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Comparison of Two Physical Activity Questionnaires in Obese Subjects: The NUGENOB Study

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ABSTRACT

TEHARD B., W. H. M. SARIS, A. ASTRUP, J. A. MARTINEZ, M. A. TAYLOR, P. BARBE, B. RICHTEROVA, B. GUY-GRAND, T. I. A. SØRENSEN, and J. M. OPPERT. Comparison of Two Physical Activity Questionnaires in Obese Subjects: The NUGENOB Study. *Med. Sci. Sports Exerc.*, Vol. 37, No. 9, pp. 1535–1541, 2005. **Purpose:** Simple instruments are needed to assess habitual physical activity (PA) in obese subjects. In a multicenter European obesity project, we tested whether PA assessments by two questionnaires were correlated and similarly associated to selected obesity-related variables. **Methods:** A total of 757 obese subjects (75% female; age 37.1 [7.9] yr, BMI 35.5 [4.9] kg·m^{-2}, mean [SD]) completed the Baecke questionnaire (assessing work, sport, and nonsport leisure activity) and the short last 7-d version of the International Physical Activity Questionnaire (IPAQ; assessing vigorous, moderate-intensity, walking activity, and sitting). We assessed percent body fat (bioimpedance), waist circumference, and fasting plasma concentrations of glucose, insulin, leptin, and FFA. Insulin sensitivity was assessed by the HOMA index for insulin resistance ($HOMA_{IR}$) **Results:** Using the IPAQ, only about one third of men and women were classified as insufficiently active. Total habitual PA assessments by the Baecke and IPAQ were significantly related (Spearman $\rho = 0.51$ in total sample, $P \leq 0.0001$, with adjustment for age, gender, and center). Using principal component analysis, we built two uncorrelated indices corresponding to general obesity (determined by high body fat and leptin) and abdominal obesity (determined by high waist circumference and $HOMA_{IR}$). PA scores from both questionnaires were negatively related to general and abdominal obesity indices, except for abdominal obesity with the IPAQ in men **Conclusions:** Total PA assessments by the two questionnaires were found to correlate significantly, and the general pattern of associations of PA with general obesity was similar for the two questionnaires. However, the IPAQ may capture less of the relationships between PA and abdominal obesity than the Baecke, especially in men. Reporting of habitual PA in obese subjects with the IPAQ warrants further evaluation against objective assessment methods. **Key Words:** BAECKE, IPAQ, BODY FAT, NUTRITION, MULTICENTER STUDY

Obesity, defined as excess body fat with negative health consequences, is a serious public health concern worldwide (20). Excess body fat, especially abdominal fat, increases the risk of many conditions, including insulin resistance and type 2 diabetes (20). Obesity is recognized as a multifactorial disease resulting from an interplay between genetic factors and lifestyle influences including physical activity habits (20).

The relationship between physical activity and obesity is complex. It is generally accepted that low physical activity levels are associated with body weight gain over time (10). On the other hand, increased body weight and obesity also result in decreased physical activity (5). Increasing physical activity is thus part of most weight-loss and maintenance programs (12). Moreover, increased levels of physical activity or fitness in obese subjects may substantially reduce their risk of metabolic disease and of all-cause as well as cardiovascular mortality (13). As a first step, obese subjects

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are encouraged to progressively meet a minimum of 30 min·d^{-1} of moderate-intensity physical activity (12,20), in line with current guidelines for the general population (22). Further increase in duration or intensity may be needed for prevention of weight regain after initial weight loss (12,29).

An improvement in the assessment of habitual physical activity in obese subjects is needed to document actual levels of physical activity in obese populations in order to better understand the role of physical activity in obesity-related diseases and to assess concurrent changes in weight and physical activity. Questionnaires represent the most widely used method to assess habitual physical activity in large numbers of subjects, as they are generally well accepted by participants and easy to administer at a low cost (19,23). Numerous questionnaires measuring various dimensions of physical activity have been developed, some of which have been tested for validity and repeatability (19,23). However, few of these instruments have been studied in obese populations.

The questionnaire designed by Baecke et al. (4) is an instrument that is simple to use and that has been extensively used in physical activity research over the past 20 yr (19,23) including in studies dealing with total and abdominal fatness (4,11). Importantly, physical activity assessment using the Baecke questionnaire was validated against energy expenditure measurements using the double-labeled water technique ($r = 0.62$ in 19 healthy men aged 40 yr) (24). Reliability was demonstrated with correlations ranging from 0.65 to 0.93 for 11-month and 1-month test-retest, respectively (23). A more recent instrument is the International Physical Activity Questionnaire (IPAQ), which was primarily designed for surveillance purposes and to allow comparisons between populations (7). A 12-country reliability and validity study considering whether this new instrument had acceptable measurement properties showed that 75% of test-retest correlations (in the 12 countries) were above 0.65 and that the overall estimation of physical activity by this questionnaire was correlated, though moderately ($r = 0.30$), to a 7-d measurement by accelerometers (7). It has been used increasingly in various populations and settings (8,9,25–27). In contrast with the Baecke questionnaire, which provides results expressed in arbitrary units, physical activity assessment by the IPAQ is based on current recommendations for moderate (22) and vigorous (3) activity. This could be of particular interest in obese subjects, both for research and clinical purposes. However, we are not aware of IPAQ data specifically collected in obese subjects.

Therefore, the aim of this study was to compare physical activity assessment with the Baecke and IPAQ in obese subjects participating in a large multicenter European project. The hypotheses that we wanted to test were that physical activity data obtained by the two questionnaires would be related and that physical activity variables from each questionnaire would be similarly associated with selected obesity-related variables.

METHODS

Subjects. Subjects were participants in the NUGENOB (NUtrient-GENe interactions in human OBesity) study, a multicenter obesity research project supported by the European Community (Contract no. QLK1-CT-2000-00618) (www.nugenob.org). A total of 771 obese Caucasian subjects (75% women) who had been recruited from eight clinical centers in seven European countries (United Kingdom, The Netherlands, France (two centers), Spain, Czech Republic, Sweden, and Denmark) were included from May 2001 until September 2002. Inclusion criteria were body mass index (BMI) $\geq$30 kg·m^{-2}, and age 20–50 yr. Exclusion criteria were weight change greater than 3 kg within the 3 months before the study; hypertension, diabetes, or hyperlipidemia treated by drugs; untreated thyroid disease; surgically or drug-treated obesity; pregnancy; simultaneous or recent participation in other trials; and alcohol or drug abuse. Subjects were recruited through the media, from waiting lists, other ongoing population studies, by self-referral or referral from a general physician or other clinical units and local obesity organizations. All subjects were in good health before entering the study as assessed by a medical history followed by a physical examination when indicated. The study protocol was approved by the ethics committee from each center. All subjects gave written informed consent before participating in the study.

Protocol. All data were collected following standardized operating procedures (www.nugenob.org). Recruited subjects were contacted by a research assistant 2–3 wk before they followed a 1-d clinical investigation at each center. They were informed that a questionnaire battery on their lifestyle habits (including physical activity) and medical history would be mailed to their home within a few days. Instructions on how to fill the questionnaires were printed at the beginning of the forms. Also during this contact, an appointment was arranged for a visit to the research center approximately 10 d before the clinical investigation day. At this visit, questionnaires were checked by the research assistant and any queries clarified. On the clinical investigation day, subjects arrived at the clinical research center at 8:00 a.m. after a 12-h overnight fast and a preceding 3-d period during which they had to maintain their usual physical activity and dietary habits and avoid excessive alcohol consumption. After subjects voided their bladder, they underwent anthropometric and body composition measurements. Venous blood samples were taken to determine circulating metabolite and hormone levels. Subjects then underwent a series of clinical tests that are not within the scope of this paper (www.nugenob.org).

Physical activity questionnaires. The Baecke questionnaire assesses the habitual level of physical activity according to the context in which it occurs, as described in detail elsewhere (4,23). The time frame of recall is not clearly specified but refers to usual activity, such as in the past year. The questionnaire, briefly, consists of 16 questions organized in three sections: physical activity at work (questions 1 to 8), sport during leisure time (questions 9 to

12), and physical activity during leisure excluding sport (questions 12 to 16). Questions in each section are scored on a 5-point Likert scale, ranging from "never" to "always" or "very often." The two most frequently reported sports activities are explored in additional questions about the number of months per year and hours per week of participation. The three derived indices, work, sports, and leisure, are scored in arbitrary units ranging from 1 to 5. The sum of the three indices gives an indicator of total physical activity. Additionally, for the purpose of the present report, a walking index was created by adding scores of the items "At work I walk" and "During leisure time I walk," and a sitting index was built by adding scores of the items "At work I sit" and "During leisure time I watch television."

The IPAQ version that we used was the short last 7-d recall questionnaire, which is detailed elsewhere (7) (www.ipaq.ki.se). This version consists of seven questions assessing the frequency and duration of participation in vigorous, moderate-intensity, and walking activity as well as the time spent sitting during a weekday, globally in all contexts of everyday life. Scores for vigorous, moderate, and walking activity are calculated in minutes per week, as is time spent sitting. The sum of the three activity scores gives an indicator of total physical activity. After multiplying the number of hours per week of each type of activity by an average metabolic cost (MET), an energy expenditure indicator can also be obtained expressed in MET-minutes per week. A MET is the ratio of the working metabolic rate of an activity divided by the resting metabolic rate (RMR) (19). One MET represents the metabolic rate of an individual at rest (sitting quietly) and is set at 3.5 mL of oxygen consumed per kilogram of body mass per minute, or approximately 1 $kcal \cdot kg^{-1} \cdot h^{-1}$. As proposed by the IPAQ executive committee (www.ipaq.ki.se), the minutes per week for vigorous, moderate, and walking activity were multiplied by a factor of 8, 4, or 3.3, respectively.

Recommendations for data truncation made by the IPAQ executive committee as of April 2004 were applied (www.ipaq.ki.se). All walking, moderate, and vigorous time variables exceeding 2 $h \cdot d^{-1}$ were truncated to be equal to 2 h. When these time variables were lower than 10 $min \cdot d^{-1}$, they were recoded to zero. Physical activity status (insufficiently active, sufficiently active, or highly active) was defined according to guidelines also set out by the IPAQ executive committee (www.ipaq.ki.se). Individuals were considered as sufficiently active if they had performed a minimum of 3 d of vigorous activity of at least 20 $min \cdot d^{-1}$ (3) or a minimum of 5 d of moderate-intensity activity or walking of at least 30 $min \cdot d^{-1}$ (22), or a minimum of 5 d of any combination of walking, moderate, or vigorous activity accumulating a total of at least 600 $MET \cdot min \cdot wk^{-1}$. Individuals were considered as highly active if they had performed vigorous activity on a minimum of 3 d accumulating at least 1500 $MET \cdot min \cdot wk^{-1}$ or a minimum of 7 d of any combination of walking, moderate, or vigorous activity accumulating a total of at least 1500 $MET \cdot min \cdot wk^{-1}$.

Anthropometric and body composition measurements. Body weight was measured on calibrated scales, and height was measured using a wall-mounted stadiometer. Waist circumference was measured midway between the lower rib and iliac crest using an inelastic tape, with the participant in a standing position and wearing only nonrestrictive underwear. Three measurements were performed and their mean used. Body composition was assessed by bioimpedance analysis using the same device in all centers (Bodystat®; QuadScan 4000, Isle of Man, British Isles). The percentage of body fat was calculated from total fat mass (kg) and body weight.

Biological measurements. All blood samples were shipped to a core laboratory at one center (University of Maastricht, The Netherlands) where all measurements were performed. Plasma concentrations of glucose, insulin, free fatty acids (FFA), and leptin were determined. Plasma glucose concentrations (ABX Diagnostics, Montpellier, France) were measured on a COBAS MIRA automated spectrophotometric analyzer (Roche Diagnostica, Basel, Switzerland). FFA (NEFA C kit, Wako Chemicals, Neuss, Germany) were measured on a COBAS FARAH centrifugal spectrophotometer (Roche Diagnostica). Standard samples with known concentrations were included in each run for quality control. Plasma insulin and serum leptin concentrations were measured with a double antibody radioimmunoassay (Insulin RIA 100, Kabi-Pharmacia, Uppsala, Sweden; Human leptin RIA kit, Linco Research Inc., St. Charles, MO). Insulin sensitivity was assessed, using fasting plasma glucose and insulin concentrations, by the HOMA index for insulin resistance ($HOMA_{IR}$) calculated according to the equation of Matthews et al. (17).

Statistical analyses. For data management, a local database was established at each clinical research center with subjects identified by study number. All centers used the Epidata software (http://www.epidata.dk) for entering all raw data in predefined data-entry files prepared by the coordinating center (Institute of Preventive Medicine, Copenhagen). Data were regularly transferred to the coordinating center and integrated in the overall database. A robustness analysis was performed for inclusion and exclusion criteria on the overall NUGENOB database, resulting in exclusion of 14 obese subjects. Analyses in the present report were thus based on data from 757 individuals. Descriptive data are presented as the mean and SD. Partial Spearman correlations adjusted for age and center (and gender for the total sample) were used to measure associations between Baecke and IPAQ indices for total physical activity, walking, and sitting. We then used principal component analysis in order to explore the associations between obesity-related variables (percentage of body fat, waist circumference, $HOMA_{IR}$, FFA, and leptin) and age. This type of analysis reduces the information from these variables to summarized scores (principal factors) that could then be correlated to physical activity indices from the two questionnaires. The number of statistical tests to be performed is thus limited. The principal component analysis was carried out with quartimax rotation to represent the linear proximity

TABLE 1. Characteristics and physical activity data of obese subjects from the Nugenob study.

Variables	Women N	Women Mean (SD)	Men N	Men Mean (SD)
Age (yr)	566	36.6 (8.0)	191	38.5 (7.6)
BMI (kg·m^{-2})	566	35.8 (4.9)	191	34.8 (4.8)
Percent body fat	562	44.0 (5.0)	191	30.5 (5.4)
Waist circumference (cm)	560	103.2 (12.0)	191	114.2 (12.0)
Glucose (mM·L^{-1})	566	5.30 (0.80)	191	5.70 (0.90)
Insulin (μU·mL^{-1})	564	9.8 (5.8)	191	11.7 (7.9)
HOMA$_{IR}$	564	2.33 (1.52)	191	3.12 (2.65)
FFA (mM·L^{-1})	566	0.54 (0.15)	191	0.44 (0.13)
Leptin (ng·mL^{-1})	565	34.4 (13.6)	191	14.5 (9.4)
Baecke questionnaire				
Leisure index	537	2.7 (0.7)	180	2.6 (0.6)†
Sport index	537	2.2 (0.6)	184	2.4 (0.7)†
Work index	526	2.5 (0.7)	179	2.6 (0.8)
Total index	498	7.4 (1.2)	174	7.5 (1.3)
Walking index	556	3.1 (0.7)	185	3.1 (0.7)
Sitting index	556	3.5 (0.8)	185	3.5 (0.7)
IPAQ				
Vigorous activity (min·wk^{-1})	526	88.8 (158.3)	179	138.2 (200.8)†
Moderate activity (min·wk^{-1})	521	161.5 (235.6)	175	175.5 (244.7)
Walking (min·wk^{-1})	541	335.4 (290.2)	178	293.9 (293.9)
Sitting (min·wk^{-1})	503	2224.2 (1083.8)	174	2148.5 (1211.6)
Total activity (MET·min·wk^{-1})	497	2465.8 (2234.5)	168	2831.2 (2717.2)
Activity group (%)				
Insufficiently active	165	32.7	64	37.0
Sufficiently active	267	52.9	68	39.3
Highly active	73	14.4	41	23.7†

HOMA$_{IR}$, HOMA index for insulin resistance. Comparisons between genders were performed using ANOVA with adjustment for center and age or chi-square tests.
†, $P \leq 0.01$.

between obesity-related variables. These principal factors are such linear combinations of the original variables that make the principal factors uncorrelated. Only factors with eigenvalues that were greater than 1.0 were retained for the final solution. Standardized principal factor scores were used as scores of the various indices. The relationships between these new summary scores and the level of habitual physical activity as assessed by the Baecke and IPAQ were studied by calculating partial Spearman correlation coefficients adjusted for age and center. Analyses were performed with SAS software version 8.2 (SAS, Cary, NC).

RESULTS

Characteristics of the study subjects and data from the two physical activity questionnaires are presented by gender in Table 1. Only a few significant differences were found between gender. The leisure and sport indices from the Baecke and the time spent in vigorous activity as assessed by the IPAQ were higher in men compared to women. Subjects classified as insufficiently active represented 32.7 and 37.0% of obese women and men, respectively; men appeared more often classified as highly active than women. Correlations between physical activity scores (total activity, walking, and sitting indices) from the two questionnaires are shown in Table 2. All correlations were significantly different from zero, and, for each score, of about the same magnitude in men and women. Coefficients were highest (about 0.50) for total physical activity and sitting, and lowest (about 0.40) for walking.

TABLE 2. Correlations between physical activity scores from the Baecke questionnaire and IPAQ in obese subjects.

Variables	Women (N = 566)	Men (N = 191)	Total (N = 757)
Total activity	0.51	0.49	0.51
Walking	0.41	0.41	0.40
Sitting	0.48	0.50	0.48

Values are Spearman rank correlation coefficients with adjustment for center and age (and sex for total sample).
$P \leq 0.0001$ for all coefficients.

Table 3 gives the factor-loading matrix of obesity-related variables that were included in principal component analyses together with age. Data from men and women were pooled because of similar patterns of gender-specific matrices (data not shown). The first two axes were retained (Table 3). Percentage of body fat, leptin levels, and, to a lesser extent, FFA levels had high loadings on the first factor. Waist circumference and HOMA$_{IR}$ had high loadings on the second factor. The first factor was considered as a "general obesity" index, whereas the second factor was interpreted as a construct of "abdominal obesity."

Correlations between physical activity scores for each questionnaire and the two obesity indices generated by principal component analysis are presented in Table 4. For the Baecke questionnaire, in men and women, leisure, sport and total physical activity indices were negatively correlated with both general and abdominal obesity indices (except for the leisure index with abdominal obesity in men). No significant relationship was found for the work index. For the IPAQ, vigorous, moderate, and total physical activity indices were negatively related to the general obesity index in both genders and to the abdominal obesity index in women. No significant relationship was found for the sitting and walking indices from both questionnaires, except a weak positive correlation (ρ = 0.10) between the Baecke sitting index and the general obesity index in women.

DISCUSSION

The objective of this study was to compare physical activity data as assessed by the Baecke questionnaire and the IPAQ in obese subjects from a large European multicenter study. Major findings of the present report are 1) a fair level of correlation (0.51) between the two questionnaires for assessment of total habitual physical activity, 2) a similar pattern of associations between physical activity and general

TABLE 3. Factor-loading matrix of age and obesity-related variables.

Variables	Factors 1	Factors 2	
Age	−0.09	0.14	
Percent body fat	0.89	0.14	
Waist circumference	0.10	0.83	
HOMA$_{IR}$	−0.01	0.82	
FFA	0.63	−0.28	
Leptin	0.85	0.15	
% of explained variation	24.1	19.0	Total = 43.1

Factor 1 termed "general obesity" index and factor 2 termed "abdominal obesity" index are uncorrelated linear combinations of original variables provided by principal component analysis (see text). Data are combined results for men (N = 191) and women (N = 566). HOMA$_{IR}$, HOMA index for insulin resistance.

TABLE 4. Correlations between physical activity indices from the Baecke questionnaire and IPAQ and obesity-related factors.

Variables	Baecke				IPAQ				
	Leisure	Sport	Work	Total	Sitting	Walking	Moderate	Vigorous	Total
					Women (N=566)				
General obesity index	−0.13††	−0.18‡	−0.06	−0.20‡	0.05	0.03	−0.11††	−0.10†	−0.08
Abdominal obesity index	−0.11†	−0.17‡	0.06	−0.12††	−0.06	−0.04	−0.12††	−0.13††	−0.16††
					Men (N=191)				
General obesity index	−0.25‡	−0.28‡	0.03	−0.24††	0.04	−0.07	−0.17†	−0.18††	−0.19††
Abdominal obesity index	−0.11	−0.25††	0.00	−0.15†	0.00	0.12	−0.06	−0.06	0.01

Values are Spearman rank correlation coefficients with adjustment for center and age. †, $P \leq 0.05$; ††, $P \leq 0.01$; ‡, $P \leq 0.0001$.

obesity with both instruments, 3) a rather high proportion of subjects categorized as sufficiently or highly active given the fact that this is a study in an obese population.

In this study, we report physical activity data as assessed by the IPAQ specifically in obese subjects. Because the IPAQ was made available only recently, there are few data with which to compare these results. Our findings for mean total physical activity estimated by the IPAQ appear to lie between the contrasting results provided by two recent surveys in general population samples of European countries: total physical activity was higher in the EUPASS study (5606 MET·min·wk^{-1} in 4995 men and women from eight countries) (25) and was lower in the Eurobarometer 2002 survey (1862 and 2287 MET·min·wk^{-1} among women and men, respectively, in 1000 subjects from representative samples in each of the 15 EU member states) (27). In contrast, values for the leisure, sport, work, and total activity indices from the Baecke questionnaire observed in our obese subjects were close to those found recently at inclusion into the STORM study, a large European pharmacological weight-loss trial (N = 261 obese subjects, 80% women, leisure: 2.73, sport: 2.12, work: 2.72) (31).

In this study, only about one third of obese men and women were considered as insufficiently active based on data from the IPAQ. This seems rather low for obese subjects, especially considering that extreme outlier values were removed before analyses, as recommended (www.ipaq.ki.se). Results were not modified when outlier data (N = 266) were not removed (data not shown). Even in populations not selected on obesity, there are few IPAQ data describing the frequency of subjects meeting current physical activity recommendations. In one study in a general population from a Brazilian city (N = 3182 subjects older than 20 yr), the prevalence of obesity defined as a BMI over 30 kg·m^{-2} was 15.2% in women and 13.2% in men (9). The proportion of insufficiently active subjects was 43.1 and 47.8% in obese women and men, respectively, which is higher than found in our study. It is, however, difficult to compare our findings with these data from a developing country. Concerning studies that used instruments other than the IPAQ, in a German report where physical activity was assessed by the Stanford 7-d Recall questionnaire at entry into a weight-loss intervention, 61.5% of 109 obese subjects (mean age: 46 yr, mean BMI: 38 kg·m^{-2}) did not meet current physical activity recommendations (33).

Our data may therefore give some indirect support to the notion that the IPAQ leads to overestimation of habitual physical activity, as recently suggested (28). Overreporting is an important concern when assessing habitual physical activity by self-report (19). Studies using room indirect calorimetry or the double-labeled water technique for measuring energy expenditure have documented that obese individuals are particularly prone to such overestimation of physical activity (6,15,32). Physical activity overreporting in inactive or obese individuals might be due in part to a so-called social desirability response bias, reflecting an attempt to mask an inability to meet perceived expectations about activity (1,6). Note that, for the Baecke questionnaire, evaluation of misreporting is difficult because physical activity indices are expressed in arbitrary units that are difficult to compare with energy expenditure measurements provided by other assessment methods. For the IPAQ, it was hypothesized that because the questionnaire asks the average daily time spent in moderate or vigorous activity, subjects might tend to overreport this mean time per day by reporting the day that they were most active (28). Whether overreporting with the IPAQ in obese subjects arises from the structure of this questionnaire or from some characteristics of obese patients, or both, would need further investigation before the validity of the questionnaire is established for this type of subject.

We found significant correlations between the IPAQ and Baecke questionnaire for total physical activity and sitting and walking activity in our obese subjects. This result's showing a fair level of agreement between the two questionnaires in obese subjects is of interest. Indeed, both questionnaires aim to provide a detailed assessment of habitual physical activity. However, they differ in the specific dimensions of physical activity assessed, the time frame of recall, and the expression of results. The Spearman ρ value of about 0.50 for total physical activity in this obese population is higher than correlations previously reported between IPAQ items and existing physical activity indicators from national surveys in several European countries (about 0.30 or lower) (26). It is in the range of correlations found in previous studies comparing total activity from the Baecke with other questionnaires such as Minnesota Leisure Time Physical Activity (0.36), Paffenbarger Harvard Alumni (0.56), Framingham Index (0.57), Godin (0.61), and Lipid Research Clinics (0.68) (23). These previous comparisons with the Baecke questionnaire were, however, performed in limited numbers of normal-weight subjects.

To obtain a comprehensive picture of the relationships of data from each questionnaire with selected obesity-related variables, we used the principal component analysis method. This allowed us to summarize the information at hand, by data reduction of a number of anthropometric, body composition, and biological variables. Two uncorrelated summary measures were built and interpreted as meaningful indices of general and abdominal obesity. The first principal factor included mostly percentage of body fat and plasma leptin. The adipocyte-derived hormone leptin is involved in the maintenance of energy balance through appetite and neuroendocrine adaptations, resulting in a reduction in food intake (16). Leptin may be viewed as a biological marker for body fat content, based on a well-documented positive correlation between plasma leptin concentrations and total fat mass or percentage of body fat (16). The second principal factor included waist circumference and $HOMA_{IR}$. Although it does not allow differentiation between subcutaneous and intraabdominal (visceral) fat, waist circumference is currently the most widely used anthropometric indicator of abdominal fat (20). Abdominal fat accumulation is a known correlate of insulin resistance, independent of total adiposity (20). This was well reflected in our abdominal obesity index, as percentage of body fat was not a significant contributor to this principal factor.

When looking at correlations between the two main factors obtained by principal component analysis and physical activity indices, an important finding of this study is the similar trend for negative relationships between general obesity and physical activity scores with both questionnaires (Baecke leisure and sport activity; IPAQ moderate and vigorous activity). The overall level of correlations appeared higher for the Baecke than for the IPAQ. Results for the Baecke questionnaire are in line with a study by Hunter et al. (11) showing significant correlations between leisure and sport indices with percentage of body fat in 137 white men ($r = -0.24$ and -0.47, respectively). Our findings of lower values for these correlation coefficients might be explained by the fact that our population consisted only of obese individuals, whereas subjects in the study by Hunter et al. (11) were selected to represent a wide range of adiposity and included normal-weight as well as obese subjects. Concerning the IPAQ, there is one study that showed a negative association between BMI, as a measure of overall obesity, and moderate activity as assessed by the IPAQ in women from a population sample of residents from Ghent, Belgium (8). When considering the abdominal obesity index in men from this study, there was no relationship with IPAQ indices in contrast with results obtained with the Baecke. We are not aware of IPAQ data in relation to indicators of abdominal fat or related metabolic parameters. In the study by Hunter et al. (11), the sport index from the Baecke questionnaire was significantly correlated ($r = -0.23$) with the ratio of waist-to-hip circumference as an indicator of abdominal fat, whereas there was no correlation with the leisure index, in agreement with our findings. Importantly, our abdominal obesity index included the HOMA index for insulin resistance. Previous studies have documented negative associations between physical activity and insulin resistance indices (18), independent of overall corpulence (BMI) or body fat. Increased insulin sensitivity at a given level of adiposity with higher levels of physical activity, either vigorous or nonvigorous, is thought to be an important pathway for type 2 diabetes prevention (18).

In obese men and women from this study, the work index from the Baecke questionnaire was not significantly correlated with general or abdominal obesity indices. Such differential association between leisure time and occupational physical activity with BMI and total or abdominal fat has been shown in a number of studies including some using the Baecke questionnaire (11). Low energy expenditure in most current professional occupations, resulting in little variation in physical activity at work, has been proposed as one explanation (11). However, SD for the Baecke work index in the present study were of about the same magnitude as those for the leisure and sport indices. The validity of the work index for the Baecke questionnaire appears lower than the other indices when measures of physical fitness are used as criterion (2). Confounding by other lifestyle variables, particularly dietary habits, could also contribute.

Several limitations of the present study need to be considered. Study subjects were healthy obese subjects seeking treatment who were assessed only once. Test-retest evaluations, or follow-up data after the weight-loss intervention, were not part of the core NUGENOB protocol. We did not have objective measurements of physical activity with which to compare the baseline self-report assessments. Given the likely overestimation of habitual physical activity by the IPAQ suggested by our data, further investigation of the reliability and validity properties of the various existing instruments seems warranted in obese subjects. Only two studies investigated the validity and reliability of physical activity questionnaires (other than the Baecke) among overweight subjects, suggesting that that the ability to measure physical activity by self-report was reduced among overweight subjects (21,30). The use of a pedometer might be an interesting alternative option to objectively evaluate ambulatory activity in relation with obesity-related variables (19). We found that neither walking as assessed by the IPAQ nor the Baecke walking index that we built were associated with obesity indices. The difficulties in accurately assessing walking through self-report have been noted (14). The use of accelerometry-based motion sensors would provide additional information on physical activity intensity (19).

In conclusion, although they measure different dimensions of habitual physical activity, this study, in a large sample of obese subjects, shows a fair level of agreement for the assessment of total physical activity between the IPAQ and Baecke questionnaire. The data, however, suggest that the short last 7-d IPAQ may capture less of the relationships between physical activity and abdominal obesity than the Baecke questionnaire, especially in men, compared to associations observed between physical activity and general obesity. The rather high proportion of sufficiently active subjects as assessed by the IPAQ in this study points to the need for further evaluation of this questionnaire in obese subjects versus objective methods of assessing physical activity and energy expenditure. At this stage, because the IPAQ was primarily designed for surveillance and monitoring purposes, its applicability to research or clinical use in obesity may be questioned.

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