Free-living physical activity energy expenditure is strongly related to glucose intolerance in Cameroonian adults independently of obesity.

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**Objective:** We examined the cross-sectional association between objectively measured free-living physical activity energy expenditure (PAEE) and glucose tolerance in adult Cameroonian adults without known diabetes.

**Research design and methods:** PAEE was measured in 34 volunteers using the doubly labelled water method and indirect calorimetry (resting). Fasting blood glucose (FBG) and 2 hours post-load blood glucose (2-h BG) were measured during a standard 75g OGTT.

**Results:** There was a significant negative correlation between PAEE and 2 hour glucose (r=-0.43, p=0.01) but not with fasting glucose (r=0.1, p=0.57). The inverse association between PAEE and 2 hour glucose remained after adjustment for age, sex, smoking alcohol consumption and BMI (β=-0.017, 95%CI: -0.033, -0.002) and was unchanged after further adjustment for waist circumference, body fat percentage or aerobic fitness.

**Conclusion:** PAEE is inversely associated with 2 hour glucose independently of adiposity or fitness. Interventions aimed at increasing PAEE could play an important role in diabetes prevention in developing countries.
Developing countries are undergoing a rapid epidemiologic transition characterised by rising prevalence of obesity, diabetes and cardiovascular diseases (CVD). Recent changes in diet and physical activity patterns have been suggested as possible risk factors (1). It is important to understand the association between modifiable exposure variables with risk factors for chronic diseases in order to design appropriate intervention strategies. We examined the cross-sectional association between physical activity energy expenditure (PAEE) and glucose tolerance in non-diabetic adult Cameroonian adults.

RESEARCH DESIGN AND METHODS

Cross-sectional study of 17 men and 17 women recruited from an urban and a rural residential area of Cameroon. Ethical approval for the study was obtained from the Cameroon National Ethics Committee and all participants provided signed informed consent.

Height and waist circumference were measured using standard clinical procedures. Body weight (BW) was measured using an electronic scale (Tanita® TBF-531 scales, Tanita UK Ltd, Uxbridge, Middlesex, UK). Total body water (TBW) was measured by deuterium dilution. Fat-free mass were calculated from TBW assuming a hydration factor of 73%, and fat mass derived as the difference between BW and fat-free mass.

Resting energy expenditure (REE) was measured using the MedGem handheld indirect calorimeter (HealthTech Inc., Golden, Colorado, USA). Total energy expenditure (TEE) was measured by the doubly labelled water (DLW) method. Two baseline urine samples were collected on separate days prior to the administration of a standard dose of DLW (174 mg/kg BW of oxygen-18 and 70mg/kg BW of deuterium). Post-dose urine samples were collected daily for the next six days. TEE was calculated using Schoeller’s estimation of CO₂ production, assuming a respiratory quotient of 0.85. PAEE (kJ·day⁻¹·kg⁻¹) was calculated as 0.9 × TEE – REE, taking the thermogenic effect of food into account. Aerobic fitness was estimated by linear extrapolation of the individually observed heart rate response to a standardised step test up to age-predicted maximum HR.

Capillary blood glucose was measured after an overnight fast (fasting blood glucose; FBG), and then 2 hours after ingestion of 75g of glucose dissolved in 250 – 300 ml of water (2-h BG). This was done using a HemoCue B-Glucose Analyzer (HemoCue AB, Ängelholm, Sweden).

Statistical analyses were done using STATA® version 10 SE (StataCorp LP, Texas, USA). The Student’s t test was used to assess differences in the descriptive variables. The independent associations between PAEE with FBG and 2-h BG were assessed by multiple linear regression analyses.

RESULTS

The mean age (± SD) of the study participants was 34.5 ± 7.5 years. Body fat was significantly lower in men than in women (18.5 ± 9.3 vs. 34.6 ± 7.2%, p<0.001), but the difference in BMI was of borderline significance (25.4 ± 3.6 vs. 28.4 ± 5.1 kg/m², p=0.05).

TEE (191.4 ± 55.9 vs. 143 ± 22.6 kJ·kg⁻¹·day⁻¹, p=0.002) and PAEE (73.9 ± 49.7 vs. 45.4 ± 17.4 kJ·kg⁻¹·day⁻¹, p=0.03) were significantly higher in men compared to women. There was no difference in mean fasting blood glucose (4.3 ± 0.7 vs. 4.6 ± 0.6 mmol·L⁻¹, p=0.21) and 2-h BG (5.9 ± 1.8 vs. 6.3 ± 1.1 mmol·L⁻¹, p=0.43) between men and women.

BMI, waist circumference, and body fat were not significantly correlated with FBG or 2-h BG. PAEE was not significantly
correlated with FBG ($r=0.11$, $p=0.53$) but inversely correlated with 2-h BG ($r=-0.43$, $p=0.011$).

In unadjusted linear regression analyses (table 1; model 1), PAEE was significantly negatively associated with 2-h BG ($\beta=-0.016$, 95% CI: -0.028, -0.004). This association remained largely unchanged when adjusted for age, sex, smoking and alcohol consumption ($\beta=-0.018$, 95% CI: -0.032, -0.004). Further adjustments for BMI, waist circumference, body fat or VO2max (table 1; models 2 - 5) did not change the results. There was no significant sex interaction.

CONCLUSIONS

In a sample of non-diabetic Cameroonian adults, comparable in BMI to national survey data (2), we observed a strong inverse association between PAEE and 2-h PG but not FPG independent of obesity/adiposity. This association was unchanged after adjustment for age, sex, smoking and alcohol consumption as confounders, and also was not affected by adjustment for cardiorespiratory fitness. There were borderline significant associations between PAEE and body fat with FBG, but no significant associations were observed between BMI, waist circumference or cardiorespiratory fitness and FBG or 2-h BG in this study. The difference in pattern of association between PAEE and 2-h BG or FBG may relate to the fact that these biochemical parameters reflect different pathophysiological processes (3). Since the risk of future diabetes as well as CVD outcomes is more closely associated with impaired glucose tolerance than impaired fasting glucose (4), our observations have public health importance for the prevention of these metabolic disorders.

The cross-sectional nature of these analyses limits any inference about direction of causality. However, results from trials are unequivocal about the role of physical inactivity in the development of diabetes (5). The small sample size of this study could have limited the statistical power to detect an association between PAEE and 2-h BG. However, the precise measurement of the exposure as used in the present study acts to increase statistical power and may be one explanation for our ability to detect this association in a small study.

Our results are in agreement with other studies in Caucasians using objective measurement of physical activity with adjustment for measurement error (6). They are also in agreement with studies in other ethnic groups, which have used less precise measures of PAEE but in larger samples (7).

This is the first report of objectively-measured free-living PAEE and its association with glucose tolerance in an African population. These results suggest that low levels of PAEE may be a factor underlying the rise of diabetes in this population (8). Public health efforts to increase overall PAEE could play an important role in diabetes prevention and CVD reduction in developing countries.
REFERENCES
Table 1: Independents effect of objectively measured free-living PAEE on FBG and 2-h BG

<table>
<thead>
<tr>
<th></th>
<th>FBG (mmol/L)</th>
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<th>2-h BG (mmol/L)</th>
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<td>P</td>
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<td>0.009</td>
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Participants: n = 34 for all models

* Post-hoc power calculation indicated a 10% power to refute the null hypothesis of no association between PAEE and FBG (the CI of the effect estimate includes zero). The association between PAEE and 2h-BG had a 76% power, even though the CI of this association was wider than that of the PAEE vs. FGB association.

Model 1 is unadjusted. Models 2-5 are adjusted for age, sex, smoking and alcohol consumption.

β = regression coefficient. CI = confidence interval. R² = variance. P = p value
PAEE = Physical activity energy expenditure (in kJ/kg/day). VO2max = Estimated maximum oxygen uptake (in mL/kg/min)