-hr PG, mean (95% CI), mmol/l</td>
<td>6.0 (5.5-6.5)</td>
<td>5.6 (5.3-5.8)</td>
<td>5.7 (5.5-6.0)</td>
<td>0.055</td>
</tr>
</tbody>
</table>

**Plasma Glucose Status**

- Normal glucose tolerance, % (n)
  - Men: 79 (53)
  - Women: 91 (96)
  - Total: 86 (149)
- Isolated IFG, % (n)
  - Men: 2 (1)
  - Women: 1 (1)
  - Total: 1 (2)
- Isolated IGT, % (n)
  - Men: 13 (9)
  - Women: 8 (8)
  - Total: 10 (17)
- IFG & IGT, % (n)
  - Men: 2 (1)
  - Women: 1 (1)
  - Total: 1 (2)
- Newly diagnosed diabetes, % (n)
  - Men: 5 (3)
  - Women: 0 (0)
  - Total: 2 (3)

**Accelerometer derived variables, average daily time, mean (95% CI), hrs**

- Time accelerometer worn
  - Men: 14.8 (14.5-15.1)
  - Women: 14.8 (14.6-15.1)
  - Total: 14.8 (14.6-15.0)
  - P for sex difference: 0.840
- Sedentary time*
  - Men: 8.5 (8.2-8.8)
  - Women: 8.3 (8.1-8.6)
  - Total: 8.4 (8.2-8.6)
  - P for sex difference: 0.283
- Light intensity activity*
  - Men: 5.6 (5.3-6.0)
  - Women: 6.1 (5.8-6.3)
  - Total: 5.8 (5.7-6.0)
  - P for sex difference: 0.045
- Moderate-vigorous intensity activity*
  - Men: 0.7 (0.6-0.8)
  - Women: 0.5 (0.4-0.5)
  - Total: 0.6 (0.5-0.6)
  - P for sex difference: <0.001
- Moderate-vigorous intensity activity by CSA and diary*
  - Men: 0.8 (0.7-0.9)
  - Women: 0.5 (0.5-0.6)
  - Total: 0.6 (0.6-0.7)
  - P for sex difference: <0.001

**Percent time at each activity level while accelerometer worn, mean**
<table>
<thead>
<tr>
<th>Category</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary time</td>
<td>57.2 (54.9-59.5)</td>
<td>55.9 (54.2-57.6)</td>
<td>56.6 (55.2-58.0)</td>
<td>0.328</td>
</tr>
<tr>
<td>Light intensity activity</td>
<td>23.0 (21.7-24.3)</td>
<td>24.5 (23.5-25.5)</td>
<td>23.8 (23.0-34.6)</td>
<td>0.063</td>
</tr>
<tr>
<td>Moderate-vigorous intensity activity</td>
<td>4.5 (4.0-5.1)</td>
<td>3.2 (2.8-3.6)</td>
<td>3.9 (3.5-4.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Moderate-vigorous intensity activity by CSA and diary</td>
<td>5.2 (4.5-5.8)</td>
<td>3.5 (3.1-4.0)</td>
<td>4.3 (4.0-4.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Current Smokers, % (n)</td>
<td>2 (1)</td>
<td>2 (2)</td>
<td>2 (3)</td>
<td>0.828</td>
</tr>
<tr>
<td>Family history of diabetes, % (n)</td>
<td>16 (11)</td>
<td>26 (28)</td>
<td>22 (39)</td>
<td>0.130</td>
</tr>
<tr>
<td>University/further education, % (n)</td>
<td>66 (44)</td>
<td>49 (52)</td>
<td>56 (96)</td>
<td>0.038</td>
</tr>
<tr>
<td>Moderate/heavy alcohol drinkers, % (n)</td>
<td>45 (30)</td>
<td>23 (24)</td>
<td>31 (54)</td>
<td>0.007</td>
</tr>
<tr>
<td>Full time employment, % (n)</td>
<td>79 (53)</td>
<td>40 (42)</td>
<td>55 (95)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Household income ≥ $1500 /week, % (n)</td>
<td>52 (35)</td>
<td>30 (32)</td>
<td>39 (67)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

*Means adjusted for time accelerometer worn; Statistical comparisons are adjusted for age. Sedentary time (<100 counts/min), light-intensity activity (100-1951 counts/min), moderate-to-vigorous intensity activity (≥1952 counts/min).
Table 2: Regression analysis of physical activity measures with 2-hr post-challenge plasma glucose

<table>
<thead>
<tr>
<th>Model</th>
<th>Sedentary time, hrs/day</th>
<th>B</th>
<th>95% CI</th>
<th>P-value</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td></td>
<td>0.35</td>
<td>0.17 to 0.53</td>
<td>&lt;0.001</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Light-intensity activity, hrs/day</td>
<td>-0.30</td>
<td>-0.49 to -0.12</td>
<td>0.002</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Moderate-to-vigorous intensity activity, hrs/day</td>
<td>-1.08</td>
<td>-1.76 to -0.41</td>
<td>0.002</td>
<td>0.11</td>
</tr>
<tr>
<td>Model 2</td>
<td></td>
<td>0.29</td>
<td>0.11 to 0.48</td>
<td>0.002</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Light-intensity activity, hrs/day</td>
<td>-0.25</td>
<td>-0.45 to -0.06</td>
<td>0.012</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Moderate-to-vigorous intensity activity, hrs/day</td>
<td>-1.07</td>
<td>-1.77 to -0.37</td>
<td>0.003</td>
<td>0.15</td>
</tr>
<tr>
<td>Model 3</td>
<td></td>
<td>0.23</td>
<td>0.04 to 0.42</td>
<td>0.019</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Light-intensity activity, hrs/day*</td>
<td>-0.22</td>
<td>-0.42 to -0.03</td>
<td>0.023</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Moderate-to-vigorous intensity activity, hrs/day†</td>
<td>-0.81</td>
<td>-1.53 to -0.09</td>
<td>0.029</td>
<td>0.18</td>
</tr>
<tr>
<td>Model 4: Sex interactions (men reference)</td>
<td>Sedentary time, hrs/day</td>
<td>-0.22</td>
<td>-0.52 to 0.08</td>
<td>0.148</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Light-intensity activity, hrs/day</td>
<td>0.27</td>
<td>-0.13 to 0.66</td>
<td>0.181</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Moderate-to-vigorous intensity activity, hrs/day</td>
<td>0.52</td>
<td>-0.81 to 1.84</td>
<td>0.445</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Model 1: Adjusted for age, sex, time accelerometer worn
Model 2: Adjusted for age, sex, height, waist circumference, time accelerometer worn, accelerometer unit, family history of diabetes, alcohol intake, education, income, and smoking status.
Model 3: Adjusted for above covariates and moderate-to-vigorous physical activity (*) or sedentary time (†).
Model 4: Adjusted for same covariates as Model 2, examining the sex interaction
Table 3: Regression analysis of physical activity measures with fasting plasma glucose

<table>
<thead>
<tr>
<th>Model</th>
<th>B</th>
<th>95% CI</th>
<th>P-value</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary time, hrs/day</td>
<td>0.05</td>
<td>0.00 to 0.11</td>
<td>0.046</td>
<td>0.13</td>
</tr>
<tr>
<td>Light-intensity activity, hrs/day</td>
<td>-0.04</td>
<td>-1.00 to 0.11</td>
<td>0.117</td>
<td>0.12</td>
</tr>
<tr>
<td>Moderate-to-vigorous intensity activity, hrs/day</td>
<td>-0.15</td>
<td>-0.35 to 0.05</td>
<td>0.141</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>Model 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary time, hrs/day</td>
<td>0.04</td>
<td>-0.02 to 0.09</td>
<td>0.163</td>
<td>0.15</td>
</tr>
<tr>
<td>Light-intensity activity, hrs/day</td>
<td>-0.03</td>
<td>-0.09 to 0.02</td>
<td>0.248</td>
<td>0.15</td>
</tr>
<tr>
<td>Moderate-to-vigorous intensity activity, hrs/day</td>
<td>-0.08</td>
<td>-0.29 to 0.13</td>
<td>0.439</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>Model 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary time, hrs/day*</td>
<td>0.04</td>
<td>-0.02 to 0.09</td>
<td>0.224</td>
<td>0.15</td>
</tr>
<tr>
<td>Light-intensity activity, hrs/day*</td>
<td>-0.03</td>
<td>-0.09 to 0.03</td>
<td>0.281</td>
<td>0.15</td>
</tr>
<tr>
<td>Moderate-to-vigorous intensity activity, hrs/day†</td>
<td>-0.04</td>
<td>-0.26 to 0.09</td>
<td>0.706</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>Model 4: Sex interactions (men reference)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary time, hrs/day</td>
<td>-0.03</td>
<td>-0.12 to 0.06</td>
<td>0.549</td>
<td>0.15</td>
</tr>
<tr>
<td>Light-intensity activity, hrs/day</td>
<td>0.03</td>
<td>-0.09 to 0.15</td>
<td>0.613</td>
<td>0.15</td>
</tr>
<tr>
<td>Moderate-to-vigorous intensity activity, hrs/day</td>
<td>0.03</td>
<td>-0.37 to 0.42</td>
<td>0.898</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Model 1: Adjusted for age, sex, time accelerometer worn
Model 2: Adjusted for age, sex, height, waist circumference, time accelerometer worn, accelerometer unit, family history of diabetes, alcohol intake, education, income, and smoking status.
Model 3: Adjusted for above covariates and moderate-to-vigorous physical activity (*) or sedentary time (†).
Model 4: Adjusted for same covariates as Model 2, examining the sex interaction
Figure 1: Associations of 2-hr plasma glucose with quartiles of percentage of waking hours spent in sedentary time (A: cut-points men 51.19, 58.44, 64.05; women 51.05, 55.55, 62.85, light-intensity activity (B: cut-points men 19.26, 22.65, 26.27; women 20.19, 24.47, 27.54), and moderate-to-vigorous intensity activity (C: cut-points men 2.94, 5.03, 6.96; women 1.90, 2.91, 4.72). Marginal means (95% CI) adjusted for age, sex, height, waist circumference, family history of diabetes, alcohol intake, education level, income, smoking status, accelerometer unit, and percent moderate-to-vigorous intensity activity (sedentary, light-intensity) or percent sedentary (moderate-to-vigorous intensity).