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Development and validation of a questionnaire for the assessment of physical activity in epidemiological studies in Sub-Saharan Africa

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Objective To develop and validate a questionnaire for measuring physical activity within Sub-Saharan Africa.

Methods We designed the Sub-Saharan Africa Activity Questionnaire (SSAAQ), based upon existing questionnaires and an activity survey carried out in Cameroon. The questionnaire targeted past-year occupation, walking/cycling and leisure-time activities, and was administered by trained interviewers on two occasions, 10–15 days apart to 89 urban and rural consenting Cameroonians aged 19–68 years. Reliability was assessed by inter-interview comparison and repeatability coefficients (standard deviation of the test-retest difference). Validation was performed against a 24-hour heart rate monitoring and accelerometer recording.

Results The questionnaire was highly reproducible ($\rho = 0.95$; $P < 0.001$). The inter-interview difference did not differ significantly from 0, with a repeatability coefficient of 0.46–1.46 hours. Total energy expenditure from the questionnaire was significantly correlated to heart rate monitoring ($\rho = 0.41$–0.63; $P < 0.05$) and accelerometer measures ($\rho = 0.60$–0.74; $P < 0.01$). Subject's self ranking of their activity did not match the questionnaire's quartiles of activity.

Conclusions The present study presents the design and confirms the reliability and validity of SSAAQ in a rural and urban population of Cameroon and shows that subject's self ranking of activity might not accurately serve epidemiological purpose.

Keywords Questionnaires; heart rate; energy metabolism; exercise; reproducibility of results; Africa; monitoring, physiologic; epidemiology methods

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In recent decades the main focus of health policies in Sub-Saharan Africa has been communicable diseases; a relatively low burden of diabetes mellitus and cardiovascular diseases has been reported.[1] However, there is clear evidence of the rising incidence and prevalence of non-communicable diseases (NCD) in developing countries.[2,3] It is estimated that by 2020, NCD in Sub-Saharan Africa will be almost 50% of the burden of disease.[4] Rapid urbanization with changes in lifestyle, especially dietary habits and physical activity patterns could explain at least partially the ongoing epidemiological transition.[5]

Population studies on other continents have demonstrated the protective effect of physical activity in the primary prevention of diabetes and cardiovascular risk factors.[6] Evidence to support or disprove this assumption is lacking in African populations. Where available, conclusions are mostly based upon self-assessment of activity level and classification into broad activity groups, and more recently a 7-day recall of activity.[7,8] Studies of physical activity in these populations were not mainly designed to address epidemiological purposes, some attempted to compare measurement instruments or measure interseasonal variation.[9,10] There is a need for accurate epidemiological assessment of physical activity with regard to the rising burden of non-communicable diseases in these populations.

The question of the most appropriate method for population-based study of physical activity has been extensively debated,[11,12] and questionnaires are the best consensual

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method for this purpose.[13] Several questionnaires have been validated in various parts of the world, however socio-cultural differences require the development and validation of a specific questionnaire to be used in different populations.[14,15] These specificities also need to be taken into account when designing a valid internationally agreed questionnaire which would allow for cross-country comparisons of epidemiological studies.[16]

The present study, which is part of a project to tackle the emerging pandemic of NCD in Sub-Saharan Africa,[17] addresses the design and validation of a questionnaire for the measurement of physical activity—'the Sub-Saharan Africa Activity Questionnaire (SSAAQ)'—to be used in epidemiological surveys in these populations.

Material and Methods

Designing the questionnaire

The Sub-Saharan Africa Activity Questionnaire (SSAAQ) was designed to be administered by an interviewer to allow for the literacy level expected in the target populations, and the standardization of data collection. The percentage of the population completing primary school in Cameroon is estimated at 64% and 69% for males and females, respectively.[18]

The core was built upon existing validated questionnaires.[19] The SSAAQ is shown in the Appendix. We aimed to evaluate occupation, leisure-time activity, and walking and cycling to work over the past 12 months to account for seasonal variations in activity.[20] Frequency of performance, duration of sessions and intensity were required for each activity reported. Twenty volunteers from urban and rural Cameroon were asked to provide us with a full listing of activities they had ever performed and were administered the questionnaire for the purpose of piloting. The questionnaire was revised accordingly.

Occupation

Job title and its corresponding code was recorded, with further classification into three categories according to the type of activity performed, whether light, moderate or intense to avoid misclassification of activity intensity between individuals with the same job title, based upon the description provided by Kriska *et al.*[19] Duration of employment was recorded for each job in order to allow for multiple occupations.

Walking and cycling

Pace and time were recorded.

Leisure-time activities that had been performed at least six times over the past year were reported in terms of frequency and duration. Past month leisure-time physical activity was also recorded for the purpose of comparison with habitual leisure-time activity.

Self-assessment of current year physical activity by the subject was done using a closed-ended question: 'how would you describe your physical activity—nil, light, moderate, intense'.

Data interpretation

The average daily or weekly duration of each activity was computed and the metabolic cost calculated using Ainsworth's compendium.[21] This metabolic cost is expressed as a metabolic equivalent (MET) score which is the ratio of the working metabolic rate divided by the resting metabolic rate. One MET = 1 kilo cal per kg of body weight per hour (kcal.kg^{-1}.h^{-1}) and represents the energy expenditure at rest.[22] For occupation 1.5, 2.5 and 6 MET were used as energy estimate of light, moderate, and heavy occupations, respectively.[21] Estimates of total energy expenditure were computed assuming that the time not reported was spent at the resting metabolic rate (1 kcal.kg^{-1}.h^{-1}).

Calculations

$$\frac{\text{(months/year)} \times \text{(4.3 weeks/month)} \times \text{(days/week)} \times \text{(ACTIVITY hours/day)}}{\text{365 days/year}} = \text{ACTIVITY hours/day}$$

Expenditure in MET was calculated by multiplying the number of hours for a given activity by its MET score.

Testing for reliability and validity

The study population consisted of a convenience sample of 102 urban and rural dwellers recruited from Yaoundé, the capital city of Cameroon, and Bafut, a rural area of western Cameroon where subsistence farming is the main occupation. We aimed for equal gender, age group and residence distribution. Thirteen subjects were excluded from the analysis because of incomplete data due to participants' time constraints. Eighty-nine subjects aged 19–68 years were therefore included in the analysis; their characteristics are shown in Table 1.

Procedure

The questionnaire was administered to each participant on two separate occasions 10–15 days apart. This time span between the two interviews was felt to be long enough to avoid simple recall of previous answers, but short enough to avoid consistent change in activity over time.

Between the two interviews, each subject wore, over a 24-hour period, either a motion sensor, a heart rate monitor or both depending on their acceptability. For personal convenience of the volunteers, only six subjects wore a motion sensor in the urban sub-sample. The motion sensor used was a Caltrac™ accelerometer (Hemokinetics), consistently worn on the anterior left hip by the subjects using an adjustable-size belt that records bodily movements and expresses the results as kilocalories of energy expended, taking into consideration age, sex, weight and height entered prior to the recording. Heart rate was recorded using a Polar Accurex Plus™ heart rate monitor (Polar, Finland) consisting of a chest transmitter to detect heart rate and a wrist watch which records the minute-to-minute heart rate from the transmitter. Data were subsequently downloaded to a computer using a serial interface with its communication software (Polar Training Advisor). Day-period recordings were used in the analysis.

The questionnaire was administered by two trained interviewers at each site. Coding and categorization especially for occupational activity needed standardization. This was achieved by role-play sessions in addition to the guidelines provided. The Bafut 8-day/week calendar was taken into consideration, and current events were used as references to help in frequency and duration recall.

Statistical analysis

Data were analysed using SPSS 7.5 for Windows software. Results are expressed as means and standard deviation or

Table 1 Characteristics of the urban and rural study population

	Female		Male	
	Urban	Rural	Urban	Rural
N	15	30	20	24
Age (years)	38 (2)	46 (2)	40 (2)	48 (2)
Body mass index (kg/m^2)	29.3 (3.8)	25.9 (0.8)	22.7 (0.9)	23.8 (0.9)
Systolic blood pressure (mmHg)	121 (3)	124 (4)	122 (3)	136 (3)
Diastolic blood pressure (mmHg)	74 (3)	81 (2)	80 (2)	84 (2)
Leisure-time activity (hours/week)	40.5 (6.4)	16.0 (2.7)	38.4 (9.7)	13.5 (4.0)
Occupational activity (hours/week)	33.0 (5.1)	23.7 (2.2)	35.0 (5.5)	24.7 (4.0)
Walking to work at slow pace (hours/week)	4.9 (2.0)	3.6 (1.5)	10.2 (3.9)	2.0 (1.0)
Walking to work at brisk pace (hours/week)	0.9 (0.5)	12.2 (3.7)	2.0 (1.1)	10.2 (3.9)
Total expenditure from SSAAQ (MET-hours/day)	38.8 (2.1)	37.4 (3.4)	51.5 (5.6)	51.6 (5.8)
AUC[a] heart rate (beats/day)	17 964 (846)	18 395 (1021)	17 741 (2230)	16 152 (1617)
Motion sensor expenditure (MET-hours/day)	–	31.8 (1.2)	–	35.2 (2.1)

NB: Results are expressed as mean (standard error).

[a] Area Under the Curve.

median and range. Reliability was assessed by means of Spearman's rank order correlation between estimates from the two interviews. We also calculated the coefficient of repeatability as suggested by Bland and Altman.[23] Repeatability coefficient was calculated by plotting the difference between the test and retest results for each subject, then calculating the mean and standard deviation of the differences, which we compared to zero.[24] To assess the validity of SSAAQ, estimates of physical activity from the questionnaire and motion sensor and/or the heart rate monitor were compared. Heart rate variability expressed as the area under the minute-to-minute heart rate curve above individual resting heart rate using the trapezoidal formula was computed.

The National Ethical Committee of the Ministry of Public Health of Cameroon approved the study.

Results

Study population

We studied 45 women (66.7% rural) and 44 male (54.5% rural) with a median age of 41 and 43 years, respectively (Table 1). They reported a mean 2.3 and 1.9 hours/day of leisure activities for rural women and men, respectively, and 5.8 and 5.5 hours/day for urban women and men, respectively; 4.7 hours and 4.9 hours/working day in rural women and men, respectively, and 6.6 hours in urban women and 7.0 hours in urban men for occupational activities. A higher proportion of rural population had intense occupational activities compared to urban ($P < 0.05$). Similarly, rural subjects walked more often at a brisk pace than urban subjects ($P < 0.05$).

Practicality

It took 5–26 min to complete the physical activity questionnaire with a median of 9 min and 12 min in the rural and urban populations, respectively.

Reliability

The overall correlation coefficient between time reported in the two interviews in this population was 0.95 ($P < 0.001$). The total estimates of energy expenditure from the questionnaire were similar in both interviews ($P < 0.001$).

Occupational activity was similar between the two interviews for both sexes in urban and rural populations in terms of time spent in activity and energy expenditure ($P < 0.001$). The Spearman rank order correlation coefficients are shown in Table 2. The mean difference between the two interviews was 1.86 min, with a repeatability coefficient of 0.8 hours for the whole sample. The repeatability coefficient was R = 0.94 hours (95% CI : –0.31, 0.15) for the subjects <30 years of age, R = 0.84 hours (95% CI : –0.13, 0.14) for subjects aged 30–49 years, and R = 0.74 hours (95% CI : –0.22, 0.12) for those aged ⩾50 years.

Walking time records were highly reproducible with the inter-interview Spearman ρ above 0.74 in all age and sex groups for the expenditure and the time spent, even when accounting for the pace of walk (Table 2). Cycling was not computed because only three rural subjects cycled. The repeatability coefficient for the subjects <30 years, 30–49 years, and ⩾50 years was R = 0.86 hours (95% CI : –0.12, 0.30), R = 1.12 hours (95% CI : –0.20, 0.16), and R = 0.58 hours (95% CI : –0.15, 0.10), respectively.

Leisure-time activity reports were also highly reproducible though less than the other sections of the questionnaire in the rural population. Indeed, in urban dwellers the reports of leisure-time activity are given with an inter-interview correlation coefficient between 0.94 and 1.0 ($P < 0.001$) while in rural populations it could be as low as 0.57 in some subgroups, though significant ($P = 0.004$) (Table 2). The repeatability coefficient for the subjects <30 years, 30–49 years, and ⩾50 years was R = 0.72 hours (95% CI : –0.34, 0.51), R = 1.04 hours (95% CI : –0.24, 0.11) and R = 1.42 hours (95% CI : –0.31, 0.45), respectively.

Low reproducibility group

Further analysis of the subjects with the lowest agreement in leisure-time activity reports between the two interviews showed (inter-interview leisure-time difference >2 hours/day) there were 17 subjects, mostly rural (88%) with high physical activity related energy expenditure, and taking part mainly in

Table 2 Spearman rank order correlation between interview 1 and 2

	Female		Male	
	Rural	Urban	Rural	Urban
N	30	15	24	20
Occupational activity				
Hours/working day	0.85	0.98	0.83	0.91
MET	0.97	0.78	0.95	0.93
Walking				
Slow pace	0.87	0.85	0.74	0.99
Brisk pace	0.98	1.00	0.86	0.88
MET	0.96	0.81	0.87	0.90
Leisure-time activity				
Past month				
Hours/day	0.77	0.94	0.64*	0.99
MET	0.80	0.94	0.62*	0.99
Current year				
Hours/day	0.57*	1.00	0.69	0.99
MET	0.68	0.98	0.57*	0.99
Total expenditure	0.96	0.88	0.93	0.86

Unless otherwise specified, P values are all < 0.001.

* $P < 0.01$.

leisure farming and housework with variability recorded in the estimation of time spent in those activities but not in their frequency. In this subgroup, the correlation between total expenditure computed from the two interviews was statistically significant ($\rho = 0.93$; $P < 0.001$).

Validity (Table 3)

Validity was assessed against motion sensor results expressed as movement count or energy expenditure estimates (kcal/day) converted to MET/day, and heart rate monitoring results expressed as area under the minute-to-minute heart rate curve and above individual resting heart rate.

Heart rate monitor versus questionnaire

Heart rate monitoring correlated significantly with daily occupational expenditure calculated from the questionnaire in both men and women of urban and rural settings ($P < 0.05$) with the lowest correlation coefficient in rural women ($\rho = 0.44$). Likewise, leisure-time physical activity correlated significantly with heart rate monitoring with the coefficient varying from 0.38 in rural women to 0.75 in rural men. Correlation with walking to work or for leisure varied from $\rho = 0.50$ to $\rho = 0.62$ ($P < 0.01$). As shown in Table 3, total energy expenditure estimates calculated from the questionnaire data were significantly correlated with heart rate variability in all subgroups with $\rho = 0.41$–0.63.

Motion sensor versus questionnaire

Correlation with motion sensor was analysed only in the rural population. Six subjects in the urban sample wore the motion sensor, because of the small sample size, no analysis was done on this measure. Motion sensor measurement of total energy

Table 3 Correlation between physical activity estimated by the questionnaire, the motion sensor and heart rate monitor

	Female		Male	
	Urban	Rural	Urban	Rural
N	15	30	20	24
Occupational activity				
Motion sensor	–	0.42*	–	0.40*
Heart rate monitor	0.72**	0.44*	0.47*	0.49*
Walking to work and for leisure				
Motion sensor	–	0.47*	–	0.23
Heart rate monitor	0.56*	0.54**	0.62**	0.50*
Leisure-time activity				
Motion sensor	–	0.33	–	0.80**
Heart rate monitor	0.70**	0.38*	0.44*	0.75**
Total				
Motion sensor	–	0.74**	–	0.60**
Heart rate monitor	0.63**	0.41*	0.54*	0.59**

* $P < 0.05$; ** $P < 0.01$.

expenditure did not correlate significantly with separate components of questionnaire-derived energy expenditure. The correlation coefficient was 0.42 and 0.40 (NS) for occupation, 0.47 ($P < 0.05$) and 0.23 for walking in rural women and men, respectively. The highest correlation was found with leisure-time activities in rural men ($\rho = 0.80$, $P < 0.001$). Total energy expenditure estimates from the questionnaire and total energy expenditure measured by motion sensor were significantly correlated in both women ($\rho = 0.74$, $P < 0.001$) and men ($\rho = 0.60$, $P < 0.01$).

Self-assessment of physical activity

The subjects' evaluation of their activity did not correlate with estimates from the questionnaire or objective measures of activity. However, in the urban sub-sample none of those reporting light physical activity for the past year were found within the upper quartile of energy expenditure. Likewise, all the urban subjects reporting intense physical activity were found in the 3rd or 4th quartile of energy expenditure.

Discussion

It was our intention to design a questionnaire for the accurate assessment of physical activity in epidemiological studies in Sub-Saharan African populations. We developed the SSAAQ from existing questionnaires and an activity survey, and studied its reproducibility and validity among a group of rural and urban dwellers in the Republic of Cameroon. We report satisfactory repeatability and validity data based upon test-retest study and correlation with objective measurements of physical activity, achieved within an acceptable time for interview and coding.

The issue of objective reference measures for physical activity questionnaire validation has been extensively debated. Heart rate monitoring and motion sensor correlates well with doubly labelled water, the gold standard in free-living conditions.[22,25] However, the behaviour changes induced by the use of a device are difficult to estimate. In the pilot phase of SSAAQ evaluation, few subjects had to be re-examined because they stopped their habitual activity on the day they wore the equipment, being afraid of damaging it. Participants were therefore strongly advised to carry on with their normal activities during the study. Unfortunately, for practical reason, we did not perform calibration for the heart rate monitoring in the present study,[26] and therefore studied individual heart rate variability as a reflection of activity status.

To compute energy expenditure, we used Ainsworth's compendium of metabolic cost of activities.[21] The compendium is based on measurements performed in a western population and might possibly reflect the activity-performance pattern. Indeed being a carpenter in a western country would not mean exactly the same as in a developing country, because of the type of equipment and the labour intensity of the job. Whether these data can be used in SSA without error is therefore questionable. To reduce the potential errors, a simple scale was used based upon the type of activity performed rather than the job title to estimate occupation related expenditure.

For energy expenditure estimates, MET were preferred to kcal. Indeed, using kcal would mean that a 100 kg person expends twice as much energy while walking than a 50 kg person, which is probably not true. Moreover, it is also not clear whether the relationship between energy expenditure and resting metabolic rate for a particular activity is the same for all individuals. Thus, there is a need for tables providing sex, age and weight specific reference values for energy expenditure per activity for all such studies. However, to date, MET are the best estimates of activity related energy expenditure, especially in epidemiological studies.[22]

The aims and findings of the present study are consistent with the available literature, as the need to develop and validate an activity questionnaire accounting for population specificities is emphasized.[27,28] The repeatability and test-retest correlation coefficients obtained are comparable to those previously reported, with a similar time span (2 weeks) between test and retest.[28,29]

As could be anticipated, repeatability in our study population was higher than observed where a 5–11 months time span existed between two consecutive interviews.[27] We chose a relatively short interval between interviews to avoid the influence of seasonal variation. However, the relatively low reproducibility observed in some subgroups of our study population may simply reflect their true activity pattern. We had only one strange report of hours of activity per day. Unstructured or non-systematic activity patterns have been reported in some groups in western countries, especially in children and the elderly.[30,31] In Africa, Benefice reported similar findings in adolescent girls of rural Senegal.[10] Global observation of SSA communities has never been reported. This might weaken the validity analysis based upon one 24-hour recording with objective measurements, and recording over several days might overcome day-to-day variation but not solve the question of seasonality in activity.

Total expenditure calculated from the SSAAQ in both the rural and urban subjects examined was correlated to heart rate monitoring and movement sensor data, with comparable coefficients as reported in previous questionnaire validity studies. For example, in the Pima Indians,[28] Spearman ρ varied from 0.27 to 0.80 with the motion sensor, which is comparable to that found in this study, which was 0.18–0.81.

Taken separately, the different components of activity as reported did not always significantly correlate with the motion sensor. However, they correlated well with heart rate monitoring, with the highest coefficients observed with walking in all subgroups but one. Indeed, most SSA rural populations depend on walking as their main method of transportation. This activity is well structured and probably among the most adequately reported during interview. It also represents the major difference between individual activity levels within a community. Its related energy expenditure was significantly higher in rural populations of all age groups in our study. Urban dwellers reported mean 5.5–5.8 hours/day of leisure-time activity without over-expenditure due to typical urban sedentary activities (cinema and TV watching, reading and writing, housework …). These data confirm those of a previous study that suggested high energy expenditure in rural populations where their habitual diet consist of rather high fat, alcohol and energy foods.[32]

Indeed, Africa has 600 million inhabitants distributed among more than a thousand tribal groups originating from different physical environments, with variable literacy, cultural background and lifestyle.[18] It is therefore sociologically and economically complex, comprising hunter-gatherers, rural populations living on subsistence farming, and a rapidly growing semi-urban and urban population with a lifestyle varying from nearly rural to western type. This influences the type of activities and the method of transportation. Occupation might differ in pattern and intensity, as a result of seasonality and, because of low salary levels, people being dependent on having more than one job. Therefore, unlike westernized countries where the main difference in energy expenditure is mostly attributable to leisure-time activity,[33] Sub-Saharan Africans' physical activity might be much more variable.

In this light, the design of SSAAQ allowed for flexibility in activity patterns as observed in the target populations. Our results suggest that physical activity can be accurately assessed by means of appropriately designed and standardized questionnaire and data collection procedure in SSA communities. We suggest that our methods could serve as a basis for physical activity survey in SSA as they emphasize the socio-cultural and economic background of the population under study. However, as this study was conducted in two samples of Cameroonians, international standardization and validation of SSAAQ is needed.

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KEY MESSAGES

- The Sub-Saharan Africa Activity Questionnaire was based upon several existing questionnaires and aims at the evaluation of past-year occupational and leisure-time activity, and also emphasizes walking time.
- It is shown to be repeatable and valid in urban and rural Cameroonians suggesting that physical activity can be accurately assessed by means of appropriately designed and standardized questionnaire and data collection procedure in SSA communities.
- The design of SSAAQ allows for flexibility in activity patterns as observed in the target populations. We therefore suggest that our methods could serve as a basis for physical activity survey in SSA as they emphasize the socio-cultural and economic background of the population under study.
- International standardization and validation of SSAAQ is needed.

References

1 Murray CJL, Lopez AD. Mortality by cause for eight regions of the world: global burden of disease study. *Lancet* 1997;**349:**1269–76.

2 Mbanya JCN, Minkoulou EM, Salah JN, Balkau B. The prevalence of hypertension in a rural and an urban population of Cameroon. *Int J Epidemiol* 1998;**27:**181–85.

3 Muna WFT. Cardiovascular disorders in Africa. *World Health Stat Q* 1993;**46:**125–33.

4 Gwatkin DR, Guillot M, Heuveline P. The burden of disease among the global poor. *Lancet* 1999;**354:**586–89.

5 Kaufman JS, Owoaje EE, James SA *et al*. Determinants of hypertension in West Africa: contribution of anthropometric and dietary factors to urban-rural and socio-economic gradients. *Am J Epidemiol* 1996;**143:**1203–18.

6 Pan XR, Li GW, Hu YH *et al*. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. *Diabetes Care* 1997;**20:**537–44.

7 Sparling PB, Noakes TD, Steyn K *et al*. Level of physical activity and CHD risk factors in black South African men. *Med Sci Sports Exerc* 1994;**26:**896–902.

8 Levitt NS, Steyn K, Lambert EV *et al*. Modifiable risk factors for Type 2 diabetes mellitus in a peri-urban community in South Africa. *Diabet Med* 1999;**16:**946–50.

9 Heini AF, Minghelli G, Diaz E *et al*. Free-living energy expenditure assessed by two different methods in rural Gambian men. *Eur J Clin Nutr* 1996;**50:**284–89.

10 Benefice E, Cames C. Physical activity patterns of rural Senegalese adolescent girls during the dry and rainy seasons measured by movement registration and direct observation methods. *Eur J Clin Nutr* 1999;**53:**636–43.

11 LaPorte RE, Montoye HJ, Caspersen CJ. Assessment of physical activity in epidemiologic research: problems and prospects. *Public Health Rep* 1985;**100:**131–46.

12 Pols MA, Peeters PH, Kemper HC, Grobbee DE. Methodological aspects of physical activity assessment in epidemiological studies. *Eur J Epidemiol* 1998;**14:**63–70.

13 Melanson EL Jr, Freedson PS. Physical activity assessment: a review of methods. *Crit Rev Food Sci Nutr* 1996;**36:**385–96.

14 Philippaerts RM, Westerterp KR, Lefevre J. Doubly labelled water validation of three physical activity questionnaires. *Int J Sports Med* 1999;**20:**284–89.

15 Jacobs DR Jr, Ainsworth BE, Hartman TJ *et al*. A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Med Sci Sports Exerc* 1993;**25:**81–91.

16 Booth M. Assessment of physical activity: an international perspective. *Res Q Exerc Sport* 2000;**71:**S114–20.

17 Unwin N, Mugusi F, Aspray T *et al*. Tackling the emerging pandemic of non-communicable diseases in sub-Saharan Africa: the Essential NCD Health Intervention Project. *Public Health* 1999;**113:**141–46.

18 *State of World Population 1999*. New York: United Nations Population Fund.

[19] Kriska AM, Knowler WC, LaPorte RE *et al*. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. *Diabetes Care* 1990;**13:**401–11.

[20] Adams AM. Seasonal variations in energy balance among agriculturalists in central Mali: compromise or adaptation? *Eur J Clin Nutr* 1995;**49:**809–23.

[21] Ainsworth BE, Haskell WL, Leon AS *et al*. Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exerc* 1993;**25:**71–80.

[22] Jette M, Sidney K, Blumchen G. Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. *Clin Cardiol* 1990;**13:**555–65.

[23] Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;**i:**307–10.

[24] British Standards Institution. *Precision of test methods. I: Guide for determination and reproducibility for a standard test method.* BS5497, Part I. London: BSI, 1979.

[25] Davidson L, McNeill G, Haggarty P *et al*. Free-living energy expenditure of adult men assessed by continuous heart-rate monitoring and doubly-labelled water. *Br J Nutr* 1997;**78:**695–708.

[26] Ceesay SM, Prentice AM, Day KC *et al*. The use of heart rate monitoring in the estimation of energy expenditure: a validation study using indirect whole-body calorimetry. *Br J Nutr* 1989; **61:**175–86.

[27] Pols MA, Peeters PHM, Ocké MC *et al*. Estimation of reproducibility and relative validity of the questions included in the EPIC physical activity questionnaire. *Int J Epidemiol* 1997;**26:**S181–S189.

[29] Martinez-Gonzalez MA, Martinez JA, Hu FB *et al*. Physical inactivity, sedentary lifestyle and obesity in the European Union. *Int J Obes Relat Metab Disord* 1999;**23:**1192–201.

[30] Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. *J Clin Epidemiol* 1993;**46:**153–62.

[31] Trost SG, Pate RR, Freedson PS *et al*. Using objective physical activity measures with youth: how many days of monitoring are needed? *Med Sci Sports Exerc* 2000;**32:**426–31.

[32] Mennen LI, Mbanya JC, Cade J *et al*. The habitual diet in rural and urban Cameroon. *Eur J Clin Nutr* 2000;**54:**150–54.

[33] Powell KE, Washburn RA, Kriska A, Haile G. Physical activity behaviors in lower and higher socioeconomic status populations. *Am J Epidemiol* 1991;**133:**1246–56.

Appendix 1: The Sub-Saharan Africa Activity Questionnaire

SECTIONS 1 & 2: OCCUPATIONAL ACTIVITIES; WALKING/CYCLING TO WORK (PAST YEAR)

Job name	code	Date at start and finish (mm/yy)		months held	cycle to work	walk to work (min/day)		Job schedule			cat. A,B,C
		start	finish		min/day	slow pace	brisk pace	mo./year	d/week	hr/day	
								___/12	___/7		
								___/12	___/7		
								___/12	___/7		
								___/12	___/7		
								___/12	___/7		

SECTION 3: LEISURE-TIME ACTIVITIES

In the table below, check all activities the subject did at least 6 times over the past year. Do not include activities related to his/her job.

1 ☐ Housework	12 ☐ Painting	23 ☐ Aerobic dancing	34 ☐ Table Tennis
2 ☐ Needle work	13 ☐ Construction work	24 ☐ Swimming	35 ☐ Cycling
3 ☐ Hair dressing	14 ☐ Hunting	25 ☐ Leisure walking	36 ☐ Horse riding
4 ☐ Home repairs	15 ☐ Fishing	26 ☐ Jogging	37 ☐ Classical dance
5 ☐ Gardening (around the house)	16 ☐ Teaching (at home)	27 ☐ Gymnastic	38 ☐ Light traditional dance
6 ☐ Light farming	17 ☐ Reading/Writing	28 ☐ Karaté/Wrestling	39 ☐ Vigorous traditional dance
7 ☐ Intense farming	18 ☐ Type writing/computer work	29 ☐ Football	40 ☐ Sexual intercourse
8 ☐ Wood splitting	19 ☐ Video game	30 ☐ Handball	41 ☐ Playing music
9 ☐ Animal rearing	20 ☐ Indoor games	31 ☐ Basketball	42 ☐ Singing
10 ☐ Driving	21 ☐ Cinema/Video/TV watching	32 ☐ Volleyball	43 ☐
11 ☐ Carpentry	22 ☐ Discussions (meetings)	33 ☐ Lawn Tennis	44 ☐

2.1 PAST YEAR
Write down the number of session per week, the number of month per year and the mean duration of a session for each activity performed over the past year.

2.2. PAST MONTH
Write down the number of session over the past month and the mean duration of a session for each activity performed during this period of time.

PAST YEAR					PAST MONTH	
Activity	Code	Month/year	Sessions/wk	Min./session	Sessions/week	Min./Session

SECTION 4: PERSONAL EVALUATION OF PHYSICAL ACTIVITY

- **How would you describe your physical activity for the past year?**
  intense ☐ moderate ☐ light ☐ null ☐
- **Would you like to do (more, less, the same)?**
  More ☐ Less ☐ The same ☐ Doesn't know ☐