Objectively Measured Sedentary Time, Physical Activity, and Metabolic Risk

The Australian Diabetes, Obesity and Lifestyle Study (AusDiab)

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OBJECTIVE — We examined the associations of objectively measured sedentary time and physical activity with continuous indexes of metabolic risk in Australian adults without known diabetes.

RESEARCH DESIGN AND METHODS — An accelerometer was used to derive the percentage of monitoring time spent sedentary and in light-intensity and moderate-to-vigorous–intensity activity, as well as mean activity intensity, in 169 Australian Diabetes, Obesity and Lifestyle Study (AusDiab) participants (mean age 53.4 years). Associations with waist circumference, triglycerides, HDL cholesterol, resting blood pressure, fasting plasma glucose, and a clustered metabolic risk score were examined.

RESULTS — Independent of time spent in moderate-to-vigorous–intensity activity, there were significant associations of sedentary time, light-intensity time, and mean activity intensity with waist circumference and clustered metabolic risk. Independent of waist circumference, moderate-to-vigorous–intensity activity time was significantly beneficially associated with triglycerides.

CONCLUSIONS — These findings highlight the importance of decreasing sedentary time, as well as increasing time spent in physical activity, for metabolic health.

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Increased time spent in sedentary behaviors and decreased time spent in moderate-to-vigorous–intensity physical activity have been reported to be independently associated with the risk of metabolic syndrome and its components (1–6). Consistent limitations of these studies include the self-report of sedentary time and physical activity and the dichotomous measurement of the metabolic syndrome attributes and overall metabolic risk. Previous studies addressing these limitations were conducted in middle-aged adults with a family history of diabetes (7) or only examined one component (hyperglycemia) of the metabolic syndrome (8).

We examined the associations of objectively assessed sedentary, light, and moderate-to-vigorous–intensity physical activity time and mean intensity of physical activity with continuously measured metabolic risk variables and with a clustered metabolic risk score in a sample of Australian adults without known diabetes.

RESEARCH DESIGN AND METHODS

— Detailed methodology for both the Australian Diabetes, Obesity and Lifestyle Study (AusDiab) and this cross-sectional substudy have previously been published (8–10). In brief, on the day of recruitment to this study, participants underwent biochemical, anthropometric, and behavioral assessments as part of the larger set of AusDiab survey procedures. A uniaxial accelerometer (ActiGraph model 7164; ActiGraph, Pensacola, FL) was used to measure sedentary and physical activity time during waking hours for 7 consecutive days. A total of 169 adults (67 men and 102 women) met the accelerometer inclusion criteria (8).

Accelerometer data were summarized as the percentage of monitoring time spent in each of three different intensity levels (sedentary, light, and moderate to vigorous). A cutoff of <100 counts/min was chosen to define sedentary time (7,8). Freedson's cutoffs (11) were used to differentiate moderate-to-vigorous–intensity activity (counts/min $\geq$1,952) from light-intensity activity (100–1,951 counts/min). The data were also expressed as mean intensity of activity during monitoring time (total accelerometer counts per total monitoring time).

Multiple linear regression analysis, adjusted for potential confounders, examined the associations of sedentary and physical activity time with the individual metabolic risk variables and with a clustered metabolic risk score based on these metabolic risk variables. This score was computed using principal component analysis (12,13) using the standardization and weightings from the representative 1999–2000 baseline AusDiab sample (n = 11,029 with complete metabolic data). Analyses were conducted using SPSS version 13 (SPSS, Chicago, IL).

RESULTS

— The age range of participants was 30–87 years; the majority (98.8%) spoke English at home. Compared with the broader 2005 AusDiab population with the same exclusion criteria (n = 5,836), participants in this substudy were slightly younger (mean age 53.4 vs. 56.6 years), and a higher proportion had attended university or further

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Abbreviations: AusDiab, Australian Diabetes, Obesity and Lifestyle Study.

Table 1—*Standardized regression coefficients of percentage of time spent in sedentary, light-intensity, and moderate-to-vigorous–intensity activity and mean activity intensity with continuous metabolic risk variables and clustered metabolic risk in 169 adults without known diabetes*

		Standardized regression coefficients (95% CI)			
	Mean ± SD	Sedentary	Light intensity	Moderate-to-vigorous intensity	Mean activity intensity
Waist circumference (cm)	91.5 ± 12.6	0.22 (0.09–0.36)	−0.20 (−0.34 to −0.06)	−0.16 (−0.31 to −0.004)	−0.27 (−0.42 to −0.12)
Triglycerides (log, mmol/l)*	0.10 ± 0.31	0.19 (0.03–0.34)	−0.14 (−0.30 to 0.02)	−0.23 (−0.40 to −0.06)	−0.24 (−0.41 to −0.07)
HDL cholesterol (mmol/l)*	1.45 ± 0.59	−0.12 (−0.26 to 0.02)	0.11 (−0.03 to 0.25)	0.07 (−0.08 to 0.22)	0.05 (−0.10 to 0.20)
Systolic blood pressure (mmHg)†	124 ± 22	0.06 (−0.08 to 0.20)	−0.07 (−0.21 to 0.07)	0.000 (−0.15 to 0.15)	−0.10 (−0.25 to 0.06)
Diastolic blood pressure (mmHg)†	68.9 ± 12.9	0.03 (−0.11 to 0.17)	−0.05 (−0.19 to 0.10)	0.06 (−0.10 to 0.21)	−0.01 (−0.17 to 0.15)
Fasting plasma glucose (mmol/l)	5.21 ± 0.49	0.13 (−0.02 to 0.28)	−0.12 (−0.27 to 0.04)	−0.08 (−0.24 to 0.09)	−0.18 (−0.34 to −0.02)
Clustered metabolic risk score*†	0.06 ± 1.77	0.23 (0.08–0.38)	−0.20 (−0.35 to −0.04)	−0.17 (−0.34 to −0.01)	−0.25 (−0.41 to −0.09)

All models adjusted for age (years), sex, employment status, alcohol intake (self-reported as none, light, and moderate to heavy), income (household income ≥$1,500/week, yes/no), education (attended university or further education, yes/no), smoking status (current or ex/nonsmoker), diet quality (Diet Quality Index Revised: scale 1–100 [refs. 18–20]), and family history of diabetes. *Additional adjustment for lipid-lowering medication (n = 23), †additional adjustment for hypertensive medication (n = 29), sedentary time (<100 accelerometer counts/min), light-intensity physical activity (100–1,951 counts/min), moderate-to-vigorous–intensity physical activity (≥1,952 counts/min), and mean activity intensity (total counts/total monitoring time).

education (54 vs. 40%) and were in the highest income bracket (38 vs. 26%). The proportion of those with the metabolic syndrome (14) in this sample tended to be lower (30 vs. 37%) than that of AusDiab, though this did not reach statistical significance (P = 0.083). Similar to recent findings in Swedish adults (15), participants spent, on average, the majority of wearing time either sedentary (57%) or in light-intensity activity (39%), with only 4% of wearing time spent in moderate-to-vigorous–intensity activity. Sedentary and light-intensity time were strongly correlated (Pearson's r = −0.96); correlations were weak between sedentary and moderate-to-vigorous–intensity time (Pearson's r = −0.27) and between light-intensity and moderate-to-vigorous–intensity activity (Pearson's r = −0.02).

Table 1 shows that all activity variables were significantly associated with waist circumference and clustered metabolic risk; all except for light-intensity activity (P = 0.088) were also significantly associated with triglycerides. The effect sizes of these associations were clinically significant. For example, on average, each 10% increase in sedentary time was associated with a 3.1-cm (95% CI 1.2–5.1) larger waist circumference.

When moderate-to-vigorous–intensity activity was included in the model, the significant associations of sedentary time, light-intensity activity, and mean activity intensity with waist circumference and the clustered metabolic risk score remained statistically significant. When sedentary time was included in the model for moderate-to-vigorous–intensity activity, only the association with triglycerides remained statistically significant (β = −0.18 [95% CI −0.36 to −0.01], P = 0.038). Similarly, only the inverse association of moderate-to-vigorous–intensity activity with triglycerides remained statistically significant when waist circumference was included in the model (β = −0.18 [−0.34 to −0.02], P = 0.027).

CONCLUSIONS — Following adjustment for several potential confounding variables, we observed significant independent associations of sedentary time, light-intensity time, and mean activity intensity with waist circumference and clustered metabolic risk score and of moderate-to-vigorous–intensity activity with triglycerides. Importantly, all levels of activity were measured objectively, using the same measurement tool. This allows for the direct comparison of the

different intensities of activity with the outcome measures. When associations with waist circumference were examined, sedentary time was independent of moderate-to-vigorous–intensity physical activity; however, moderate-to-vigorous–intensity activity was not independent of sedentary time. This suggests that sedentary time may have a stronger influence on waist circumference than moderate-to-vigorous physical activity.

On average, the majority of waking hours (>90%) were spent either in sedentary or in light-intensity activity. These two variables were highly negatively correlated. This has important clinical and public health implications, as it suggests that metabolic benefits may be obtained by substituting light-intensity activity for sedentary time. Activities of daily living have been shown to result in substantial increases in total daily energy expenditure and resistance to fat gain (16). Regular participation in moderate-to-vigorous–intensity activity should still be promoted as the predominant physical activity message. However, promoting a reduction in sedentary time through increasing light-intensity day-to-day activity may be another important public health message for reducing central obesity and overall metabolic risk.

Our findings are consistent with those of larger-scale population-based studies with more representative samples, in which self-reported measures of sedentary time have been shown to be significantly associated with metabolic risk (2,6). However, as these are cross-sectional associations, prospective studies, or, ideally, intervention trials using objective measures are required to determine the physiological and behavioral mechanisms that underlie these associations. Nevertheless, there is important public health implications for reducing time spent in sedentary behavior and increasing time spent in both light and moderate-to-vigorous–intensity physical activity (17).

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