Energy Expenditure and Dietary Intake in Overweight *versus* Non-overweight Guadeloupian Adults

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ABSTRACT

Objective: *Obesity is the source of many health problems in Guadeloupe. The aim of this study was to describe the relationships between daily energy intake and expenditure, and weight status.*

Methods: *Three consecutive daily recalls for activities and food intake were used to assess energy expenditure and energy intake in 20- to 60-year old Guadeloupian men and women.*

Results: *The absolute daily energy expenditure was correlated to the body weight ($r = 0.64$, $p > 0.001$) and to the daily energy intake with more strength in the normal-weight group ($r = 0.52$, $p < 0.001$) than in the overweight group ($r = 0.26$, $p < 0.05$). In both weight groups, the higher the metabolism was, the larger was the difference between energy intake and energy expenditure.*

Conclusion: *Under-reporting was probably present in overweight women. However, higher energy intake and expenditure were observed in larger persons who were consequently not identified as less active.*

Gasto de Energía e Ingesta Dietética en Guadalupanos Adultos con Sobrepeso frente a Aquellos sin Sobrepeso

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RESUMEN

Objetivo: *La obesidad es fuente de muchos problemas de salud en Guadalupe. El objetivo de este estudio fue describir las relaciones entre la ingesta energética y el gasto de energía diarios, y el estado del peso.*

Métodos: *Tres reportes consecutivos diarios sobre las actividades y la ingesta de alimentos, fueron usados para evaluar el gasto de energía y el consumo de energía fueron usados el consume de alimentos fueron usados para evaluar el gasto de energía y la ingesta energética en hombres y mujeres guadalupanos de 20 a 60 años de edad.*

Resultados: *El valor absoluto del gasto diario de energía fue correlacionado con el del peso del cuerpo ($r = 0.64$, $p > 0.001$) y la ingesta diaria de energía con más fuerza en el grupo de peso normal ($r = 0.52$, $p < 0.001$ que en el grupo de sobrepeso ($r = 0.26$, $p < 0.05$). En ambos grupos, mientras más alto era el metabolismo, mayor era la diferencia entre la ingesta y el consumo de energía.*

Conclusión. *En el caso de las mujeres obesas, probablemente los reportes quedaron por debajo de la realidad. Sin embargo, se observaron ingesta y gasto de energía más altos en personas más corpulentas, que por consiguiente no fueron identificadas como menos activas*

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INTRODUCTION

As emphasized in many reports worldwide, overweight and obesity have reached epidemic proportions (1). In the French West Indies, a similar alarming pattern has been observed, with increased obesity among youngsters and a drastically increased prevalence of overweight and all types of obesity in the general population (2). A clear picture of the determinants is required so that strategies for the proper care and primary and secondary prevention of these public health problems can be developed in the near future.

A substantial body of data is available on the problem of overweight, with studies ranging from the molecular bases to psychological considerations (3, 4). One perspective assumes that the problem is partially an environmental and social one (4) and emphasizes the finding that variations in

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the prevalence of overweight are related to cultural aspects (5). From this point of view, it is likely that the overwhelming increase in the incidence of overweight and obesity may have slightly differing explanations in different areas. Thus, a local picture of the basic determinants for weight gain, *ie* dietary intakes and energy expenditures, has to be drawn, starting with those people who have already become overweight.

Across a wide range of species, the inverse relationship between daily energy expenditure relative to body weight has proven to be strong (6). In humans, the current literature often reports higher dietary intake in adult men and women with higher levels of body fat and body weight (7) to fill their higher absolute energy cost of activities and cost of living (8). Other studies, however, have failed to show differences in diet and physical activity in persons stratified by weight status, in particular between overweight (not obese) persons and their normal-weight counterparts (9, 10). Thus, there are discrepancies in the literature as to whether overweight persons have differential dietary intake and energy expenditure. The latter survey concerned women in a South African rural village with a subtropical climate, and it cannot be excluded that these environmental factors contribute to such discrepancy.

The purpose of this study was to examine the energy expenditure and dietary intake in overweight and non-overweight adults living in Guadeloupe, in the Caribbean. Overweight individuals are expected to have higher absolute requirements, but the discomfort related to moving in the heat may partly lead them to adopt sedentary lifestyles and thus in fact reduce their energy expenditure. We hypothesized differences in energy expenditure and energy intakes based on weight status (*ie* overweight and obese *versus* normal weight).

SUBJECTS AND METHODS

The participants were workers visiting two of the three main medical centres of the island for their compulsory annual medical examination. All of them were exposed to tropical climate conditions characterized by high temperature and humidity (temperature between 20°C and 29°C for the coldest months, and between 23°C and 31°C for the hottest months, average humidity 77%). Out of the 173 persons interviewed, 58 Guadeloupian adults (27 males and 31 females) agreed to participate in this study and provided plausible and complete recalls. Body weight was measured to the nearest 0.1 kg with the subject wearing lightweight clothing and no shoes. Height was measured to the nearest 1 cm using a stadiometer. The body mass index (BMI) was calculated as body weight (kg) divided by height (m) squared ($kg.m^{-2}$) and was used to separate subgroups of men and women. Normal-weight and underweight subjects (BMI < 25 $kg.m^{-2}$) were grouped together and compared with overweight and obese persons (BMI ≥ 25 $kg.m^{-2}$) except in the description of the BMI distribution. Before participation in the study, written informed consent was obtained from each worker. The study was approved by the local Ethics Committee, and the investigation conforms to the principles outlined in the Declaration of Helsinki.

The reported energy expenditure (EE), reported energy intake (EI) and reported macronutrient intake were assessed in free-living conditions using three consecutive 24-hour recalls. On the first day of the recall, a log was filled in together by the participant and a trained investigator who taught the former the required way to record the information (times, detailed quantity and quality of the food and drinks ingested, intensity and description of activities). On the following two days, the subjects followed their regular routine and recorded in the recall log in the evening. Measurements based on recall of physical activities and dietary intakes have demonstrated good agreement with their respective gold standards (11, 12). The dietary records were coded and analysed using computerized software (Profile for Windows, version 6.7.4, 4d Engine) that allowed for the addition of new meal composition and was based on the CIQUAL 1995 food composition table. This database edited by the French health authorities lists the micro and macronutrient composition of a large number of foods. The records were analysed for total protein, fats and carbohydrates. Total reported EI was expressed in MJ/day and macronutrient intake in percentage of reported EI.

The calculations of reported energy expenditure were made using Microsoft® Office Excel 2003 for Windows, as follows: each item of physical activity was assigned an estimated MET level based on the Compendium of Physical Activities (13). One MET by definition is estimated to 1 kcal or 4.18 J/kg body weight *per* hour. The MET equivalent for an activity would then be the kcal or 4.18 J/kg body weight *per* hour assigned to that activity multiplied by the time in hours spent in the particular activity. The EE per day was calculated as the sum of the MET levels for all activities to which was added the thermic effect of food assumed to equal 10% of the day energy intake. An average EE data of the three study days was used in the analyses. Values are presented as mean ± SD. The normality of the distributions of BMI and EE was assessed in men and women independently using the Kolmogorov-Smirnov test. The results of this test suggested that the data were normally distributed. Student's t tests (features of overweight *vs* non-overweight persons) were performed on age, height, weight and BMI for each gender. Multivariate analyses of variance with two group factors, each with two valences (normal weight/overweight; men/women) were performed for the other relevant variables. *Post-hoc* Newman-Keuls tests were performed in case of significant interaction effect. Bravais-Pearson correlations were used to analyse the relationship between absolute EE and EI, and between the mean of EE and EI and their difference. Data were analysed using Statistical software for Windows (version 5.5; Statsoft Inc, USA). Statistical significance was set at $p < 0.05$.

RESULTS

The anthropometric characteristics and macronutritional profile are reported in the Table. The weight groups did not differ in height or age. The relative contribution of protein, fats and carbohydrates to the average daily energy intake was similar in all groups.

Table: Anthropometric and nutritional characteristics of the subjects.

	Females				gender effect	Males				other effect
	Normal weight		Overweight[a]			Normal weight		Overweight[a]		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Age (years)	35.3	7.4	40.9	8.9		39.3	11.8	40.2	9.2	
Weight (kg)	58.3	6.6	76.1	9.2	###	68.2	5.3	82.2	5.6	***
Height (m)	1.65	0.08	1.63	0.06	###	1.74	0.06	1.71	0.06	
BMI (kg/m²)	21.3	2.1	28.5	2.4		22.5	1.6	28.1	1.8	***
Energy expenditure (J/kg/day)	155.1	23.0	158.6	22.9		170.9	40.2	149.0	25.7	
Energy intake (J/kg/day)	137.0	14.3	111.5	14.0	##	141.1	9.6	128.8	6.1	***; 1
Fats (% of energy intake)	33.7	4.3	35.1	5.4		36.4	4.2	36.3	3.5	
Proteins (% of energy intake)	15.1	2.0	14.7	2.5		15.9	1.8	15.9	1.6	
Carbohydrates (% of energy intake)	51.2	6.1	50.1	6.9		47.6	5.9	47.9	5.1	
Energy expenditure on energy intake ratio	1.2	0.3	1.4	0.2		1.2	0.3	1.2	0.2	2

BMI: body mass index

[a]: overweight was defined as BMI ≥ 25 kg.m^{-2}) and included persons with obesity (BMI ≥ 30 kg.m^{-2})

##, ###: differences related to the gender with $p < 0.01$, $p < 0.001$, respectively ***: differences related to the weight status, $p < 0.001$

Other effects: 1) significant interaction between weight status and gender ($p < 0.05$). All the subgroups are different one from another, except the normal weight men and women together ($p = 0.63$). 2) Significant interaction effect ($p < 0.05$) between the weight status and the gender status. The overweight women differ from all other subgroups.

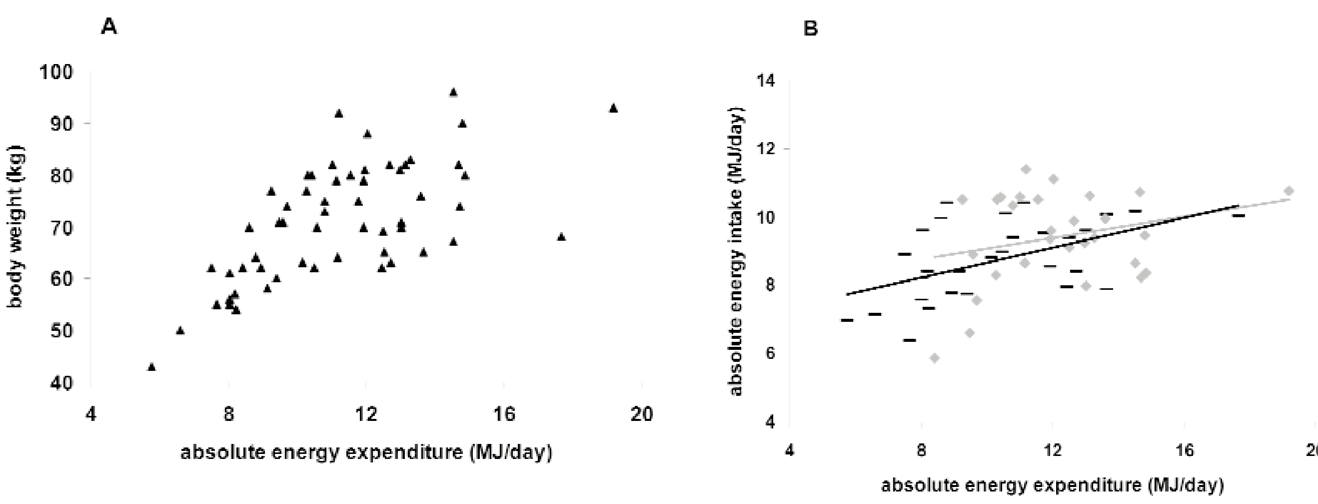

Fig. 1A**:** Relationship between the absolute energy expenditure and body weight in all participants (r = 0.64, $p < 0.001$). **B.** Relationship between the absolute energy expenditure and intake in normal-weight (–) and overweight (♦) participants. Linear regression of normal-weight and overweight groups.

Energy expenditure. The absolute EE was significantly correlated to the body weight (Fig. 1). It was higher in the overweight than the normal-weight persons ($p < 0.01$) and in the males than in the females ($p < 0.05$). The male to female difference was not significantly affected by the weight status. There was no gender, weight status, nor interaction effect on the energy expenditure relative to body weight (Table). Among the main determinants of absolute EE, the EE related to the physical activity, whether related to the weight or not, was not affected by the gender, the weight status or their interaction (all $p > 0.33$). Not surprisingly, the resting meta-

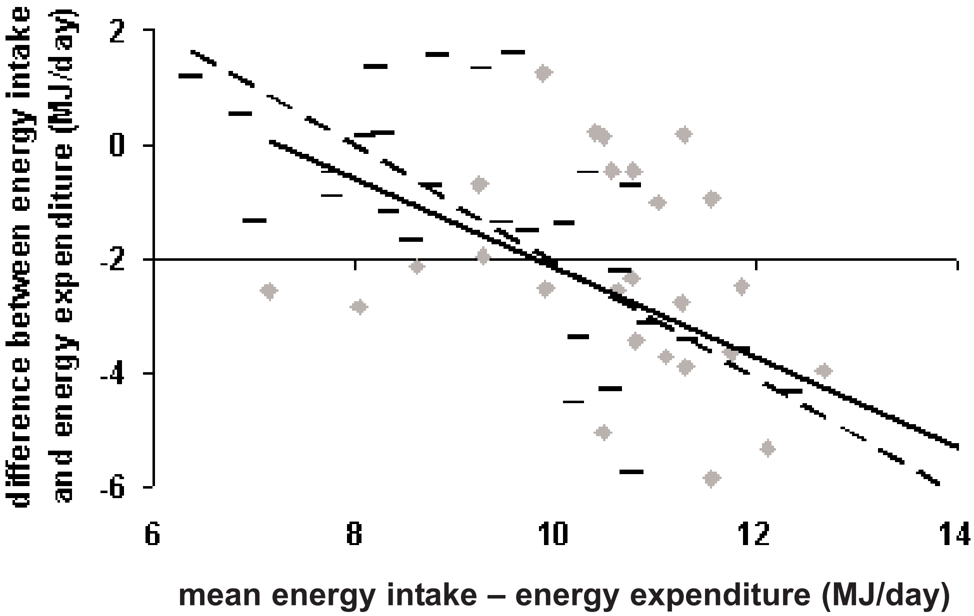

Fig. 2. Bland-Altman Plot: difference between energy expenditure and energy intake plotted against their mean. – normal subjects ♦ overweight subjects. Linear regression of —— normal-weight and ---- overweight groups.

bolic rate was significantly higher in males than in females ($p < 0.001$) in the overweight than in the normal weight ($p < 0.001$), with no significant interaction ($p = 0.30$).

Energy intake. The absolute EI was higher in the overweight group than in the normal-weight group, and higher in males than in females (both $p < 0.001$). The difference related to the weight status was similar in the men and women as there was no interaction effect between these two factors ($p = 0.21$). The EI relative to body weight (Table) was lower in the overweight group as compared with the normal-weight group ($p < 0.001$) and in women as compared with men ($p < 0.01$). The difference between normal-weight and overweight persons was affected by gender (interaction effect: $p < 0.05$). *Post hoc* analyses revealed that this variable was higher in normal-weight males as compared with overweight males, as well as between normal-weight and overweight females. The overweight males and females differed ($p < 0.001$) whilst the normal-weight males and females were similar ($p = 0.63$).

Energy intake related to energy expenditure. The EI was correlated (Fig. 1) with the EE in the normal-weight group (r = 0.52, $p < 0.001$) but this association was less strong in the overweight group (r = 0.26, $p < 0.05$). There was no gender or weight status effect on the ratio between EE and EI (Table). However, the difference between EI and EE was submitted to an interaction effect of the gender and the weight status ($p < 0.05$), the normal-weight and overweight men not differing from each other (-2.0 ± 2.6 MJ *vs* 1.7 ± 2.6 MJ, respectively) when normal-weight and overweight women differed (-1.2 ± 2.6 MJ *vs* -3.6 ± 1.8 MJ, respectively). The difference between EI and EE was correlated to its mean in both weight groups (r = 0.49 and r = 0.75 in the overweight and normal-weight groups, respectively, $p < 0.001$, Fig. 2).

DISCUSSION

In this study, the two major determinants of body mass were examined in overweight and normal-weight Guadeloupian adults. It was shown that both absolute energy intake and expenditure were higher in the overweight as compared with the normal-weight groups. Although the shortness of the observation period and the simplicity of the methods used preclude drawing conclusions regarding energy balance, this investigation provides information on the weight gain pattern in Guadeloupe, which is of importance for the prevention of many chronic non-communicable diseases.

It is likely that these findings can be generalized. The participants in the study were representative of the Guadeloupian population in terms of BMI since the distribution of BMI did not differ in the men ($\chi^2 = 0.62$; $p < 0.74$) or women ($\chi^2 = 2.32$; $p < 0.32$) in the study when compared with that of a larger sample (n = 536) of the Guadeloupian population studied earlier by the regional health services.

A standardized dietary recall over three consecutive days was chosen to assess nutritional intake. Although its accuracy is questionable, it has been widely used to estimate nutrient intakes of population groups and compare them with dietary recommendations to an extent that is acceptable, especially as compared with other direct or indirect assessment tools (14). The main potential bias associated with this technique is misreporting. Since under-reporting is consistently worse in people with obesity (15), it may have prejudiced the results. Investigations of misreporting (16) have shown it to be a complex phenomenon mainly arising from needs for social desirability, but that other factors, such as ethnicity or cultural differences in attitudes towards food and weight, contribute to this process. For example, it was shown in a well-studied ethnic subgroup of African-American overweight women with Type 2 diabetes mellitus that the widespread energy under-reporting among them severely compromised the validity of self-reported dietary data (17). In older African-American men and women, some results suggest that misreporting may occur less frequently as compared with other racial groups in relation to different ideal body sizes (18). According to some authors (19) but not all (20), a larger body size is preferred in the Caribbean area, with a potential negative influence on the promotion of health-related weight-loss programmes. The discrepancies observed may reflect differences between islands. In the present study, the interviews were conducted to minimize bias related to the potential tendencies of the subjects to win approval and avoid censure, and the participants were invited to be as honest as possible. They were carefully informed regarding the fact that any form of misreporting would invalidate further analysis, but it cannot be fully excluded that misreporting occurred and that the overweight persons under-reported to a greater degree than the lean persons. The energy expenditure on energy intake ratio was superior to one in all groups. Figure 2 shows that the highest the metabolism, the biggest is the difference between intake and expenditure, and that phenomenon is statistically more marked in the overweight group. Especially in the women, the energy intake of the overweight group appeared particularly low with regard to the expenditure, which seemed very plausible. Thus, it is likely that under-reporting occurred in the overweight Guadeloupian women studied here, in whom such an energy imbalance is improbable. It then compromises the use of the EI/EE ratio as an index for weight gain or loss. This does not jeopardize the overall analysis, however, because it simply underestimates the amplitude of the difference in energy intake between overweight and non-overweight women characterized by a smaller intake in the leanest group.

We hypothesized that the weight status would affect relative energy expenditure. Larger body-size persons are expected to have higher requirements to fulfil (21) when they have a normal physical activity level. In cases of very low activity – which we assumed – whether or not it reflects previous sedentary lifestyle that may have contributed to the actual situation of overweight, their weight-relative energy expenditure should be lower than that of normal-weight persons. For these levels of inactivity, the energy intake is not responsive, *ie* there is no proportional counterbalance for the expenditures (22).

We observed that 1) the energy intake and expenditure were significantly correlated in both groups 2) the energy expenditure differences were associated to the resting metabolic rate, and not to the energy expenditure due to physical activity, and 3) both energy expenditure and intake were higher in the overweight men and women as compared with their normal-weight counterparts. This reflects a preserved physical activity level despite overweight and a normal counterbalance of the energy intake by the energy output, during a period without loss or gain of weight. Such an analysis is very compatible with the conclusions of Prentice *et al* (23), which were based on a large number of doubly-labelled water measurements in individuals from affluent societies. According to their findings, patterns of physical activity were quite similar at different levels of body mass index except in massive obesity. Thus, in the relation between energy expenditure and body size, Guadeloupe seems to follow the pattern described for affluent societies to which it belongs, as a part of France. However, as a part of the West Indies, its cultural influences are various and include strong rural characteristics (24). It thus might have shown a different pattern. In a rural village of South Africa, diet was not affected by the weight status (10). In rural women of the United States of America (USA), significant differences in the daily calories consumed were noted across BMI groups (9). Obese women consumed significantly fewer calories than normal-weight women but no difference was observed between overweight and normal-weight women, nor between overweight and obese women.

To conclude, we have shown that Guadeloupe, despite its geographic location in the Caribbean area, follows the pattern of affluent societies in terms of the relative influence of body size and energy exchanges. The results support the idea that overweight and non-overweight persons have similar physical activity levels and suggest that tropical climate does not lead to a more sedentary lifestyle in the heaviest. This study suggests differences between men and women regarding the validity of self-reported energy intake. Further investigations are required to study this issue and consequently improve the understanding of energy imbalance.

REFERENCES

1. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO Consultation. Geneva, Switzerland: World Health Organization, 2000. (WHO technical report series 894).
2. Observatoire régional de la santé de la Guadeloupe. CALBAS: Enquête sur les Comportements ALimentaires en BASse – Terre, résultats préliminaires. Regional Public Health Conference 2005, Pointe à Pitre.

3. Palou A, Serra F, Bonet ML, Picó C. Obesity: molecular bases of a multifactorial problem. Eur J Nutr 2000; **39:** 127– 44.
4. Hill JO, Peters JC. Environmental contributions to the obesity epidemic. Science 1998; **280:** 1371– 4.
5. Mercer SL, Green LW, Rosenthal AC, Husten CG, Khan LK, Dietz WH. Possible lessons from the tobacco experience for obesity control. Am J Clin Nutr 2003; **77:** 1073S–1082S.
6. Speakman JR. Body size, energy metabolism and lifespan. J Exp Biol 2005; **208:** 1717 – 39.
7. Welle S, Forbes GB, Statt M, Barnard RR, Amatruda JM. Energy expenditure under free-living conditions in normal-weight and overweight women. Am J Clin Nutr 1992; **55:** 14–21.
8. Butte NF, Treuth MS, Mehta NR, Wong WW, Hopkinson JM, Smith EO. Energy requirements of women of reproductive age. Am J Clin Nutr 2003; **77:** 630–8.
9. Pullen CH, Noble Wlaker S, Hagemen PA, Boeckner LS, Oberdorfer MK. Differences in eating and activity markers among normal weight, overweight, and obese rural women. Wom Health Iss 2005; **15:** 209 –15.
10. Faber M, Kruger HS. Dietary intake, perceptions regarding body weight, and attitudes toward weight control of normal weight, and obese black females in a rural village in South Africa. Ethn Dis 2005; **15:** 238–45.
11. Trabulsi J, Schoeller DA. Evaluation of dietary assessment instruments against doubly labeled water, a biomarker of habitual energy intake. Am J Physiol Endocrinol Metab 2001; **281:** E891–9.
12. Motl RW, Dishman RK, Dowda M, Pate RR. Factorial validity and invariance of a self-report measure of physical activity among adolescent girls. Res Q Exerc Sport 2004; **75:** 259–71.
13. Ainsworth BE, Haskell WL, Leon AS, Jacobs DR Jr, Montoye HJ, Sallis JF et al. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc 1993; **25:** 71– 80.
14. FAO (Food and Agriculture Organization) of the United Nations. Uses of food consumption and anthropometric surveys in the Caribbean. 2004. Rome.
15. Braam LA, Ocke MC, Bueno-de-Mesquita HB, Seidell JC. Determinants of obesity-related Under-reporting of energy intake. Am J Epidemiol 1998; **147:** 1081– 6.
16. Maurer J, Taren DL, Teixeira PJ, Thomson CA, Lohman TG, Going SB et al: The psychosocial and behavioral characteristics related to energy misreporting. Nutr Rev 2006; **64:** 53–66.
17. Samuel-Hodge CD, Fernandez LM, Henriquez-Roldan CF, Kohnston LF, Keyserling TC. A comparison of self-reported energy intake with total energy expenditure estimated by accelerometer and basal metabolic rate in African-American women with type 2 diabetes. Diabetes Care 2004; **27:** 663–9.
18. Tomoyasu NJ, Toth MJ, Poehlman ET. Misreporting of total energy intake in older African Americans. Int J Obes Rel Metab Disord 2000; **24:** 20–6.
19. Simeon DT, Rattan R, Panchoo K, Kungeesingh KV, Ali AC, Abdool PS. Body image of adolescents in a multi-ethnic Caibbean population. Eur J Clin Nutr 2003; **57:** 157–62.
20. Tull ES, Butler C, Wickramasuriya T, Fraser H, Chambers EC, Brock V et al. Should body size preference be a target of health promotion efforts to address the epidemic of obesity in Afro-Caribbean women? Ethn Dis 2001; **11:** 652 – 60.
21. Schulz LO, Schoeller DA. A compilation of total daily energy expenditures and body weights in healthy adults. Am J Clin Nutr 1994; **60:** 676 – 81.
22. Melzer K, Kayser B, Saris WHM, Pichard C. Effects of physical activity on food intake. Clin Nutr 2005; **24:** 885 – 95.
23. Prentice AM, Black AE, Coward WA, Cole TJ. Energy expenditure in overweight and obese adults in affluent societies: an analysis of 319 doubly-labelled water measurements. Eur J Clin Nutr 1996; **50:** 93–7.
24. Armet A. Société et santé à la Martinique, le système et le masque. Editions Présence. africaine, Paris; 1990.