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Examining the reliability and validity of a modified version of the International Physical Activity Questionnaire, long form (IPAQ-L) in Nigeria

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Key words: Physical activity, measurements, public health, IPAQ, Nigeria

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ABSTRACT

Objectives: To investigate the reliability and validity of a modified version of the long International Physical Activity Questionnaire (Hausa IPAQ-LF) in Nigeria.

Design: Cross-sectional study, examining the test-retest reliability and construct validity of the Hausa IPAQ-LF compared with anthropometric and biological variables.

Setting: Metropolitan Maiduguri, the capital city of Borno State in Nigeria.

Participants: 180 Nigerian adults (50% women) with a mean age of 35.6 (SD=10.3) years, purposively selected from neighbourhood with diverse socioeconomic status and walkability.

Outcome measures: Domains (domestic PA, occupational PA, leisure-time PA, active transportation and sitting time) and intensities of PA (vigorous, moderate and walking) were measured with the Hausa IPAQ-LF on two different occasions, eight days apart. Outcomes for construct validity were measured BMI, SBP and DBP.

Results: The Hausa IPAQ-LF demonstrated good test-retest reliability (ICC>75) for total PA (ICC=0.79, 95% CI=0.65-0.82), occupational PA (ICC=0.77, 95% CI=0.68-0.82), active transportation (ICC=0.82, 95% CI=0.75-0.87) and vigorous intensity activities (ICC=0.82, 95% CI=0.76-0.87). Reliability was substantially higher for total PA (ICC=0.80), occupational PA (ICC=0.78), leisure-time PA (ICC=0.75) and active transportation (ICC=0.80) in men than women, but domestic PA (ICC=0.38) and sitting time (ICC=0.71) demonstrated substantial reliability coefficients in women than men. For the construct validity, domestic PA was significantly related mainly with SBP (ρ = -0.27) and DBP (ρ = -0.17), and leisure-time PA and total PA were significantly related only with SBP (ρ = -0.16) and BMI ((ρ = -0.29), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$).

Conclusions: The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria.

ARTICLE SUMMARY

Strengths and limitations of this study.

- Systematic adaptation and tailoring of items on the original IPAQ-LF to reflect the common PA behaviours of adults in Nigeria.
- The first study to describe the cultural adaptation and translations of the IPAQ-LF and explore its psychometric relevance in an African country.
- Findings establish evidence to support the feasibility of using a modified IPAQ-LF to reliably collect context specific PA behaviours of adults in the African region.
- The non-availability of objective criterion measures of PA to validate the modified IPAQ-LF limit comparability of our validity findings to that of many studies from the developed countries.
- The use of non-probability sampling technique may limit generalizability of findings to other samples of Nigerian adults with different characteristics from the study's sample.

INTRODUCTION

The importance of physical activity (PA) for promoting health and preventing disease is well established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it is important to have standardized, reliable and valid instruments that can be used to accurately describe population levels and patterns of PA within and across countries.[4, 5] In this context, the international physical activity questionnaire (IPAQ) was developed to obtain internationally comparable data on health-related physical activity of adults (18-65 years).[5, 6] Two versions of the IPAQ that could be administered by interview or self-completed were developed. The short form (SF) was designed for population surveillance of PA; while the long form (LF) was designed to be appropriate for use in research that requires detailed information on different PA domains, including PA at work, household, during leisure and transportation, and time spent in sedentary activities.[6]

The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts have been made to translate and adapt the IPAQ in many other countries, but most of the research in this context were from the Western developed countries.[7-14] In Africa, the psychometric properties of IPAQ have only been tested in South-Africa as part of the initial development process of the questionnaire,[5] and in older adults.[15] Because the largest increases and burden of non-communicable diseases (NCDs) are in the low-income countries where the understanding of evidence-based strategies for increasing PA remains poor,[16-19] improving PA research is a top priority for low-income countries.[20] However, to advance PA research in Africa, it is important to first develop or tailor standardized measures to be culturally sensitive to PA behaviours of people in the region countries. Because Nigeria is the most populous country in Africa with culture and languages similar to most of the other West African countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this country.

Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF in sub-Saharan African countries can impact PA research and surveillance in the African region where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the present study was to investigate the test-retest reliability and construct validity of a modified version of the IPAQ-LF among adults in Nigeria.

METHODS

Participants

A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status and walkability in Maiduguri city were recruited for the study. The neighbourhood selection strategy has been described in details elsewhere.[26] Maiduguri with an estimated population of 749,123 people is the largest and capital city of Borno State in North-Eastern Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and Chad Republic, and Hausa language is the common means of communication for commercial activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this study if they were willing to complete a written survey twice in English Language, the official language in Nigeria. Additional eligibility criteria included living within the identified neighbourhood categories in the last 12 months, being adults (18-65 years) and not having any disability that prevented independent walking. All participants were fully informed of the study protocol and provided written informed consent. The study protocol was approved by the Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were collected between March and May, 2012.

Measures

The adapted international physical activity questionnaire- long Hausa version

The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly, interviews were conducted with public health experts, exercise scientists and not highly educated local people to identify the items and examples of PA on the original questionnaires that needed to be culturally adapted. Several cultural adaptations were made to the original items to reflect the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with words that are more representative of the language used in Nigeria, like 'very hard' and 'hard' respectively. Second, examples of various intensities of activity that were common in the Nigerian culture were added, and those already on the questionnaire but not common in the Nigerian context were replaced with culturally applicable examples that are equivalent in energy intensity (METs) with the original items and examples. Third, concepts like physical activity and walking for transportation that were misconstrued outside the health context were refined to indicate they were referring to health behaviours.

After adaptation, the questionnaire was independently translated from English into Hausa language by two native speakers of Hausa who also speaks English, and able to read and write in both languages. One of the translators was familiar with the questionnaire and the second was an expert in Hausa language. The translated questionnaires were mutually revised by the translators and the research team for consistency and then back translated into English language by a third bilingual person who was familiar with the construct measured by IPAQ. The back translated version was checked by the research team for any discrepancies and to ensure that the construct measures by IPAQ had not been lost during the adaptation and translation process.

The modified questionnaire, hereafter referred to as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF), contains thirty-one questions that asked about physical activity done in the last 7-days in terms of frequency (days/week) and duration (min/day) spent in four activity domains (transportation, occupation, domestic and leisure time), and included sections on walking, moderate- and vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and motorized transportation). The Hausa IPAQ-LF

data were presented as the MET-min/week for total walking, moderate, and vigorous intensity activity and overall physical activity across the four domains, and in each of the domains. The MET intensity values used to score the Hausa IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest reliability of the Hausa IPAQ-LF, participants completed all items on the measure twice, with an interval of one week between administrations.

Anthropometrical and biological measurements

Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO were used to create the categories: underweight (< 18.5 kg/m^2), normal weight (18.5– < 25 kg/m^2), overweight (25– <30kg/m^2) and obese (≥30 kg/m^2).[28] Resting blood pressure and heart rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study, construct validity was evaluated by investigating the relationship of outcomes from the Hausa IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also by comparing the differences in time spent in PA and sitting across sociodemograpic subgroups. These types of validation for PA measures have been referred as indirect or construct validity in previous studies.[7,24,30]

Sociodemographic Characteristics

Information on age, gender, marital status, religion, income, educational level and employment status were elicited from the participants. Marital status was classified as married or not married. Educational level was classified as more than secondary school education, secondary school education and less than secondary school education. Employment status was classified into white collar (government or private employed), blue collar (self- employed, trader, artisan etc) and unemployed (homemaker, student, retired, or unable to find job).

Data Analysis

Descriptive data were reported as mean, standard deviation and percentages. Mean group differences for continuous variables by gender were examined by independent t-test, and for dichotomous variables by chi-square statistics. The two- way mixed model (single measure) intraclass correlation coefficient (ICC) with 95% confidence interval (CI) was utilized to evaluate test-retest reliability of the instrument. The reliability analyses were conducted overall, and by gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] To assess construct validity, the non-parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body mass index. Independent t-test and one-Way ANOVA were used as appropriate to compare the time spent (minutes/week) in PA across sociodemographic subgroups. Data were analyzed using Statistical Package for the Social Science (SPSS), version 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at $p<0.05$.

RESULTS

The socio-demographic characteristic of the participants are shown in Table 1. The participants comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of 23.8 ± 3.9kg/m^2. Majority of the participants were married (58.9%, n=106), had more than secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to men, the women were more likely to be married (71.1% vs 46.7%, p=0.001) and unemployed (52.2% vs 17.8%, p<0.001), but men were more likely to have more than secondary school education (76.7% vs 48.2%, p<0.001).

Test-retest Reliability

Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients were good (ICC >75) for total PA, occupational PA, active transportation and vigorous intensity (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability

(ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95% CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38, 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous intensity (very hard) activities were substantially greater in men than women.

Similarly, socioeconomic status differences were observed in the reliability coefficients of the modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were substantially higher among participants with less than secondary school education (ICC from 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and higher than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]). While reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95% CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were unemployed than in the employed subgroup.

Construct Validity

Overall, correlations between energy expenditure (MET-Min/wk) according to the modified IPAQ-LF and anthropometric and biological measures were statistically significant in the expected direction for all domains and intensities of PA, except for occupation and active transport domains and walking (table 4). In the full sample, domestic PA was mainly related with SBP (ρ = -0.27, $p< 0.01$) and DBP (ρ = -0.17, $p< 0.05$), while leisure PA and total PA were only related with SBP (ρ = -0.16, $p< 0.05$) and BMI ((ρ = -0.29, $p< 0.01$), respectively. Similarly,

moderate-intensity PA was mainly related with SBP (ρ = -0.16, p< 0.05) and DBP (ρ = -0.21, p< 0.01), but vigorous-intensity PA was only related with BMI (ρ = -0.11, p< 0.05). In the gender based analyses, total PA, domestic PA and sedentary time were more consistently related with anthropometric and biological variables. The strongest rho value (-0.41) was found for the relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was reached between total PA and DBP for the women subgroup. Only in women was domestic PA significantly related with BMI (ρ = -0.23), DBP (ρ = -0.20) and SBP (ρ = -0.31). Leisure-time PA (ρ = -0.39) and occupational PA (ρ = -0.22) were significantly related with BMI only in men. The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ = 0.19) than men (ρ = 0.15).

Table 5 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1) and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified variables, time spent in PA reported during the first administration tends to be higher than those reported during the second administration. At both time points, men reported significantly ($p<0.05$) higher mean time (Min week^{-1}) in active transportation, occupational PA, and leisure-time PA than women. However, women spent significantly ($p<0.001$) more time (Min week^{-1}) in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status, participants that had lower than secondary school education compared to those with at least secondary school education reported statistically significant higher mean time (Min week^{-1}) at both time points for total PA, active transport, occupational PA, walking and vigorous intensity activity compared to those with at least secondary school education. While participants that were employed reported statistically significant ($p<0.05$) more time (Min week^{-1}) in total PA (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1, IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.

DISCUSSION

This study examined aspects of reliability and validity of a modified version of the IPAQ-LF in Nigeria. The findings generally indicated acceptable test-retest reliability and construct validity for items of the modified IPAQ-LF among Nigerian adults. To the best of our knowledge, the present study is the only one to examine the reliability and validity of the long version of IPAQ that has been modified specifically to an indigenous African culture and language.

We found evidence for good reliability with high correlations between the test-retest for total PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that except for domestic PA and sitting time, ICC values for domains of PA were consistently above 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[32,33] Similar to a previous IPAQ-LF study in Hong Kong,[33] domestic activity demonstrated the lowest ICC value in our study. However, it is possible that the infrequent nature of household activities undertaken, especially by men may account for the low reliability reported for domestic PA in our study. In addition to the traditional African patriarchal belief that make most African men to rarely engage in indoor household activities, men in the high socioeconomic group in Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home, appliances and equipment maintenance because they are able to employ the services of domestic helpers and repair men. Our findings of lower reliability for domestic activity among men, those with more than secondary school education and those who were employed compared to their counterparts seem to support this assumption.

The highest and strongest reliability coefficients (0.82) were found for both active transportation and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and reproducible overtime than other PA domains because it is a common and ubiquitous PA behaviour in the African region. Mostly, the performance of active transportation especially walking is often out of necessity rather than choice within the African context. Our finding of higher ICC value for vigorous intensity PA is consistent with those of other studies that found the reliability of vigorous intensity activity to be higher compared to that of moderate intensity activity.[10, 30, 33, 34] Compared to structured vigorous physical activities like sports and exercise that can be more easily recalled, moderate intensity PA are often of low salience,

incidental and may not easily be remembered by people.[35, 36] Further our finding that the reliability of vigorous intensity physical activity was meaningfully higher among men than women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria are more consistent than women when responding to PA items that pertained to intense vigorous PA than other intensities of activity. Overall, the moderate to good evidence of reliability found for all items indicates that the modified IPAQ-LF is reproducible, internally consistent and is promising for research in Nigeria.

In the absence of objective criterion standards for evaluating an absolute estimate of PA, the consistency of items on IPAQ with variables known to be related to PA such as body mass index (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have been used as important construct validity measures.[7, 10, 21, 24] In the present study, the correlations of the PA domains and intensities with biological and anthropometric variables were mostly significant in the expected direction, but they were low suggesting a modest evidence of construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were comparable with the values in other studies that have evaluated the IPAQ-LF.[5, 7, 8, 24, 30, 33, 37] Because better validity coefficients have been reported for other PA measures above that of the IPAQ,[37, 38] with the present African finding, it is possible that the IPAQ-LF only have modest evidence of construct validity Worldwide.

One interesting finding was that total PA was strongly and inversely related with BMI of men and women. This is biologically plausible because total energy expenditure would be expected to have the strongest effects on BMI. Similarly, domestic PA was related with resting blood pressure and BMI in the expected direction, and this was mainly among women. Contrarily, no such gender based associations of domestic PA with health variables were found in previous studies of the western developed countries.[10, 24] It is possible that African women are accumulating domestic related PA at sufficient intensities needed to circumvent deleterious health outcomes. This kind of finding has implications for intervention strategies formulation, considering that domestic activities are common and dominant PA behaviour among women in Africa. In the present study, only in the domains of sitting and domestic PA did women

accumulate more time than men. Perhaps, promotion of the typical domestic related activities like households chores, sweeping of compound and pounding of grains as integral components of health enhancing PA (HEPA) of women in Nigeria could be an important public health strategy for controlling the rising incidence of NCDs in this country, where current estimates indicate the prevalence of overweight/obesity as 33.3% (37.7% women and 28.8% men) and that NCDs already account for 27% (28.5% in women; 25.45 in men) of all deaths.[39]

Similar to the finding of a Mexican study,[40] we found scores on the modified IPAQ-LF to be consistently lower during the second administration of the questionnaire compared to the first administration. Because familiarity with the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that participants in our study might have over-reported their PA levels during the first administration of the IPAQ. This kind of findings may have implication for the utility of IPAQ for surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA that has been associated with the IPAQ,[37,41] it may be necessary to start considering the need for multiple measurements when using the IPAQ for evaluating PA, especially in developing African countries. However, patterns of PA as measured by the modified IPAQ-LF during both administrations were consistently similar, and both administrations were able to discriminate PA in the expected direction between subgroups of our sample. For example, at both measurement time points, and consistent with hypothesis, men reported more time in active transportation, occupational PA and leisure PA than women, while women reported more time in domestic PA and sedentary activity than men. These suggest an additional support for evidence of construct validity for the modified IPAQ-LF in Nigerian adults.

Strengths and limitations

A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to reflect the common PA behaviours of people in Nigeria. This is the first study in an African country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse segment of the Nigerian population. In the Africa region, the importance of a valid and

established PA scale like the modified IPAQ-LF is not only important to monitoring the domain in which activity is performed, but also very critical to understanding studies of ecological models of health behaviours, that emphasize the importance of multiple levels of influence on health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using ecological models indicate that favourable built environmental attributes are promising for improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45] However, built environment characteristics are expected to be strongly related to specific PA types rather than overall PA.[46, 47] For example, different environmental variables can be related to walking for leisure or transportation and to moderate PA for household, occupation, recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to understanding the domain specific nature of ecological model research in the African region. One additional strength was the exploration of PA patterns by gender, educational level and employment status, the findings of which were consistent with general hypothesis on social patterns of inactivity in low-income countries.[20, 48]

However, the findings of this study should be interpreted in the light of some important limitations. Direct comparison of our validity findings with previous studies should be made with caution, because unlike in our study, the accelerometer or PA diary were utilized as a common objective criterion standard to validate the IPAQ in the majority of the studies.[5, 7, 8, 24, 30, 33, 37] Despite this issue, the validity coefficients in our study were remarkably similar to those reported in these other studies. Because the choice and availability of appropriate criterion measures are particular issues of concern for the validation of PA questionnaires in low-income countries of Africa,[5, 49, 50] the use of simple and less expensive measures like biological and anthropometric variables may represent a useful alternative. Another limitation of the study is the use of non-probability sampling technique. The study finding may have limited generalizability to other samples of Nigerians that have different characteristics from this sample. In addition, the majority of participants have more than secondary school education with potentially higher comprehension and recall ability than may be found in the general population. However, recruitment from diverse neighbourhoods and settings allowed for a sample with

reasonable heterogeneity in age, occupational status, and ethnic backgrounds and made it possible to stratify the analyses by sociodemographic characteristics.

Conclusions

Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could further contribute to our understanding of the impact of multiple levels of influence on physical activity behaviours of people in the African region.

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Contributors

ALO conceived and designed the study, conducted the statistical analysis and interpretation of data and drafted the manuscript. UMB and STP managed participants' recruitment and data collection and revised the manuscript for important intellectual contents. HBN and RDM contributed to cultural adaptation and translations of the measure and revised the manuscript for important intellectual contents. AYO contributed to study design, acquisition and interpretation of data and critically revised the manuscript for important intellectual contents. All authors read and approved the final manuscript.

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Competing interests

Authors declare there is no competing interest associated with this study.

Ethics approval

Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria (ADM/TH/EC/75).

Data sharing process

Dataset for this study available upon request from the corresponding author.

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Table 1. Descriptive characteristics of the participants (N=180)

Variables	Total sample (N=180)	Men (n=90, 50%)	Women (n=90, 50%)
Age (years)			
Mean (± SD)	35.6 ± 10.3	35.7 ± 8.3	35.5 ± 11.9
Marital status (n, %)*			
Not Married	74(41.1)	48(53.3)	26(28.9)
Married	106(58.9)	42(46.7)	64(71.1)
BMI (Kg/m^2)			
Mean (± SD)	23.8 ± 3.9	23.8 ± 3.5	23.8 ± 4.4
BMI Category (n, %)			
Underweight	14 (7.8)	4 (4.4)	10 (11.1)
Normal weight	107 (59.4)	58 (64.4)	49 (54.4)
Overweight/obese	59 (32.8)	28 (31.2)	31 (34.5)
Ethnicity (n, %)			
Hausa/Fulani	21(11.7)	10.1(11.1)	11(12.2)
Igbo	8(4.4)	5(5.6)	3(3.3)
Yoruba	10(5.6)	6(6.7)	4(4.4)
Kanuri/Shuwa Arab	44(24.4)	23(25.6)	21(23.3)
Others	97(53.9)	46 (51.1)	51(56.7)
Educational level (n, %)*			
> Secondary School	111 (62.7)	11 (12.2)	17(19.5)
Secondary	38 (21.5)	10 (11.1)	28(32.5)
<Secondary School	28 (15.8)	69 (76.7)	42(48.2)
Occupational Status (n, %)*			
Unemployed	63(35)	16(17.8)	47(52.2)
Blue Collar	45(25)	28(31.1)	17(18.9)
White Collar	72(40)	46(51.1)	26(28.9)

*- Significant difference between samples (p<0.05)
BMI- Body Mass Index

Table 2: Test-reliability based on intra-class correlation coefficient for Hausa IPAQ– LF, overall and by gender

	Total (N=180)			Women (n=90)	Men (n=90)
PA Measure (MET×min/wk)	**Test 1 (Mean (SD))**	**Test 2 (Mean (SD))**	**ICC (95%CI)**	**ICC (95%Cl)**	**ICC (95%Cl)**
Total PA, all domain	2160.6 (2691.1)	1612.8 (1612.8)	0.76 (0.65-0.82)	0.45 (0.08-0.67)	0.80 (0.69- 0.87)
Occupation	619.1(1671.5)	497.5 (1332.9)	0.77 (0.68-082)	0.64 (0.46-0.77)	0.78 (0.66 -0.85)
Active Transport	468.1 (684.7)	440.5 (605.7)	0.82 (0.75-0.87)	0.63 (0.40-0.77)	0.83 (0.73 - 0.89)
Domestic	597.6 (754.6)	473.4 (673.7)	0.50 (0.32-0.62)	0.38 (0.01-0.57)	0.33 (-0.01-0.56)
Leisure	377.0 (1096.3)	196.7 (920.2)	0.71 (0.60-0.78)	0.69 (0.53-0.79)	0.75 (0.63-0.84)
Sitting	2263.0 (715.8)	2235.4 (818.9)	0.62 (0.42-0.75)	0.71 (0.46-0.85)	0.48 (0.06-0.72)
PA by Intensity (MET×min/wk)					
Walking	613.6 (635.6)	534.6 (449.1)	0.63 (0.48-0.74)	0.57 (0.29-0.74)	0.65 (0.44-0.78)
Moderate	986.9 (1365.9)	716.1 (1164.6)	0.61 (0.46-0.71)	0.42 (0.11-0.62)	0.67 (0.49-0.78)
Vigorous	526.5 (1543.7)	394.1 (1431.1)	0.82 (0.76-0.87)	0.55 (0.30-0.71)	0.86 (0.78-0.91)

PA= Physical Activity
MET= Metabolic Energy Turnover

Table 3: Socioeconomic status differences in test- retest reliability of the Hausa IPAQ- LF (N= 180)

Socioeconomic Status	Overall PA	Active Transport	Occupation PA	Leisure PA	Domestic PA	Sitting
Educational Qualification						
More than secondary school (n=111)	0.42 (0.08-0.63)	0.67 (0.43-0.78)	0.32 (-0.06-0.57)	0.33 (-0.05-0.57)	0.58 (0.35-0.73)	0.23 (-0.63-0.63)
Secondary School (n=38)	0.55 (0.22-0.74)	0.28 (-0.21-0.57)	0.58 (0.33-0.74)	0.54 (0.25-0.71)	0.50 (0.19-0.69)	0.51 (-0.04-0.76)
Less than Secondary school (n=28)	0.89 (0.67-0.96)	0.90 (0.74-0.96)	0.82 (0.61-0.92)	0.92 (0.83-0.96)	0.90 (0.78-0.95)	0.77 (0.45-0.90)
Employment Category						
Employed (117)	0.80 (0.67-0.96)	0.83 (0.74-0.88)	0.79 (0.70-0.86)	0.79 (0.69-0.85)	0.36 (0.08-0.56)	0.56 (0.23-0.75)
Unemployed (63)	0.09 (-8.86-0.56)	0.68 (0.44-0.82)	0.16 (-0.39-0.49)	0.25 (-0.24-0.55)	0.65 (0.43-0.79)	0.68 (0.36-0.80)

PA= Physical Activity

Table 4: Construct validity of Hausa IPAQ-LF: Spearman correlations between energy expenditure (MET×min/wk) from Hausa IPAQ– LF, and anthropometric and biological variables (N=180)

	Overall (N = 180)			Female (n = 90)			Male (n = 90)		
MET×min/wk	BMI	DBP	SBP	BMI	DBP	SBP	BMI	DBP	SBP
PA Domains									
Total PA	-0.29**	-0.17*	-0.09	-0.09	-0.23**	-0.04	-0.41**	-0.08	-0.14
Occupation PA	-0.12	-0.09	-0.01	-0.02	-0.02	-0.05	-0.22**	-0.17	-0.08
Active transport PA	-0.05	-0.04	-0.01	-0.10	-0.13	-0.02	-0.04	-0.02	-0.80
Domestic PA	-0.07	-0.17*	-0.26**	-0.23**	-0.20*	-0.31**	0.04	-0.14	-0.04
Leisure PA	0.09	-0.08	-0.16*	-0.11	0.02	0.08	-0.39**	-0.12	-0.06
Sitting	0.16	-0.09	0.04	0.19	0.12	0.05	0.15	-0.09	0.05
PA Intensity									
Walking	0.90	-0.09	-0.03	0.19	-0.05	0.08	-0.05	-0.11	-0.15
Moderate	-0.02	0.21*	0.16*	0.02	-0.14	-0.08	0.02	-0.25**	-0.16
Vigorous	-0.11*	-0.06	-0.03	-0.16	-0.01	-0.02	-0.13*	-0.12	-0.11

MET= Metabolic Energy Turnover
BMI= Body Mass Index
DBP= Diastolic Blood Pressure
SBP= Systolic Blood Pressure
PA= Physical activity
*=p<0.05, **=p<0.01

Table 5: Differences in time spent in physical activity overall, and by gender and socioeconomic status sub groups

		Gender		Education			Employment	
	Total Mean ± SD	**Men** Mean ± SD	**Women** Mean ± SD	**>Secondary** Mean ± SD	**Secondary** Mean ± SD	**<Secondary** Mean ± SD	**Employed** Mean ± SD	**Unemployed** Mean ± SD
PA by domain (min/wk)								
Total PA, all domain								
IPAQ1	405.2 (507.8)	460.7 (582.9)	326.8 (367.8)	334.0 (400.8)	384.8 (514.8)	849.2 (764.1)**	441.1 (530.2)	285.1 (408.6)*
IPAQ2	308.4 (440.3)	319.7 (522.8)	291.9 (282.9)	285.1 (295.1)	184.8 (264.4)	803.0 (929.6)**	359.4 (481.6)	141.0 (185.2)*
Active Transport								
IPAQ1	35.8 (89.7)	52.4 (127.7)	19.5 (17.7)*	28.3 (47.7)	28.9 (45.02)	76.4 (198.7)*	43.8 (109.4)	21.1 (21.9)*
IPAQ2	30.4 (76.7)	41.2 (106.3)	19.3 (17.5)*	23.6 (30.6)	20.3 (30.9)	74.3 (182.6)*	36.9 (94.1)	18.3 (14.7)*
Work								
IPAQ1	160.1 (380.8)	217.5 (466.8)	79.1 (179.9)*	114.8 (291.0)	122.9 (365.6)	546.7 (615.7)**	195.5 (418.8)	41.8 (162.2)*
IPAQ2	135.3 (310.3)	172.5 (372.8)	80.6 (171.9)*	104.1 (232.2)	160.9 (196.1)	531.6 (595.8)**	164.1 (341.7)	40.1 (133.0)*
Domestic								
IPAQ1	159.6 (202.2)	82.3 (120.6)	236.9 (235.8)**	141.2 (182.4)	173.3 (238.5)	165.4 (159.4)	132.1 (170.7)	210.6 (243.8)*
IPAQ2	123.9 (163.9)	52.4 (74.9)	195.5 (190.1)**	131.9 (182.5)	107.6 (130.4)	147.3 (189.1)	112.6 (163.9)	205.0 (163.3)*
Leisure								
IPAQ1	62.4 (159.1)	75.0 (211.1)	10.5 (27.3)**	47.0 (97.3)	92.7 (209.4)	38.2 (160.1)	69.7 (157.6)	48.7 (162.3)
IPAQ2	30.5 (118.2)	50.6 (160.7)	10.1 (38.5)**	23.4 (51.4)	24.7 (91.4)	71.5 (256.5)	43.1 (143.5)	17.0 (28.7)*
Sitting								
IPAQ1	2263.0 (715.8)	2188.8 (759.7)	2330.7 (674.8)	2280.0 (618.7)	2433.9 (693.7)	2180.9 (760.8)	2159.4 (775.9)	2337.6 (667.2)
IPAQ2	2235.4 (819.9)	2208.7 (916.9)	2259.6 (728.1)	2420.7 (638.7)	2215.3 (663.1)	2160.0 (1111.4)	2170.6 (870.5)	2282.0 (785.5)
PA by Intensity (min/wk)								
Walking								
IPAQ1	178.5 (221.5)	241.1 (271.9)	128.2 (100.8)*	194.4 (268.1)	133.4 (85.6)	266.9 (285.4)*	192.0 (245.7)	133.3 (96.2)*
IPAQ2	142.5 (141.8)	148.5 (137.9)	133.7 (147.9)	151.7 (138.4)	103.6(94.7)	200.3 (209.1)*	150.7 (146.6)	115.4 (122.7)
Moderate								
IPAQ1	201.9 (326.9)	193.0 (214.5)	214.5 (247.8)	187.3 (266.5)	194.9 (386.5)	309.7 (381.7)	221.2 (347.4)	137.7 (239.9)
IPAQ2	133.9 (238.5)	114.2 (276.9)	162.7 (165.6)	132.9 (177.8)	88.0 (197.2)	319.0 (482.1)*	153.9 (266.2)	68.0 (76.4)*
Vigorous								
IPAQ1	94.1 (211.8)	123.7 (249.6)	52.2 (133.2)*	32.9 (81.9)	129.5 (208.2)	268.0 (459.7)**	90.2 (214.6)	127.1 (204.6)
IPAQ2	78.4 (206.9)	86.8 (227.4)	46.2 (73.4)	52.2 (140.2)	55.2 (127.0)	292.8 (461.5)**	92.8 (226.9)	130.9 (107.8)

PA= Physical Activity
*=p<0.05
**=p<0.001

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Examining the reliability and validity of a modified version of the International Physical Activity Questionnaire, long form (IPAQ-L) in Nigeria: A cross-sectional study

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ABSTRACT

Objectives: To investigate the reliability and aspect of validity of a modified version of the long International Physical Activity Questionnaire (Hausa IPAQ-LF) in Nigeria.

Design: Cross-sectional study, examining the reliability and construct validity of the Hausa IPAQ-LF compared with anthropometric and biological variables.

Setting: Metropolitan Maiduguri, the capital city of Borno State in Nigeria.

Participants: 180 Nigerian adults (50% women) with a mean age of 35.6 (SD=10.3) years, purposively selected from neighbourhood with diverse socioeconomic status and walkability.

Outcome measures: Domains (domestic physical activity [PA], occupational PA, leisure-time PA, active transportation and sitting time) and intensities of PA (vigorous, moderate and walking) were measured with the Hausa IPAQ-LF on two different occasions, eight days apart. Outcomes for construct validity were measured BMI, SBP and DBP.

Results: The Hausa IPAQ-LF demonstrated good test-retest reliability (ICC>75) for total PA (ICC=0.79, 95% CI=0.65-0.82), occupational PA (ICC=0.77, 95% CI=0.68-0.82), active transportation (ICC=0.82, 95% CI=0.75-0.87) and vigorous intensity activities (ICC=0.82, 95% CI=0.76-0.87). Reliability was substantially higher for total PA (ICC=0.80), occupational PA (ICC=0.78), leisure-time PA (ICC=0.75) and active transportation (ICC=0.80) in men than women, but domestic PA (ICC=0.38) and sitting time (ICC=0.71) demonstrated substantial reliability coefficients in women than men. For the construct validity, domestic PA was significantly related mainly with SBP (ρ = -0.27) and DBP (ρ = -0.17), and leisure-time PA and total PA were significantly related only with SBP (ρ = -0.16) and BMI ((ρ = -0.29), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$).

Conclusions: The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria.

ARTICLE SUMMARY

Strengths and limitations of this study.

- Systematic adaptation and tailoring of items on the original IPAQ-LF to reflect the common PA behaviours of adults in Nigeria.
- The first study to describe the cultural adaptation and translations of the IPAQ-LF and explore its psychometric relevance in an African country.
- Findings establish evidence to support the feasibility of using a modified IPAQ-LF to reliably collect context specific PA behaviours of adults in the African region.
- Exploring construct validity through the relationships of PA with BMI and resting blood pressure was an important limitation of this study.
- The use of non-probability sampling technique may limit generalizability of findings to other samples of Nigerian adults with different characteristics from the study's sample.

INTRODUCTION

The importance of physical activity (PA) for promoting health and preventing disease is well established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it is important to have standardized, reliable and valid instruments that can be used to accurately describe population levels and patterns of PA within and across countries.[4, 5] In this context, the international physical activity questionnaire (IPAQ) was developed to obtain internationally comparable data on health-related PA of adults (18-65 years).[5, 6] Two versions of the IPAQ that could be administered by interview or self-completed were developed. The short form (SF) was designed for population surveillance of PA; while the long form (LF) was designed to be appropriate for use in research that requires detailed information on different PA domains, including PA at work, household, during leisure and transportation, and time spent in sedentary activities.[6]

The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts have been made to translate and adapt the IPAQ in many other countries, but most of the research in this context were from the Western developed countries.[7-14] In Africa, the psychometric properties of IPAQ have only been tested in South-Africa as part of the initial development process of the questionnaire,[5] and in older adults.[15] Because the largest increases and burden of non-communicable diseases (NCDs) are in the low-income countries where the understanding of evidence-based strategies for increasing PA remains poor,[16-19] improving PA research is a top priority for low-income countries.[20] However, to advance PA research in Africa, it is important to first develop or tailor standardized measures to be culturally sensitive to PA behaviours of people in the region countries. Because Nigeria is the most populous country in Africa with culture and languages similar to most of the other West African countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this country.

Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF in sub-Saharan African countries can impact PA research and surveillance in the African region where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the present study was to investigate the reliability and an aspect of validity of a modified version of the IPAQ-LF among adults in Nigeria.

METHODS

Participants

A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status and walkability in Maiduguri city were recruited for the study. The sampling and neighbourhood selection strategy have been described in details elsewhere.[26] Maiduguri with an estimated population of 749,123 people is the largest and capital city of Borno State in North-Eastern Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and Chad Republic, and Hausa language is the common means of communication for commercial activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this study if they were willing to self-complete a written survey twice in either Hausa or English Language. However, researchers (UMB and STP) were in attendance to provide translation and interpretation assistance to participants (n=11) who were unable to independently complete the survey. Additional eligibility criteria included living within the identified neighbourhood categories in the last 12 months, being adults (18-65 years) and not having any disability that prevented independent walking. All participants were fully informed of the study protocol and provided signed informed consent. The study protocol was approved by the Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were collected between March and May, 2012.

Measures

The adapted international physical activity questionnaire- long Hausa version

The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly, interviews were conducted with public health experts, exercise scientists and not highly educated local people to identify the items and examples of PA on the original questionnaires that needed to be culturally adapted. Several cultural adaptations were made to the original items to reflect the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with words that are more representative of the language used in Nigeria, like 'very hard' and 'hard' respectively. Second, examples of various intensities of activity that were common in the Nigerian culture were added, and those already on the questionnaire but not common in the Nigerian context were replaced with culturally applicable examples that are equivalent in energy intensity (METs) with the original items and examples. Third, concepts like physical activity and walking for transportation that were misconstrued outside the health context were refined to indicate they were referring to health behaviours.

After adaptation, the questionnaire was independently translated from English into Hausa language by two native speakers of Hausa who also speaks English, and able to read and write in both languages. One of the translators was familiar with the questionnaire and the second was an expert in Hausa language. The translated questionnaires were mutually revised by the translators and the research team for consistency and then back translated into English language by a third bilingual person who was familiar with the construct measured by IPAQ. The back translated version was checked by the research team for any discrepancies and to ensure that the construct measures by IPAQ had not been lost during the adaptation and translation process.

The modified questionnaire (available in both Hausa and English language), hereafter referred to as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF), contains thirty-one questions that asked about physical activity done in the last 7-days in terms of frequency (days/week) and duration (minutes/day) spent in four activity domains (transportation,

occupation, domestic and leisure time), and included sections on walking, moderate- and vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and motorized transportation). The Hausa IPAQ-LF data were presented as the MET-minute/week for total walking, moderate, and vigorous intensity activity and overall physical activity across the four domains, and in each of the domains. The MET intensity values used to score the Hausa IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest reliability of the Hausa IPAQ-LF, participants self-completed all items on the measure twice, with an interval of one week between administrations.

Anthropometrical and biological measurements

Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO were used to create the categories: underweight (< 18.5 kg/m^2), normal weight (18.5– < 25 kg/m^2), overweight (25– <30kg/m^2) and obese (≥30 kg/m^2).[29] Resting blood pressure and heart rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study, construct validity was evaluated by investigating the relationship of outcomes from the Hausa IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also in part by comparing the differences in time spent in PA and sitting across sociodemograpic subgroups. These types of validation for PA measures have been referred as indirect or construct validity in previous studies.[7,24,30]

Sociodemographic Characteristics

Information on age, gender, marital status, religion, income, educational level and employment status were elicited from the participants. Marital status was classified as married or not married. Educational level was classified as more than secondary school education, secondary school

education and less than secondary school education. Employment status was classified into white collar (government or private employed), blue collar (self- employed, trader, artisan etc) and unemployed (homemaker, student, retired, or unable to find job).

Data Analysis

Descriptive data were reported as mean, standard deviation and percentages. Mean group differences for continuous variables by gender were examined by independent t-test, and for dichotomous variables by chi-square statistics. The reliability analyses were performed using 2 strategies. First, the two- way mixed model (single measure) intraclass correlation coefficient (ICC) with 95% confidence interval (CI) between the continuous scores obtained on 1st and 2nd administration of the Hausa IPAQ-LF was calculated. The ICCs were calculated overall, and by gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] Second, the Bland and Altman Method was used to assess agreement on scores of PA from the 1st and 2nd administrations.[32] Variables used for the Bland and Altman analysis were weekly time spent in moderate-to-vigorous activity (MVPA), total PA and sitting. MVPA was computed by summing the total minutes/week of reported physical activity of moderate and vigorous- intensities across all four domains. For total PA, the total minutes/week of activities in each domain were summed (total work + total transport + total domestic + total leisure-time min/week scores) to gain an overall estimate of physical activity in a week. Also, the independent t-test and one-Way ANOVA were used as appropriate to compare the time spent (minutes/week) in PA at both administrations across sociodemographic subgroups. To assess construct validity, the non-parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body mass index. Data were analyzed using Statistical Package for the Social Science (SPSS), version 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at $p<0.05$.

RESULTS

The socio-demographic characteristic of the participants are shown in Table 1. The participants comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of 23.8 ± 3.9kg/m^2. Majority of the participants were married (58.9%, n=106), had more than secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to men, the women were more likely to be married (71.1% vs 46.7%, p=0.001) and unemployed (52.2% vs 17.8%, p<0.001), but men were more likely to have more than secondary school education (76.7% vs 48.2%, p<0.001).

Reliability

Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients were good (ICC >75) for total PA, occupational PA, active transportation and vigorous intensity (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95% CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38, 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous intensity (very hard) activities were substantially greater in men than women.

Similarly, socioeconomic status differences were observed in the reliability coefficients of the modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were substantially higher among participants with less than secondary school education (ICC from 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and those with higher than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]). While reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and

leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95% CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were unemployed than in the employed subgroup.

Figures 1, 2 and 3 (Bland-Altman plots) illustrate the agreement in the scores (minutes/week) of total PA, MVPA and sitting between the first and second administrations of Hausa IPAQ-LF. For total PA, the mean difference was 106.7 minutes/week, with a wide 95% limits of agreement (-762.2 to 965.6 minutes/week). For MVPA, the mean difference was about one and half hour per week (91.6 minutes/week), and also demonstrating a wide 95% limits of agreement (-744.5 to 927.7 minutes/week). For sitting time, the mean difference was small (26 minutes/week) and the 95% limits of agreement range from -2178.1 to 2230.9 minutes/week.

Table 4 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1) and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified variables, time spent in PA reported during the first administration tends to be higher than those reported during the second administration. At both time points, men reported significantly ($p<0.05$) higher mean time (minute/week) in active transportation, occupational PA, and leisure-time PA than women. However, women spent significantly ($p<0.001$) more time (minutes/week) in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status, participants that had lower than secondary school education compared to those with at least secondary school education reported statistically significant higher mean time (minutes/week) at both time points for total PA, active transport, occupational PA, walking and vigorous intensity activity compared to those with at least secondary school education. While participants that were employed reported statistically significant ($p<0.05$) more time (minutes/week) in total PA (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1, IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.

Construct Validity

Overall, correlations between energy expenditure (MET-Minutes/week) according to the modified IPAQ-LF and anthropometric and biological measures were statistically significant in the expected direction for all domains and intensities of PA, except for occupation and active transport domains and walking (table 5). In the full sample, domestic PA was mainly related with SBP (ρ = -0.27, $p< 0.01$) and DBP (ρ = -0.17, $p< 0.05$), while leisure PA and total PA were only related with SBP (ρ = -0.16, $p< 0.05$) and BMI (ρ = -0.29, $p< 0.01$), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$). In the gender based analyses, total PA, domestic PA and sedentary time were more consistently related with anthropometric and biological variables. The strongest rho value (-0.41) was found for the relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was reached between total PA and DBP for the women subgroup. Only in women was domestic PA significantly related with BMI (ρ = -0.23), DBP (ρ = -0.20) and SBP (ρ = -0.31). Leisure-time PA (ρ = -0.39) and occupational PA (ρ = -0.22) were significantly related with BMI only in men. The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ = 0.19) than men (ρ = 0.15).

DISCUSSION

This study examined the reliability and an aspect of validity of a modified version of the IPAQ-LF in Nigeria. The findings generally indicated acceptable test-retest reliability and modest construct validity for items of the modified IPAQ-LF among Nigerian adults. To the best of our knowledge, the present study is the only one to examine the reliability and validity of the long version of IPAQ that has been modified specifically to an indigenous African culture and language.

We found evidence for good reliability with high correlations between the test-retest for total PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that except for domestic PA and sitting time, ICC values for domains of PA were consistently above 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[33,34]

Similar to a previous IPAQ-LF study in Hong Kong,[34] domestic activity demonstrated the lowest ICC value in our study. However, it is possible that the infrequent nature of household activities undertaken, especially by men may account for the low reliability reported for domestic PA in our study. In addition to the traditional African patriarchal belief that make most African men to rarely engage in indoor household activities, men in the high socioeconomic group in Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home, appliances and equipment maintenance because they are able to employ the services of domestic helpers and repair men. Our findings of lower reliability for domestic activity among men, those with more than secondary school education and those who were employed compared to their counterparts seem to support this assumption.

The highest and strongest reliability coefficients (0.82) were found for both active transportation and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and reproducible overtime than other PA domains because it is a common and ubiquitous PA behaviour in the African region. Mostly, the performance of active transportation especially walking is often out of necessity rather than choice within the African context. Our finding of higher ICC value for vigorous intensity PA is consistent with those of other studies that found the reliability of vigorous intensity activity to be higher compared to that of moderate intensity activity.[10,30,34,35] Compared to structured vigorous physical activities like sports and exercise that can be more easily recalled, moderate intensity PA are often of low salience, incidental and may not easily be remembered by people.[36,37] Further our finding that the reliability of vigorous intensity physical activity was meaningfully higher among men than women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria are more consistent than women when responding to PA items that pertained to intense vigorous PA than other intensities of activity. Overall, the moderate to good evidence of reliability found for all items indicates that the modified IPAQ-LF is reproducible, internally consistent and is promising for research in Nigeria.

Except for sitting time, the limits of agreement in the mean scores of total PA and MVPA between the first and second administrations were wide, suggesting an evidence of bias between

administrations. Large difference in PA scores between the 2 administrations would indicate that at least one of two measurements is not accurate. However, similar to the finding of a Mexican study,[38] scores on the Hausa IPAQ-LF were consistently lower during the second administration of the questionnaire compared to the first administration. Because familiarity with the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that participants in our study might have over-reported their PA levels during the first administration of the Hausa IPAQ-LF. This kind of findings may have implication for the utility of IPAQ for surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA that has been associated with the IPAQ,[39,40] it may be necessary to start considering the need for multiple measurements when using the IPAQ for evaluating PA, especially in developing African countries. However, patterns of PA as measured by the modified IPAQ-LF during both administrations were consistently similar, and both administrations were able to discriminate PA in the expected direction between subgroups of our sample. For example, at both measurement time points, and consistent with hypothesis, men reported more time in active transportation, occupational PA and leisure PA than women, while women reported more time in domestic PA and sedentary activity than men.

In the absence of objective criterion standards for evaluating an absolute estimate of PA, the consistency of items on IPAQ with variables known to be related to PA such as body mass index (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have been used as important construct validity measures.[7,10,21,24] In the present study, the correlations of the PA domains and intensities with biological and anthropometric variables were mostly significant in the expected direction, but they were low suggesting a modest evidence of construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were comparable with the values in other studies that have evaluated the IPAQ-LF.[5,7,8,24,30,33,39] Because better validity coefficients have been reported for other PA measures above that of the IPAQ,[39,41] with the present African finding, it is possible that the IPAQ-LF only have modest evidence of construct validity. However, our findings on the relationships between physical activity and biological and anthropometric variables should be interpreted in the light of an important caution. Because hypertensive and obese people may get oriented to exercise,[3] cross-

sectional associations of physical activity and blood pressure or BMI could also occur in the opposite direction and may not represent much information as indicators of construct validity of physical activity measures.

Strengths and limitations

A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to reflect the common PA behaviours of people in Nigeria. This is the first study in an African country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse segment of the Nigerian population. In the Africa region, the importance of a valid and established PA scale like the modified IPAQ-LF is not only important to monitoring the domain in which activity is performed, but also very critical to understanding studies of ecological models of health behaviours, that emphasize the importance of multiple levels of influence on health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using ecological models indicate that favourable built environmental attributes are promising for improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45] However, built environment characteristics are expected to be strongly related to specific PA types rather than overall PA.[46,47] For example, different environmental variables can be related to walking for leisure or transportation and to moderate PA for household, occupation, recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to understanding the domain specific nature of ecological model research in the African region. One additional strength was the exploration of PA patterns by gender, educational level and employment status, the findings of which were consistent with general hypothesis on social patterns of inactivity in low-income countries.[20,48]

However, the findings of this study should be interpreted in the light of some important limitations. Direct comparison of our validity findings with previous studies should be made with caution, because unlike in our study, the accelerometer or PA diary were utilized as a common objective criterion standard to validate the IPAQ in the majority of the studies.[5,7,8,24,30,33,39] Thus, examining the construct validity through the relationships of

PA with BMI and resting blood pressure was an important limitation of our study. The choice and availability of appropriate criterion measures are particular issues of concern for the validation of PA questionnaires in low-income countries of Africa [5,49,50]. Despite these issues, the validity coefficients in our study were remarkably similar to those reported in other studies, [5,7,8,24,30,33,39] and the consistency of items on IPAQ with variables known to be related to PA such as BMI, blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have previously been used as important construct validity measures.[7,10,21,24] Another limitation of the study is the use of non-probability sampling technique. The study finding may have limited generalizability to other samples of Nigerians that have different characteristics from this sample. In addition, the majority of participants have more than secondary school education with potentially higher comprehension and recall ability than may be found in the general population. Nevertheless, recruitment from diverse neighbourhoods and settings allowed for a sample with reasonable heterogeneity in age, occupational status, and ethnic backgrounds and made it possible to stratify the analyses by sociodemographic characteristics. However, because some of the participants in the present study required assistance to complete the survey, interview administration rather than self-administration of the IPAQ-LF should be encouraged in any future national studies in the African region.

Conclusions

Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could further contribute to our understanding of the impact of multiple levels of influence on PA behaviours of people in the African region.

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Contributors

ALO conceived and designed the study, contributed to cultural adaptation and acquisition of data, conducted the statistical analysis and interpretation of data and drafted the manuscript. UMB and STP managed participants' recruitment and data collection and contributed to cultural adaptation. HBN and RDM contributed to cultural adaptation and translations of the measure. AYO contributed to study design, acquisition of data and critically revised the manuscript for important intellectual contents. All authors read and approved the final manuscript.

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Competing interests

Authors declare there is no competing interest associated with this study.

Ethics approval

Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria (ADM/TH/EC/75).

Data sharing process

Dataset for this study available upon request from the corresponding author.

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Table 1. Descriptive characteristics of the participants (N=180)

Variables	Total sample (N=180)	Men (n=90, 50%)	Women (n=90, 50%)
Age (years)			
Mean (± SD)	35.6 ± 10.3	35.7 ± 8.3	35.5 ± 11.9
Marital status (n, %)*			
Not Married	74(41.1)	48(53.3)	26(28.9)
Married	106(58.9)	42(46.7)	64(71.1)
BMI (Kg/m^2)			
Mean (± SD)	23.8 ± 3.9	23.8 ± 3.5	23.8 ± 4.4
BMI Category (n, %)			
Underweight	14 (7.8)	4 (4.4)	10 (11.1)
Normal weight	107 (59.4)	58 (64.4)	49 (54.4)
Overweight/obese	59 (32.8)	28 (31.2)	31 (34.5)
Ethnicity (n, %)			
Hausa/Fulani	21(11.7)	10.1(11.1)	11(12.2)
Igbo	8(4.4)	5(5.6)	3(3.3)
Yoruba	10(5.6)	6(6.7)	4(4.4)
Kanuri/Shuwa Arab	44(24.4)	23(25.6)	21(23.3)
Others	97(53.9)	46 (51.1)	51(56.7)
Educational level (n, %)*			
> Secondary School	111 (62.7)	11 (12.2)	17(19.5)
Secondary	38 (21.5)	10 (11.1)	28(32.5)
<Secondary School	28 (15.8)	69 (76.7)	42(48.2)
Occupational Status (n, %)*			
Unemployed	63(35)	16(17.8)	47(52.2)
Blue Collar	45(25)	28(31.1)	17(18.9)
White Collar	72(40)	46(51.1)	26(28.9)

*- Significant difference between samples (p<0.05)
BMI- Body Mass Index

Table 2: Test-reliability based on intra-class correlation coefficient for Hausa IPAQ– LF, overall and by gender

PA Measure (MET×min/wk)	Total (N=180) Test 1 (Mean (SD))	Total (N=180) Test 2 (Mean (SD))	Total (N=180) ICC (95%CI)	Women (n=90) ICC (95%Cl)	Men (n=90) ICC (95%Cl)
Total PA, all domain	2160.6 (2691.1)	1612.8 (1612.8)	0.76 (0.65-0.82)	0.45 (0.08-0.67)	0.80 (0.69- 0.87)
Occupation	619.1(1671.5)	497.5 (1332.9)	0.77 (0.68-082)	0.64 (0.46-0.77)	0.78 (0.66 -0.85)
Active Transport	468.1 (684.7)	440.5 (605.7)	0.82 (0.75-0.87)	0.63 (0.40-0.77)	0.83 (0.73 - 0.89)
Domestic	597.6 (754.6)	473.4 (673.7)	0.50 (0.32-0.62)	0.38 (0.01-0.57)	0.33 (-0.01-0.56)
Leisure	377.0 (1096.3)	196.7 (920.2)	0.71 (0.60-0.78)	0.69 (0.53-0.79)	0.75 (0.63-0.84)
Sitting	2263.0 (715.8)	2235.4 (818.9)	0.62 (0.42-0.75)	0.71 (0.46-0.85)	0.48 (0.06-0.72)
PA by Intensity (MET×min/wk)					
Walking	613.6 (635.6)	534.6 (449.1)	0.63 (0.48-0.74)	0.57 (0.29-0.74)	0.65 (0.44-0.78)
Moderate	986.9 (1365.9)	716.1 (1164.6)	0.61 (0.46-0.71)	0.42 (0.11-0.62)	0.67 (0.49-0.78)
Vigorous	526.5 (1543.7)	394.1 (1431.1)	0.82 (0.76-0.87)	0.55 (0.30-0.71)	0.86 (0.78-0.91)

PA= Physical Activity
MET= Metabolic Energy Turnover

Table 3: Socioeconomic status differences in test- retest reliability of the Hausa IPAQ- LF (N= 180)

Socioeconomic Status	Overall PA	Active Transport	Occupation PA	Leisure PA	Domestic PA	Sitting
Educational Qualification						
More than secondary school (n=111)	0.42 (0.08-0.63)	0.67 (0.43-0.78)	0.32 (-0.06-0.57)	0.33 (-0.05-0.57)	0.58 (0.35-0.73)	0.23 (-0.63-0.63)
Secondary School (n=38)	0.55 (0.22-0.74)	0.28 (-0.21-0.57)	0.58 (0.33-0.74)	0.54 (0.25-0.71)	0.50 (0.19-0.69)	0.51 (-0.04-0.76)
Less than Secondary school (n=28)	0.89 (0.67-0.96)	0.90 (0.74-0.96)	0.82 (0.61-0.92)	0.92 (0.83-0.96)	0.90 (0.78-0.95)	0.77 (0.45-0.90)
Employment Category						
Employed (117)	0.80 (0.67-0.96)	0.83 (0.74-0.88)	0.79 (0.70-0.86)	0.79 (0.69-0.85)	0.36 (0.08-0.56)	0.56 (0.23-0.75)
Unemployed (63)	0.09 (-8.86-0.56)	0.68 (0.44-0.82)	0.16 (-0.39-0.49)	0.25 (-0.24-0.55)	0.65 (0.43-0.79)	0.68 (0.36-0.80)

PA= Physical Activity

Table 4: Differences in time spent in physical activity overall, and by gender and socioeconomic status sub groups

		Gender		Education			Employment	
	Total Mean ± SD	**Men** Mean ± SD	**Women** Mean ± SD	**>Secondary** Mean ± SD	**Secondary** Mean ± SD	**<Secondary** Mean ± SD	**Employed** Mean ± SD	**Unemployed** Mean ± SD
PA by domain (min/wk)								
Total PA, all domain								
IPAQ1	405.2 (507.8)	460.7 (582.9)	326.8 (367.8)	334.0 (400.8)	384.8 (514.8)	849.2 (764.1)**	441.1 (530.2)	285.1 (408.6)*
IPAQ2	308.4 (440.3)	319.7 (522.8)	291.9 (282.9)	285.1 (295.1)	184.8 (264.4)	803.0 (929.6)**	359.4 (481.6)	141.0 (185.2)*
Active Transport								
IPAQ1	35.8 (89.7)	52.4 (127.7)	19.5 (17.7)*	28.3 (47.7)	28.9 (45.02)	76.4 (198.7)*	43.8 (109.4)	21.1 (21.9)*
IPAQ2	30.4 (76.7)	41.2 (106.3)	19.3 (17.5)*	23.6 (30.6)	20.3 (30.9)	74.3 (182.6)*	36.9 (94.1)	18.3 (14.7)*
Work								
IPAQ1	160.1 (380.8)	217.5 (466.8)	79.1 (179.9)*	114.8 (291.0)	122.9 (365.6)	546.7 (615.7)**	195.5 (418.8)	41.8 (162.2)*
IPAQ2	135.3 (310.3)	172.5 (372.8)	80.6 (171.9)*	104.1 (232.2)	160.9 (196.1)	531.6 (595.8)**	164.1 (341.7)	40.1 (133.0)*
Domestic								
IPAQ1	159.6 (202.2)	82.3 (120.6)	236.9 (235.8)**	141.2 (182.4)	173.3 (238.5)	165.4 (159.4)	132.1 (170.7)	210.6 (243.8)*
IPAQ2	123.9 (163.9)	52.4 (74.9)	195.5 (190.1)**	131.9 (182.5)	107.6 (130.4)	147.3 (189.1)	112.6 (163.9)	205.0 (163.3)*
Leisure								
IPAQ1	62.4 (159.1)	75.0 (211.1)	10.5 (27.3)**	47.0 (97.3)	92.7 (209.4)	38.2 (160.1)	69.7 (157.6)	48.7 (162.3)
IPAQ2	30.5 (118.2)	50.6 (160.7)	10.1 (38.5)**	23.4 (51.4)	24.7 (91.4)	71.5 (256.5)	43.1 (143.5)	17.0 (28.7)*
Sitting								
IPAQ1	2263.0 (715.8)	2188.8 (759.7)	2330.7 (674.8)	2280.0 (618.7)	2433.9 (693.7)	2180.9 (760.8)	2159.4 (775.9)	2337.6 (667.2)
IPAQ2	2235.4 (819.9)	2208.7 (916.9)	2259.6 (728.1)	2420.7 (638.7)	2215.3 (663.1)	2160.0 (1111.4)	2170.6 (870.5)	2282.0 (785.5)
PA by Intensity (min/wk)								
Walking								
IPAQ1	178.5 (221.5)	241.1 (271.9)	128.2 (100.8)*	194.4 (268.1)	133.4 (85.6)	266.9 (285.4)*	192.0 (245.7)	133.3 (96.2)*
IPAQ2	142.5 (141.8)	148.5 (137.9)	133.7 (147.9)	151.7 (138.4)	103.6(94.7)	200.3 (209.1)*	150.7 (146.6)	115.4 (122.7)
Moderate								
IPAQ1	201.9 (326.9)	193.0 (214.5)	214.5 (247.8)	187.3 (266.5)	194.9 (386.5)	309.7 (381.7)	221.2 (347.4)	137.7 (239.9)
IPAQ2	133.9 (238.5)	114.2 (276.9)	162.7 (165.6)	132.9 (177.8)	88.0 (197.2)	319.0 (482.1)*	153.9 (266.2)	68.0 (76.4)*
Vigorous								
IPAQ1	94.1 (211.8)	123.7 (249.6)	52.2 (133.2)*	32.9 (81.9)	129.5 (208.2)	268.0 (459.7)**	90.2 (214.6)	127.1 (204.6)
IPAQ2	78.4 (206.9)	86.8 (227.4)	46.2 (73.4)	52.2 (140.2)	55.2 (127.0)	292.8 (461.5)**	92.8 (226.9)	130.9 (107.8)

PA= Physical Activity
*=p<0.05
**=p<0.001

Table 5: Construct validity of Hausa IPAQ-LF: Spearman correlations between energy expenditure (MET×min/wk) from Hausa IPAQ– LF, and anthropometric and biological variables (N=180)

	Overall (N = 180)			Female (n = 90)			Male (n = 90)		
MET×min/wk	BMI	DBP	SBP	BMI	DBP	SBP	BMI	DBP	SBP
PA Domains									
Total PA	-0.29**	-0.17*	-0.09	-0.09	-0.23**	-0.04	-0.41**	-0.08	-0.14
Occupation PA	-0.12	-0.09	0.01	0.02	0.02	-0.05	-0.22**	-0.17	-0.08
Active transport PA	-0.05	-0.04	-0.01	-0.10	-0.13	-0.02	-0.04	-0.02	-0.80
Domestic PA	-0.07	-0.17*	-0.26**	-0.23**	-0.20*	-0.31**	0.04	-0.14	-0.04
Leisure PA	0.09	-0.08	-0.16*	-0.11	0.02	0.08	-0.39**	-0.12	-0.06
Sitting	0.16	-0.09	0.04	0.19	0.12	0.05	0.15	-0.09	0.05
PA Intensity									
Walking	0.90	-0.09	-0.03	0.19	-0.05	0.08	-0.05	-0.11	-0.15
Moderate	-0.02	0.21*	0.16*	0.02	-0.14	-0.08	0.02	-0.25**	-0.16
Vigorous	-0.11*	-0.06	0.03	-0.16	0.01	0.02	-0.13*	-0.12	-0.11

MET= Metabolic Energy Turnover
BMI= Body Mass Index
DBP= Diastolic Blood Pressure
SBP= Systolic Blood Pressure
PA= Physical activity
*=p<0.05,
**=p<0.01

Examining the reliability and validity of a modified version of the International Physical Activity Questionnaire, long form (IPAQ-L) in Nigeria: A cross-sectional study

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Key words: Physical activity, measurements, public health, IPAQ, Nigeria

Word counts: 4338

ABSTRACT

Objectives: To investigate the reliability and aspect of validity of a modified version of the long International Physical Activity Questionnaire (Hausa IPAQ-LF) in Nigeria.

Design: Cross-sectional study, examining the reliability and construct validity of the Hausa IPAQ-LF compared with anthropometric and biological variables.

Setting: Metropolitan Maiduguri, the capital city of Borno State in Nigeria.

Participants: 180 Nigerian adults (50% women) with a mean age of 35.6 (SD=10.3) years, purposively selected from neighbourhood with diverse socioeconomic status and walkability.

Outcome measures: Domains (domestic physical activity [PA], occupational PA, leisure-time PA, active transportation and sitting time) and intensities of PA (vigorous, moderate and walking) were measured with the Hausa IPAQ-LF on two different occasions, eight days apart. Outcomes for construct validity were measured BMI, SBP and DBP.

Results: The Hausa IPAQ-LF demonstrated good test-retest reliability (ICC>75) for total PA (ICC=0.79, 95% CI=0.65-0.82), occupational PA (ICC=0.77, 95% CI=0.68-0.82), active transportation (ICC=0.82, 95% CI=0.75-0.87) and vigorous intensity activities (ICC=0.82, 95% CI=0.76-0.87). Reliability was substantially higher for total PA (ICC=0.80), occupational PA (ICC=0.78), leisure-time PA (ICC=0.75) and active transportation (ICC=0.80) in men than women, but domestic PA (ICC=0.38) and sitting time (ICC=0.71) demonstrated substantial reliability coefficients in women than men. For the construct validity, domestic PA was significantly related mainly with SBP (ρ = -0.27) and DBP (ρ = -0.17), and leisure-time PA and total PA were significantly related only with SBP (ρ = -0.16) and BMI ((ρ = -0.29), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$).

Conclusions: The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria.

ARTICLE SUMMARY

Strengths and limitations of this study.

- Systematic adaptation and tailoring of items on the original IPAQ-LF to reflect the common PA behaviours of adults in Nigeria.
- The first study to describe the cultural adaptation and translations of the IPAQ-LF and explore its psychometric relevance in an African country.
- Findings establish evidence to support the feasibility of using a modified IPAQ-LF to reliably collect context specific PA behaviours of adults in the African region.
- Exploring construct validity through the relationships of PA with BMI and resting blood pressure was an important limitation of this study.
- The use of non-probability sampling technique may limit generalizability of findings to other samples of Nigerian adults with different characteristics from the study's sample.

INTRODUCTION

The importance of physical activity (PA) for promoting health and preventing disease is well established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it is important to have standardized, reliable and valid instruments that can be used to accurately describe population levels and patterns of PA within and across countries.[4, 5] In this context, the international physical activity questionnaire (IPAQ) was developed to obtain internationally comparable data on health-related PA of adults (18-65 years).[5, 6] Two versions of the IPAQ that could be administered by interview or self-completed were developed. The short form (SF) was designed for population surveillance of PA; while the long form (LF) was designed to be appropriate for use in research that requires detailed information on different PA domains, including PA at work, household, during leisure and transportation, and time spent in sedentary activities.[6]

The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts have been made to translate and adapt the IPAQ in many other countries, but most of the research in this context were from the Western developed countries.[7-14] In Africa, the psychometric properties of IPAQ have only been tested in South-Africa as part of the initial development process of the questionnaire,[5] and in older adults.[15] Because the largest increases and burden of non-communicable diseases (NCDs) are in the low-income countries where the understanding of evidence-based strategies for increasing PA remains poor,[16-19] improving PA research is a top priority for low-income countries.[20] However, to advance PA research in Africa, it is important to first develop or tailor standardized measures to be culturally sensitive to PA behaviours of people in the region countries. Because Nigeria is the most populous country in Africa with culture and languages similar to most of the other West African countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this country.

Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF in sub-Saharan African countries can impact PA research and surveillance in the African region where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the present study was to investigate the reliability and an aspect of validity of a modified version of the IPAQ-LF among adults in Nigeria.

METHODS

Participants

A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status and walkability in Maiduguri city were recruited for the study. The sampling and neighbourhood selection strategy have been described in details elsewhere.[26] Maiduguri with an estimated population of 749,123 people is the largest and capital city of Borno State in North-Eastern Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and Chad Republic, and Hausa language is the common means of communication for commercial activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this study if they were willing to self-complete a written survey twice in either Hausa or English Language. However, researchers (UMB and STP) were in attendance to provide translation and interpretation assistance to participants (n=11) who were unable to independently complete the survey. Additional eligibility criteria included living within the identified neighbourhood categories in the last 12 months, being adults (18-65 years) and not having any disability that prevented independent walking. All participants were fully informed of the study protocol and provided signed informed consent. The study protocol was approved by the Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were collected between March and May, 2012.

Measures

The adapted international physical activity questionnaire- long Hausa version

The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly, interviews were conducted with public health experts, exercise scientists and not highly educated local people to identify the items and examples of PA on the original questionnaires that needed to be culturally adapted. Several cultural adaptations were made to the original items to reflect the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with words that are more representative of the language used in Nigeria, like 'very hard' and 'hard' respectively. Second, examples of various intensities of activity that were common in the Nigerian culture were added, and those already on the questionnaire but not common in the Nigerian context were replaced with culturally applicable examples that are equivalent in energy intensity (METs) with the original items and examples. Third, concepts like physical activity and walking for transportation that were misconstrued outside the health context were refined to indicate they were referring to health behaviours.

After adaptation, the questionnaire was independently translated from English into Hausa language by two native speakers of Hausa who also speaks English, and able to read and write in both languages. One of the translators was familiar with the questionnaire and the second was an expert in Hausa language. The translated questionnaires were mutually revised by the translators and the research team for consistency and then back translated into English language by a third bilingual person who was familiar with the construct measured by IPAQ. The back translated version was checked by the research team for any discrepancies and to ensure that the construct measures by IPAQ had not been lost during the adaptation and translation process.

The modified questionnaire (available in both Hausa and English language), hereafter referred to as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF), contains thirty-one questions that asked about physical activity done in the last 7-days in terms of frequency (days/week) and duration (minutes/day) spent in four activity domains (transportation,

occupation, domestic and leisure time), and included sections on walking, moderate- and vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and motorized transportation). The Hausa IPAQ-LF data were presented as the MET-minute/week for total walking, moderate, and vigorous intensity activity and overall physical activity across the four domains, and in each of the domains. The MET intensity values used to score the Hausa IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest reliability of the Hausa IPAQ-LF, participants self-completed all items on the measure twice, with an interval of one week between administrations.

Anthropometrical and biological measurements

Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO were used to create the categories: underweight (< 18.5 kg/m^2), normal weight (18.5– < 25 kg/m^2), overweight (25– <30kg/m^2) and obese (≥30 kg/m^2).[29] Resting blood pressure and heart rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study, construct validity was evaluated by investigating the relationship of outcomes from the Hausa IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also in part by comparing the differences in time spent in PA and sitting across sociodemograpic subgroups. These types of validation for PA measures have been referred as indirect or construct validity in previous studies.[7,24,30]

Sociodemographic Characteristics

Information on age, gender, marital status, religion, income, educational level and employment status were elicited from the participants. Marital status was classified as married or not married. Educational level was classified as more than secondary school education, secondary school

education and less than secondary school education. Employment status was classified into white collar (government or private employed), blue collar (self- employed, trader, artisan etc) and unemployed (homemaker, student, retired, or unable to find job).

Data Analysis

Descriptive data were reported as mean, standard deviation and percentages. Mean group differences for continuous variables by gender were examined by independent t-test, and for dichotomous variables by chi-square statistics. The reliability analyses were performed using 2 strategies. First, the two- way mixed model (single measure) intraclass correlation coefficient (ICC) with 95% confidence interval (CI) between the continuous scores obtained on 1st and 2nd administration of the Hausa IPAQ-LF was calculated. The ICCs were calculated overall, and by gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] Second, the Bland and Altman Method was used to assess agreement on scores of PA from the 1st and 2nd administrations.[32] Variables used for the Bland and Altman analysis were weekly time spent in moderate-to-vigorous activity (MVPA), total PA and sitting. MVPA was computed by summing the total minutes/week of reported physical activity of moderate and vigorous- intensities across all four domains. For total PA, the total minutes/week of activities in each domain were summed (total work + total transport + total domestic + total leisure-time min/week scores) to gain an overall estimate of physical activity in a week. Also, the independent t-test and one-Way ANOVA were used as appropriate to compare the time spent (minutes/week) in PA at both administrations across sociodemographic subgroups. To assess construct validity, the non-parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body mass index. Data were analyzed using Statistical Package for the Social Science (SPSS), version 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at $p<0.05$.

RESULTS

The socio-demographic characteristic of the participants are shown in Table 1. The participants comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of 23.8 ± 3.9kg/m^2. Majority of the participants were married (58.9%, n=106), had more than secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to men, the women were more likely to be married (71.1% vs 46.7%, p=0.001) and unemployed (52.2% vs 17.8%, p<0.001), but men were more likely to have more than secondary school education (76.7% vs 48.2%, p<0.001).

Reliability

Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients were good (ICC >75) for total PA, occupational PA, active transportation and vigorous intensity (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95% CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38, 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous intensity (very hard) activities were substantially greater in men than women.

Similarly, socioeconomic status differences were observed in the reliability coefficients of the modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were substantially higher among participants with less than secondary school education (ICC from 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and those with higher than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]). While reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and

leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95% CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were unemployed than in the employed subgroup.

Figures 1, 2 and 3 (Bland-Altman plots) illustrate the agreement in the scores (minutes/week) of total PA, MVPA and sitting between the first and second administrations of Hausa IPAQ-LF. For total PA, the mean difference was 106.7 minutes/week, with a wide 95% limits of agreement (-762.2 to 965.6 minutes/week). For MVPA, the mean difference was about one and half hour per week (91.6 minutes/week), and also demonstrating a wide 95% limits of agreement (-744.5 to 927.7 minutes/week). For sitting time, the mean difference was small (26 minutes/week) and the 95% limits of agreement range from -2178.1 to 2230.9 minutes/week.

Table 4 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1) and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified variables, time spent in PA reported during the first administration tends to be higher than those reported during the second administration. At both time points, men reported significantly ($p<0.05$) higher mean time (minute/week) in active transportation, occupational PA, and leisure-time PA than women. However, women spent significantly ($p<0.001$) more time (minutes/week) in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status, participants that had lower than secondary school education compared to those with at least secondary school education reported statistically significant higher mean time (minutes/week) at both time points for total PA, active transport, occupational PA, walking and vigorous intensity activity compared to those with at least secondary school education. While participants that were employed reported statistically significant ($p<0.05$) more time (minutes/week) in total PA (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1, IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.

Construct Validity

Overall, correlations between energy expenditure (MET-Minutes/week) according to the modified IPAQ-LF and anthropometric and biological measures were statistically significant in the expected direction for all domains and intensities of PA, except for occupation and active transport domains and walking (table 5). In the full sample, domestic PA was mainly related with SBP (ρ = -0.27, $p< 0.01$) and DBP (ρ = -0.17, $p< 0.05$), while leisure PA and total PA were only related with SBP (ρ = -0.16, $p< 0.05$) and BMI (ρ = -0.29, $p< 0.01$), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$). In the gender based analyses, total PA, domestic PA and sedentary time were more consistently related with anthropometric and biological variables. The strongest rho value (-0.41) was found for the relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was reached between total PA and DBP for the women subgroup. Only in women was domestic PA significantly related with BMI (ρ = -0.23), DBP (ρ = -0.20) and SBP (ρ = -0.31). Leisure-time PA (ρ = -0.39) and occupational PA (ρ = -0.22) were significantly related with BMI only in men. The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ = 0.19) than men (ρ = 0.15).

DISCUSSION

This study examined the reliability and an aspect of validity of a modified version of the IPAQ-LF in Nigeria. The findings generally indicated acceptable test-retest reliability and modest construct validity for items of the modified IPAQ-LF among Nigerian adults. To the best of our knowledge, the present study is the only one to examine the reliability and validity of the long version of IPAQ that has been modified specifically to an indigenous African culture and language.

We found evidence for good reliability with high correlations between the test-retest for total PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that except for domestic PA and sitting time, ICC values for domains of PA were consistently above 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[33,34]

Similar to a previous IPAQ-LF study in Hong Kong,[34] domestic activity demonstrated the lowest ICC value in our study. However, it is possible that the infrequent nature of household activities undertaken, especially by men may account for the low reliability reported for domestic PA in our study. In addition to the traditional African patriarchal belief that make most African men to rarely engage in indoor household activities, men in the high socioeconomic group in Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home, appliances and equipment maintenance because they are able to employ the services of domestic helpers and repair men. Our findings of lower reliability for domestic activity among men, those with more than secondary school education and those who were employed compared to their counterparts seem to support this assumption.

The highest and strongest reliability coefficients (0.82) were found for both active transportation and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and reproducible overtime than other PA domains because it is a common and ubiquitous PA behaviour in the African region. Mostly, the performance of active transportation especially walking is often out of necessity rather than choice within the African context. Our finding of higher ICC value for vigorous intensity PA is consistent with those of other studies that found the reliability of vigorous intensity activity to be higher compared to that of moderate intensity activity.[10,30,34,35] Compared to structured vigorous physical activities like sports and exercise that can be more easily recalled, moderate intensity PA are often of low salience, incidental and may not easily be remembered by people.[36,37] Further our finding that the reliability of vigorous intensity physical activity was meaningfully higher among men than women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria are more consistent than women when responding to PA items that pertained to intense vigorous PA than other intensities of activity. Overall, the moderate to good evidence of reliability found for all items indicates that the modified IPAQ-LF is reproducible, internally consistent and is promising for research in Nigeria.

Except for sitting time, the limits of agreement in the mean scores of total PA and MVPA between the first and second administrations were wide, suggesting an evidence of bias between

administrations. Large difference in PA scores between the 2 administrations would indicate that at least one of two measurements is not accurate. However, similar to the finding of a Mexican study,[38] scores on the Hausa IPAQ-LF were consistently lower during the second administration of the questionnaire compared to the first administration. Because familiarity with the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that participants in our study might have over-reported their PA levels during the first administration of the Hausa IPAQ-LF. This kind of findings may have implication for the utility of IPAQ for surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA that has been associated with the IPAQ,[39,40] it may be necessary to start considering the need for multiple measurements when using the IPAQ for evaluating PA, especially in developing African countries. However, patterns of PA as measured by the modified IPAQ-LF during both administrations were consistently similar, and both administrations were able to discriminate PA in the expected direction between subgroups of our sample. For example, at both measurement time points, and consistent with hypothesis, men reported more time in active transportation, occupational PA and leisure PA than women, while women reported more time in domestic PA and sedentary activity than men.

In the absence of objective criterion standards for evaluating an absolute estimate of PA, the consistency of items on IPAQ with variables known to be related to PA such as body mass index (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have been used as important construct validity measures.[7,10,21,24] In the present study, the correlations of the PA domains and intensities with biological and anthropometric variables were mostly significant in the expected direction, but they were low suggesting a modest evidence of construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were comparable with the values in other studies that have evaluated the IPAQ-LF.[5,7,8,24,30,33,39] Because better validity coefficients have been reported for other PA measures above that of the IPAQ,[39,41] with the present African finding, it is possible that the IPAQ-LF only have modest evidence of construct validity. However, our findings on the relationships between physical activity and biological and anthropometric variables should be interpreted in the light of an important caution. Because hypertensive and obese people may get oriented to exercise,[3] cross-

sectional associations of physical activity and blood pressure or BMI could also occur in the opposite direction and may not represent much information as indicators of construct validity of physical activity measures.

Strengths and limitations

A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to reflect the common PA behaviours of people in Nigeria. This is the first study in an African country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse segment of the Nigerian population. In the Africa region, the importance of a valid and established PA scale like the modified IPAQ-LF is not only important to monitoring the domain in which activity is performed, but also very critical to understanding studies of ecological models of health behaviours, that emphasize the importance of multiple levels of influence on health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using ecological models indicate that favourable built environmental attributes are promising for improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45] However, built environment characteristics are expected to be strongly related to specific PA types rather than overall PA.[46,47] For example, different environmental variables can be related to walking for leisure or transportation and to moderate PA for household, occupation, recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to understanding the domain specific nature of ecological model research in the African region. One additional strength was the exploration of PA patterns by gender, educational level and employment status, the findings of which were consistent with general hypothesis on social patterns of inactivity in low-income countries.[20,48]

However, the findings of this study should be interpreted in the light of some important limitations. Direct comparison of our validity findings with previous studies should be made with caution, because unlike in our study, the accelerometer or PA diary were utilized as a common objective criterion standard to validate the IPAQ in the majority of the studies.[5,7,8,24,30,33,39] Thus, examining the construct validity through the relationships of

PA with BMI and resting blood pressure was an important limitation of our study. The choice and availability of appropriate criterion measures are particular issues of concern for the validation of PA questionnaires in low-income countries of Africa [5,49,50]. Despite these issues, the validity coefficients in our study were remarkably similar to those reported in other studies, [5,7,8,24,30,33,39] and the consistency of items on IPAQ with variables known to be related to PA such as BMI, blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have previously been used as important construct validity measures.[7,10,21,24] Another limitation of the study is the use of non-probability sampling technique. The study finding may have limited generalizability to other samples of Nigerians that have different characteristics from this sample. In addition, the majority of participants have more than secondary school education with potentially higher comprehension and recall ability than may be found in the general population. Nevertheless, recruitment from diverse neighbourhoods and settings allowed for a sample with reasonable heterogeneity in age, occupational status, and ethnic backgrounds and made it possible to stratify the analyses by sociodemographic characteristics. However, because some of the participants in the present study required assistance to complete the survey, interview administration rather than self-administration of the IPAQ-LF should be encouraged in any future national studies in the African region.

Conclusions

Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could further contribute to our understanding of the impact of multiple levels of influence on PA behaviours of people in the African region.

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Contributors

ALO conceived and designed the study, contributed to cultural adaptation and acquisition of data, conducted the statistical analysis and interpretation of data and drafted the manuscript. UMB and STP managed participants' recruitment and data collection and contributed to cultural adaptation. HBN and RDM contributed to cultural adaptation and translations of the measure. AYO contributed to study design, acquisition of data and critically revised the manuscript for important intellectual contents. All authors read and approved the final manuscript.

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Competing interests

Authors declare there is no competing interest associated with this study.

Ethics approval

Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria (ADM/TH/EC/75).

Data sharing process

Dataset for this study available upon request from the corresponding author.

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Table 1. Descriptive characteristics of the participants (N=180)

Variables	Total sample (N=180)	Men (n=90, 50%)	Women (n=90, 50%)
Age (years)			
Mean (± SD)	35.6 ± 10.3	35.7 ± 8.3	35.5 ± 11.9
Marital status (n, %)*			
Not Married	74(41.1)	48(53.3)	26(28.9)
Married	106(58.9)	42(46.7)	64(71.1)
BMI (Kg/m^2)			
Mean (± SD)	23.8 ± 3.9	23.8 ± 3.5	23.8 ± 4.4
BMI Category (n, %)			
Underweight	14 (7.8)	4 (4.4)	10 (11.1)
Normal weight	107 (59.4)	58 (64.4)	49 (54.4)
Overweight/obese	59 (32.8)	28 (31.2)	31 (34.5)
Ethnicity (n, %)			
Hausa/Fulani	21(11.7)	10.1(11.1)	11(12.2)
Igbo	8(4.4)	5(5.6)	3(3.3)
Yoruba	10(5.6)	6(6.7)	4(4.4)
Kanuri/Shuwa Arab	44(24.4)	23(25.6)	21(23.3)
Others	97(53.9)	46 (51.1)	51(56.7)
Educational level (n, %)*			
> Secondary School	111 (62.7)	11 (12.2)	17(19.5)
Secondary	38 (21.5)	10 (11.1)	28(32.5)
<Secondary School	28 (15.8)	69 (76.7)	42(48.2)
Occupational Status (n, %)*			
Unemployed	63(35)	16(17.8)	47(52.2)
Blue Collar	45(25)	28(31.1)	17(18.9)
White Collar	72(40)	46(51.1)	26(28.9)

*- Significant difference between samples (p<0.05)
BMI- Body Mass Index

Table 2: Test-reliability based on intra-class correlation coefficient for Hausa IPAQ– LF, overall and by gender

	Total (N=180)			Women (n=90)	Men (n=90)
PA Measure (MET×min/wk)	**Test 1 (Mean (SD))**	**Test 2 (Mean (SD))**	**ICC (95%CI)**	**ICC (95%Cl)**	**ICC (95%Cl)**
Total PA, all domain	2160.6 (2691.1)	1612.8 (1612.8)	0.76 (0.65-0.82)	0.45 (0.08-0.67)	0.80 (0.69- 0.87)
Occupation	619.1(1671.5)	497.5 (1332.9)	0.77 (0.68-082)	0.64 (0.46-0.77)	0.78 (0.66 -0.85)
Active Transport	468.1 (684.7)	440.5 (605.7)	0.82 (0.75-0.87)	0.63 (0.40-0.77)	0.83 (0.73 - 0.89)
Domestic	597.6 (754.6)	473.4 (673.7)	0.50 (0.32-0.62)	0.38 (0.01-0.57)	0.33 (-0.01-0.56)
Leisure	377.0 (1096.3)	196.7 (920.2)	0.71 (0.60-0.78)	0.69 (0.53-0.79)	0.75 (0.63-0.84)
Sitting	2263.0 (715.8)	2235.4 (818.9)	0.62 (0.42-0.75)	0.71 (0.46-0.85)	0.48 (0.06-0.72)
PA by Intensity (MET×min/wk)					
Walking	613.6 (635.6)	534.6 (449.1)	0.63 (0.48-0.74)	0.57 (0.29-0.74)	0.65 (0.44-0.78)
Moderate	986.9 (1365.9)	716.1 (1164.6)	0.61 (0.46-0.71)	0.42 (0.11-0.62)	0.67 (0.49-0.78)
Vigorous	526.5 (1543.7)	394.1 (1431.1)	0.82 (0.76-0.87)	0.55 (0.30-0.71)	0.86 (0.78-0.91)

PA= Physical Activity
MET= Metabolic Energy Turnover

Table 3: Socioeconomic status differences in test- retest reliability of the Hausa IPAQ- LF (N= 180)

Socioeconomic Status	Overall PA	Active Transport	Occupation PA	Leisure PA	Domestic PA	Sitting
Educational Qualification						
More than secondary school (n=111)	0.42 (0.08-0.63)	0.67 (0.43-0.78)	0.32 (-0.06-0.57)	0.33 (-0.05-0.57)	0.58 (0.35-0.73)	0.23 (-0.63-0.63)
Secondary School (n=38)	0.55 (0.22-0.74)	0.28 (-0.21-0.57)	0.58 (0.33-0.74)	0.54 (0.25-0.71)	0.50 (0.19-0.69)	0.51 (-0.04-0.76)
Less than Secondary school (n=28)	0.89 (0.67-0.96)	0.90 (0.74-0.96)	0.82 (0.61-0.92)	0.92 (0.83-0.96)	0.90 (0.78-0.95)	0.77 (0.45-0.90)
Employment Category						
Employed (117)	0.80 (0.67-0.96)	0.83 (0.74-0.88)	0.79 (0.70-0.86)	0.79 (0.69-0.85)	0.36 (0.08-0.56)	0.56 (0.23-0.75)
Unemployed (63)	0.09 (-8.86-0.56)	0.68 (0.44-0.82)	0.16 (-0.39-0.49)	0.25 (-0.24-0.55)	0.65 (0.43-0.79)	0.68 (0.36-0.80)

PA= Physical Activity

Table 4: Differences in time spent in physical activity overall, and by gender and socioeconomic status sub groups

		Gender		Education			Employment	
	Total Mean ± SD	**Men** Mean ± SD	**Women** Mean ± SD	**>Secondary** Mean ± SD	**Secondary** Mean ± SD	**<Secondary** Mean ± SD	**Employed** Mean ± SD	**Unemployed** Mean ± SD
PA by domain (min/wk)								
Total PA, all domain								
IPAQ1	405.2 (507.8)	460.7 (582.9)	326.8 (367.8)	334.0 (400.8)	384.8 (514.8)	849.2 (764.1)**	441.1 (530.2)	285.1 (408.6)*
IPAQ2	308.4 (440.3)	319.7 (522.8)	291.9 (282.9)	285.1 (295.1)	184.8 (264.4)	803.0 (929.6)**	359.4 (481.6)	141.0 (185.2)*
Active Transport								
IPAQ1	35.8 (89.7)	52.4 (127.7)	19.5 (17.7)*	28.3 (47.7)	28.9 (45.02)	76.4 (198.7)*	43.8 (109.4)	21.1 (21.9)*
IPAQ2	30.4 (76.7)	41.2 (106.3)	19.3 (17.5)*	23.6 (30.6)	20.3 (30.9)	74.3 (182.6)*	36.9 (94.1)	18.3 (14.7)*
Work								
IPAQ1	160.1 (380.8)	217.5 (466.8)	79.1 (179.9)*	114.8 (291.0)	122.9 (365.6)	546.7 (615.7)**	195.5 (418.8)	41.8 (162.2)*
IPAQ2	135.3 (310.3)	172.5 (372.8)	80.6 (171.9)*	104.1 (232.2)	160.9 (196.1)	531.6 (595.8)**	164.1 (341.7)	40.1 (133.0)*
Domestic								
IPAQ1	159.6 (202.2)	82.3 (120.6)	236.9 (235.8)**	141.2 (182.4)	173.3 (238.5)	165.4 (159.4)	132.1 (170.7)	210.6 (243.8)*
IPAQ2	123.9 (163.9)	52.4 (74.9)	195.5 (190.1)**	131.9 (182.5)	107.6 (130.4)	147.3 (189.1)	112.6 (163.9)	205.0 (163.3)*
Leisure								
IPAQ1	62.4 (159.1)	75.0 (211.1)	10.5 (27.3)**	47.0 (97.3)	92.7 (209.4)	38.2 (160.1)	69.7 (157.6)	48.7 (162.3)
IPAQ2	30.5 (118.2)	50.6 (160.7)	10.1 (38.5)**	23.4 (51.4)	24.7 (91.4)	71.5 (256.5)	43.1 (143.5)	17.0 (28.7)*
Sitting								
IPAQ1	2263.0 (715.8)	2188.8 (759.7)	2330.7 (674.8)	2280.0 (618.7)	2433.9 (693.7)	2180.9 (760.8)	2159.4 (775.9)	2337.6 (667.2)
IPAQ2	2235.4 (819.9)	2208.7 (916.9)	2259.6 (728.1)	2420.7 (638.7)	2215.3 (663.1)	2160.0 (1111.4)	2170.6 (870.5)	2282.0 (785.5)
PA by Intensity (min/wk)								
Walking								
IPAQ1	178.5 (221.5)	241.1 (271.9)	128.2 (100.8)*	194.4 (268.1)	133.4 (85.6)	266.9 (285.4)*	192.0 (245.7)	133.3 (96.2)*
IPAQ2	142.5 (141.8)	148.5 (137.9)	133.7 (147.9)	151.7 (138.4)	103.6(94.7)	200.3 (209.1)*	150.7 (146.6)	115.4 (122.7)
Moderate								
IPAQ1	201.9 (326.9)	193.0 (214.5)	214.5 (247.8)	187.3 (266.5)	194.9 (386.5)	309.7 (381.7)	221.2 (347.4)	137.7 (239.9)
IPAQ2	133.9 (238.5)	114.2 (276.9)	162.7 (165.6)	132.9 (177.8)	88.0 (197.2)	319.0 (482.1)*	153.9 (266.2)	68.0 (76.4)*
Vigorous								
IPAQ1	94.1 (211.8)	123.7 (249.6)	52.2 (133.2)*	32.9 (81.9)	129.5 (208.2)	268.0 (459.7)**	90.2 (214.6)	127.1 (204.6)
IPAQ2	78.4 (206.9)	86.8 (227.4)	46.2 (73.4)	52.2 (140.2)	55.2 (127.0)	292.8 (461.5)**	92.8 (226.9)	130.9 (107.8)

PA= Physical Activity
*=p<0.05
**=p<0.001

Table 5: Construct validity of Hausa IPAQ-LF: Spearman correlations between energy expenditure (MET×min/wk) from Hausa IPAQ– LF, and anthropometric and biological variables (N=180)

	Overall (N = 180)			Female (n = 90)			Male (n = 90)		
MET×min/wk	BMI	DBP	SBP	BMI	DBP	SBP	BMI	DBP	SBP
PA Domains									
Total PA	-0.29**	-0.17*	-0.09	-0.09	-0.23**	-0.04	-0.41**	-0.08	-0.14
Occupation PA	-0.12	-0.09	0.01	0.02	0.02	-0.05	-0.22**	-0.17	-0.08
Active transport PA	-0.05	-0.04	-0.01	-0.10	-0.13	-0.02	-0.04	-0.02	-0.80
Domestic PA	-0.07	-0.17*	-0.26**	-0.23**	-0.20*	-0.31**	0.04	-0.14	-0.04
Leisure PA	0.09	-0.08	-0.16*	-0.11	0.02	0.08	-0.39**	-0.12	-0.06
Sitting	0.16	-0.09	0.04	0.19	0.12	0.05	0.15	-0.09	0.05
PA Intensity									
Walking	0.90	-0.09	-0.03	0.19	-0.05	0.08	-0.05	-0.11	-0.15
Moderate	-0.02	0.21*	0.16*	0.02	-0.14	-0.08	0.02	-0.25**	-0.16
Vigorous	-0.11*	-0.06	0.03	-0.16	0.01	0.02	-0.13*	-0.12	-0.11

MET= Metabolic Energy Turnover
BMI= Body Mass Index
DBP= Diastolic Blood Pressure
SBP= Systolic Blood Pressure
PA= Physical activity
*=p<0.05,
**=p<0.01

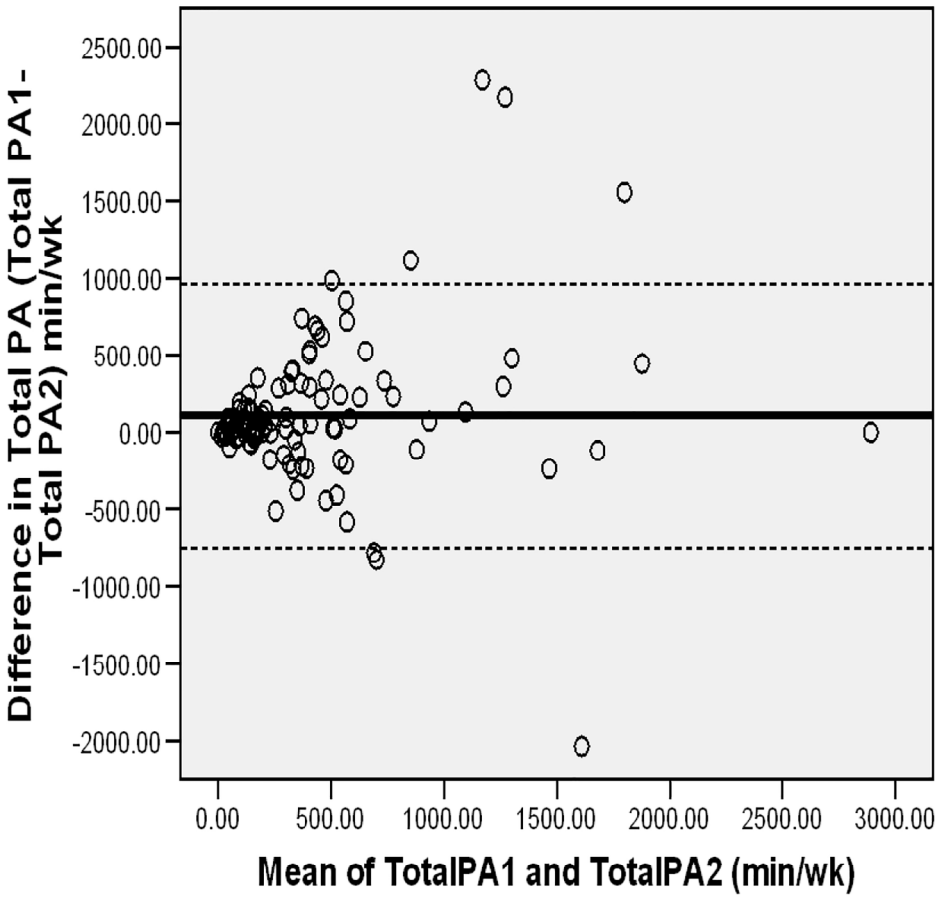

Figure 1: Bland-Altman plot min/wk reported in total physical activity (PA for the first and second administrations of Hausa IPAQ-LF. Mean difference:106.7 +/- 2SD (Standard deviation)= -762.2 to 965.6

238x265mm (300 x 300 DPI)

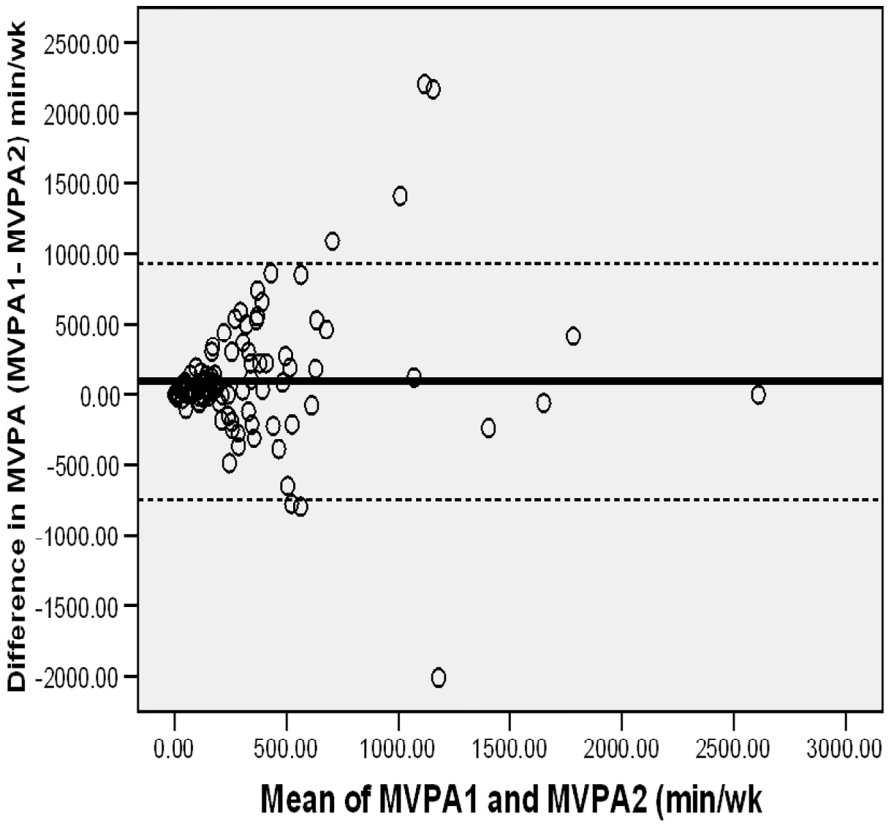

Figure 2: Bland-Altman plot for min/wk reported in moderate-to-vigorous physical activity (MVPA) for the first and second administrations of Hausa IPAQ-LF: Mean difference: 91.6 +/- 2SD (Standard Deviation)=-744.5 to 927

239x287mm (300 x 300 DPI)

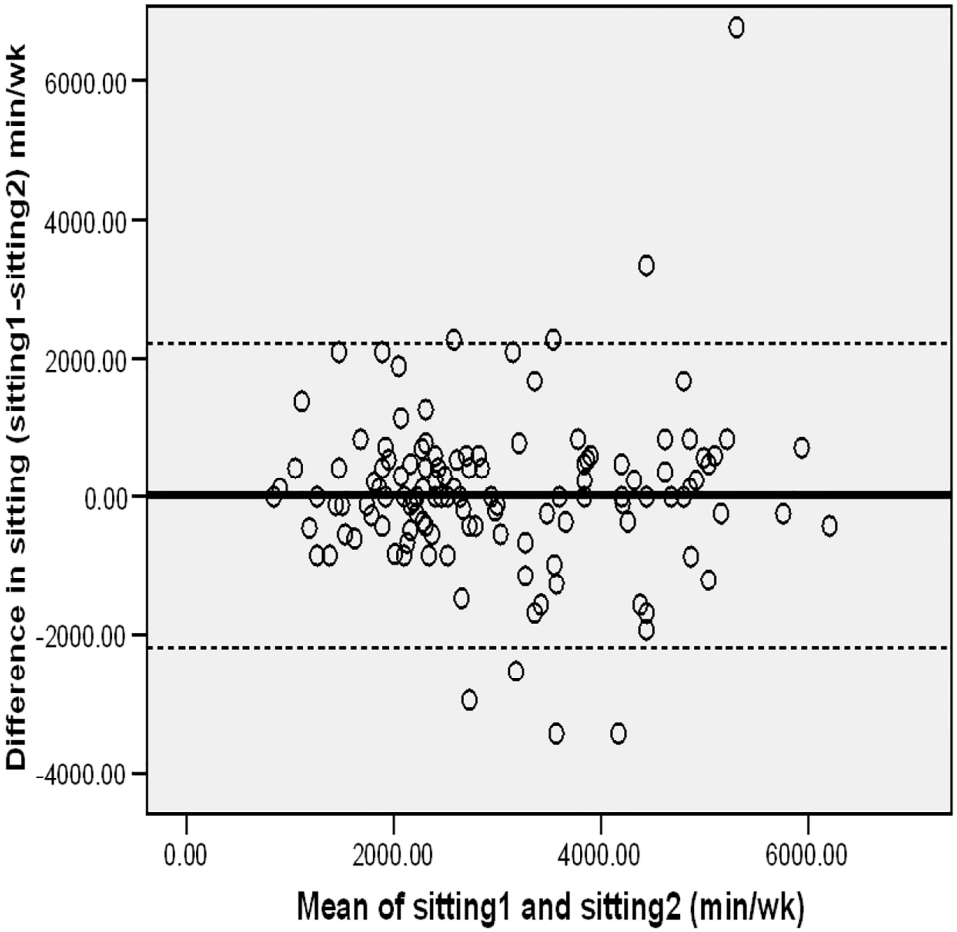

Figure 3: Bland-Altman plot min/wk reported in sitting for the first and second administration of Hausa IPAQ-LF. Mean difference: 26.4 =+/- 2SD (Standard Deviation)= -2178.1 to 2230.9

236x259mm (300 x 300 DPI)

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Examining the reliability and validity of a modified version of the International Physical Activity Questionnaire, long form (IPAQ-L) in Nigeria: A cross-sectional study

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Examining the reliability and validity of a modified version of the International Physical Activity Questionnaire, long form (IPAQ-L) in Nigeria: A cross-sectional study

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Key words: Physical activity, measurement, public health, IPAQ, Nigeria

Word counts: 4352

ABSTRACT

Objectives: To investigate the reliability and aspect of validity of a modified version of the long International Physical Activity Questionnaire (Hausa IPAQ-LF) in Nigeria.

Design: Cross-sectional study, examining the reliability and construct validity of the Hausa IPAQ-LF compared with anthropometric and biological variables.

Setting: Metropolitan Maiduguri, the capital city of Borno State in Nigeria.

Participants: 180 Nigerian adults (50% women) with a mean age of 35.6 (SD=10.3) years, recruited from neighbourhood with diverse socioeconomic status and walkability.

Outcome measures: Domains (domestic physical activity [PA], occupational PA, leisure-time PA, active transportation and sitting time) and intensities of PA (vigorous, moderate and walking) were measured with the Hausa IPAQ-LF on two different occasions, eight days apart. Outcomes for construct validity were measured BMI, SBP and DBP.

Results: The Hausa IPAQ-LF demonstrated good test-retest reliability (ICC>75) for total PA (ICC=0.79, 95% CI=0.65-0.82), occupational PA (ICC=0.77, 95% CI=0.68-0.82), active transportation (ICC=0.82, 95% CI=0.75-0.87) and vigorous intensity activities (ICC=0.82, 95% CI=0.76-0.87). Reliability was substantially higher for total PA (ICC=0.80), occupational PA (ICC=0.78), leisure-time PA (ICC=0.75) and active transportation (ICC=0.80) in men than women, but domestic PA (ICC=0.38) and sitting time (ICC=0.71) demonstrated substantial reliability coefficients in women than men. For the construct validity, domestic PA was significantly related mainly with SBP (ρ = -0.27) and DBP (ρ = -0.17), and leisure-time PA and total PA were significantly related only with SBP (ρ = -0.16) and BMI ((ρ = -0.29), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$).

Conclusions: The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria.

ARTICLE SUMMARY

Strengths and limitations of this study.

- Systematic adaptation and tailoring of items on the original IPAQ-LF to reflect the common PA behaviours of adults in Nigeria.
- The first study to describe the cultural adaptation and translations of the IPAQ-LF and explore its psychometric relevance in an African country.
- Findings establish evidence to support the feasibility of using a modified IPAQ-LF to reliably collect context specific PA behaviours of adults in the African region.
- Exploring construct validity through the relationships of PA with BMI and resting blood pressure was an important limitation of this study.
- The use of non-probability sampling technique may limit generalizability of findings to other samples of Nigerian adults with different characteristics from the study's sample.

INTRODUCTION

The importance of physical activity (PA) for promoting health and preventing disease is well established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it is important to have standardized, reliable and valid instruments that can be used to accurately describe population levels and patterns of PA within and across countries.[4, 5] In this context, the international physical activity questionnaire (IPAQ) was developed to obtain internationally comparable data on health-related PA of adults (18-65 years).[5, 6] Two versions of the IPAQ that could be administered by interview or self-completed were developed. The short form (SF) was designed for population surveillance of PA; while the long form (LF) was designed to be appropriate for use in research that requires detailed information on different PA domains, including PA at work, household, during leisure and transportation, and time spent in sedentary activities.[6]

The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts have been made to translate and adapt the IPAQ in many other countries, but most of the research in this context were from the Western developed countries.[7-14] In Africa, the psychometric properties of IPAQ have only been tested in South-Africa as part of the initial development process of the questionnaire,[5] and in older adults.[15] Because the largest increases and burden of non-communicable diseases (NCDs) are in the low-income countries where the understanding of evidence-based strategies for increasing PA remains poor,[16-19] improving PA research is a top priority for low-income countries.[20] However, to advance PA research in Africa, it is important to first develop or tailor standardized measures to be culturally sensitive to PA behaviours of people in the region countries. Because Nigeria is the most populous country in Africa with culture and languages similar to most of the other West African countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this country.

Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF in sub-Saharan African countries can impact PA research and surveillance in the African region where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the present study was to investigate the reliability and an aspect of validity of a modified version of the IPAQ-LF among adults in Nigeria.

METHODS

Participants

A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status and walkability in Maiduguri city were recruited for the study. The sampling and neighbourhood selection strategy have been described in details elsewhere.[26] Maiduguri with an estimated population of 749,123 people is the largest and capital city of Borno State in North-Eastern Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and Chad Republic, and Hausa language is the common means of communication for commercial activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this study if they were willing to self-complete a written survey twice in either Hausa or English Language. However, researchers (UMB and STP) were in attendance to provide translation and interpretation assistance to participants (n=11) who required help to complete the survey. Additional eligibility criteria included living within the identified neighbourhood categories in the last 12 months, being adults (18-65 years) and not having any disability that prevented independent walking. All participants were fully informed of the study protocol and provided signed informed consent. The study protocol was approved by the Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were collected between March and May, 2012.

Measures

The adapted international physical activity questionnaire- long Hausa version

The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly, interviews were conducted with public health experts, exercise scientists and not highly educated local people to identify the items and examples of PA on the original questionnaires that needed to be culturally adapted. Several cultural adaptations were made to the original items to reflect the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with words that are more representative of the language used in Nigeria, like 'very hard' and 'hard' respectively. Second, examples of various intensities of activity that were common in the Nigerian culture were added, and those already on the questionnaire but not common in the Nigerian context were replaced with culturally applicable examples that are equivalent in energy intensity (METs) with the original items and examples. Third, concepts like physical activity and walking for transportation that were misconstrued outside the health context were refined to indicate they were referring to health behaviours.

After adaptation, the questionnaire was independently translated from English into Hausa language by two native speakers of Hausa who also speaks English, and able to read and write in both languages. One of the translators was familiar with the questionnaire and the second was an expert in Hausa language. The translated questionnaires were mutually revised by the translators and the research team for consistency and then back translated into English language by a third bilingual person who was familiar with the construct measured by IPAQ. The back translated version was checked by the research team for any discrepancies and to ensure that the construct measures by IPAQ had not been lost during the adaptation and translation process.

The modified questionnaire (available in both Hausa and English language), hereafter referred to as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF), contains thirty-one questions that asked about physical activity done in the last 7-days in terms of frequency (days/week) and duration (minutes/day) spent in four activity domains (transportation,

occupation, domestic and leisure time), and included sections on walking, moderate- and vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and motorized transportation). The Hausa IPAQ-LF data were presented as the MET-minute/week for total walking, moderate, and vigorous intensity activity and overall physical activity across the four domains, and in each of the domains. The MET intensity values used to score the Hausa IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest reliability of the Hausa IPAQ-LF, participants self-completed all items on the measure twice, with an interval of one week between administrations.

Anthropometrical and biological measurements

Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO were used to create the categories: underweight (< 18.5 kg/m^2), normal weight (18.5– < 25 kg/m^2), overweight (25– <30kg/m^2) and obese (≥30 kg/m^2).[29] Resting blood pressure and heart rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study, construct validity was evaluated by investigating the relationship of outcomes from the Hausa IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also in part by comparing the differences in time spent in PA and sitting across sociodemograpic subgroups. These types of validation for PA measures have been referred as indirect or construct validity in previous studies.[7,24,30]

Sociodemographic Characteristics

Information on age, gender, marital status, religion, income, educational level and employment status were elicited from the participants. Marital status was classified as married or not married. Educational level was classified as more than secondary school education, secondary school

education and less than secondary school education. Employment status was classified into white collar (government or private employed), blue collar (self- employed, trader, artisan etc) and unemployed (homemaker, student, retired, or unable to find job).

Data Analysis

Descriptive data were reported as mean, standard deviation and percentages. Mean group differences for continuous variables by gender were examined by independent t-test, and for dichotomous variables by chi-square statistics. The reliability analyses were performed using 2 strategies. First, the two- way mixed model (single measure) intraclass correlation coefficient (ICC) with 95% confidence interval (CI) between the continuous scores obtained on 1st and 2nd administration of the Hausa IPAQ-LF was calculated. The ICCs were calculated overall, and by gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] Second, the Bland and Altman Method was used to assess agreement on scores of PA from the 1st and 2nd administrations.[32] Variables used for the Bland and Altman analysis were weekly time spent in moderate-to-vigorous activity (MVPA), total PA and sitting. MVPA was computed by summing the total minutes/week of reported physical activity of moderate and vigorous- intensities across all four domains. For total PA, the total minutes/week of activities in each domain were summed (total work + total transport + total domestic + total leisure-time min/week scores) to gain an overall estimate of physical activity in a week. Also, the independent t-test and one-Way ANOVA were used as appropriate to compare the time spent (minutes/week) in PA at both administrations across sociodemographic subgroups. To assess construct validity, the non-parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body mass index. Data were analyzed using Statistical Package for the Social Science (SPSS), version 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at $p<0.05$.

RESULTS

The socio-demographic characteristic of the participants are shown in Table 1. The participants comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of 23.8 ± 3.9kg/m^2. Majority of the participants were married (58.9%, n=106), had more than secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to men, the women were more likely to be married (71.1% vs 46.7%, p=0.001) and unemployed (52.2% vs 17.8%, p<0.001), but men were more likely to have more than secondary school education (76.7% vs 48.2%, p<0.001).

Reliability

Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients were good (ICC >75) for total PA, occupational PA, active transportation and vigorous intensity (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95% CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38, 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous intensity (very hard) activities were substantially greater in men than women.

Similarly, socioeconomic status differences were observed in the reliability coefficients of the modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were substantially higher among participants with less than secondary school education (ICC from 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and those with higher than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]). While reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and

leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95% CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were unemployed than in the employed subgroup.

Figures 1, 2 and 3 (Bland-Altman plots) illustrate the agreement in the scores (minutes/week) of total PA, MVPA and sitting between the first and second administrations of Hausa IPAQ-LF. For total PA, the mean difference was 106.7 minutes/week, with a wide 95% limits of agreement (-762.2 to 965.6 minutes/week). For MVPA, the mean difference was about one and half hour per week (91.6 minutes/week), and also demonstrating wide 95% limits of agreement (-744.5 to 927.7 minutes/week). For sitting time, the mean difference was small (26 minutes/week) and the 95% limits of agreement range from -2178.1 to 2230.9 minutes/week.

Table 4 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1) and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified variables, time spent in PA reported during the first administration tends to be higher than those reported during the second administration. At both time points, men reported significantly ($p<0.05$) higher mean time (minute/week) in active transportation, occupational PA, and leisure-time PA than women. However, women spent significantly ($p<0.001$) more time (minutes/week) in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status, participants that had lower than secondary school education compared to those with at least secondary school education reported statistically significant higher mean time (minutes/week) at both time points for total PA, active transport, occupational PA, walking and vigorous intensity activity compared to those with at least secondary school education. While participants that were employed reported statistically significant ($p<0.05$) more time (minutes/week) in total PA (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1, IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.

Construct Validity

Overall, correlations between energy expenditure (MET-Minutes/week) according to the modified IPAQ-LF and anthropometric and biological measures were statistically significant in the expected direction for all domains and intensities of PA, except for occupation and active transport domains and walking (table 5). In the full sample, domestic PA was mainly related with SBP (ρ = -0.27, $p< 0.01$) and DBP (ρ = -0.17, $p< 0.05$), while leisure PA and total PA were only related with SBP (ρ = -0.16, $p< 0.05$) and BMI (ρ = -0.29, $p< 0.01$), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$). In the gender based analyses, total PA, domestic PA and sedentary time were more consistently related with anthropometric and biological variables. The strongest rho value (-0.41) was found for the relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was reached between total PA and DBP for the women subgroup. Only in women was domestic PA significantly related with BMI (ρ = -0.23), DBP (ρ = -0.20) and SBP (ρ = -0.31). Leisure-time PA (ρ = -0.39) and occupational PA (ρ = -0.22) were significantly related with BMI only in men. The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ = 0.19) than men (ρ = 0.15).

DISCUSSION

This study examined the reliability and an aspect of validity of a modified version of the IPAQ-LF in Nigeria. The findings generally indicated acceptable test-retest reliability and modest construct validity for items of the modified IPAQ-LF among Nigerian adults. To the best of our knowledge, the present study is the only one to examine the reliability and validity of the long version of IPAQ that has been modified specifically to an indigenous African culture and language.

We found evidence for good reliability with high correlations between the test-retest for total PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that except for domestic PA and sitting time, ICC values for domains of PA were consistently above 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[33,34]

Similar to a previous IPAQ-LF study in Hong Kong,[34] domestic activity demonstrated the lowest ICC value in our study. However, it is possible that the infrequent nature of household activities undertaken, especially by men may account for the low reliability reported for domestic PA in our study. In addition to the traditional African patriarchal norm that make most African men to rarely engage in indoor household activities, men in the high socioeconomic group in Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home, appliances and equipment maintenance because they are able to employ the services of domestic helpers and repair men. Our findings of lower reliability for domestic activity among men, those with more than secondary school education and those who were employed compared to their counterparts seem to support this assumption.

The highest and strongest reliability coefficients (0.82) were found for both active transportation and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and reproducible overtime than other PA domains because it is a common and ubiquitous PA behaviour in the African region. Mostly, the performance of active transportation especially walking is often out of necessity rather than choice within the African context. Our finding of higher ICC value for vigorous intensity PA is consistent with those of other studies that found the reliability of vigorous intensity activity to be higher compared to that of moderate intensity activity.[10,30,34,35] Compared to structured vigorous physical activities like sports and exercise that can be more easily recalled, moderate intensity PA are often of low salience, incidental and may not easily be remembered by people.[36,37] Further our finding that the reliability of vigorous intensity physical activity was meaningfully higher among men than women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria are more consistent than women when responding to PA items that pertained to intense vigorous PA than other intensities of activity. Overall, the moderate to good evidence of reliability found for all items indicate that the modified IPAQ-LF is reproducible, internally consistent and is promising for research in Nigeria.

Except for sitting time, the limits of agreement in the mean scores of total PA and MVPA between the first and second administrations were wide, suggesting an evidence of bias between

administrations. Large difference in PA scores between the 2 administrations would indicate that at least one of the two measurements is not accurate. However, similar to the finding of a Mexican study,[38] scores on the Hausa IPAQ-LF were consistently lower during the second administration of the questionnaire compared to the first administration. Because familiarity with the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that participants in our study might have over-reported their PA levels during the first administration of the Hausa IPAQ-LF. This kind of findings may have implication for the utility of IPAQ for surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA that has been associated with the IPAQ,[39,40] it may be necessary to start considering the need for multiple measurements when using the IPAQ for evaluating PA, especially in developing African countries. However, patterns of PA as measured by the modified IPAQ-LF during both administrations were consistently similar, and both administrations were able to discriminate PA in the expected direction between subgroups of our sample. For example, at both measurement time points, and consistent with hypothesis, men reported more time in active transportation, occupational PA and leisure PA than women, while women reported more time in domestic PA and sedentary activity than men.

In the absence of objective criterion standards for evaluating an absolute estimate of PA, the consistency of items on IPAQ with variables known to be related to PA such as body mass index (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have been used as important construct validity measures.[7,10,21,24] In the present study, the correlations of the PA domains and intensities with biological and anthropometric variables were mostly significant in the expected direction, but they were low suggesting a modest evidence of construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were comparable with the values in other studies that have evaluated the IPAQ-LF.[5,7,8,24,30,33,39] Because better validity coefficients have been reported for other PA measures above that of the IPAQ,[39,41] with the present African finding, it is possible that the IPAQ-LF only have modest evidence of construct validity. However, our findings on the relationships between physical activity and biological and anthropometric variables should be interpreted in the light of an important caution. Because hypertensive and obese people may get oriented to exercise,[3] cross-

sectional associations of physical activity and blood pressure or BMI could also occur in the opposite direction and may not represent much information as indicators of construct validity of physical activity measures.

Strengths and limitations

A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to reflect the common PA behaviours of people in Nigeria. This is the first study in an African country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse segment of the Nigerian population. In the Africa region, the importance of a valid and established PA scale like the modified IPAQ-LF is not only important to monitoring the domain in which activity is performed, but also very critical to understanding studies of ecological models of health behaviours, that emphasize the importance of multiple levels of influence on health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using ecological models indicate that favourable built environmental attributes are promising for improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45] However, built environment characteristics are expected to be strongly related to specific PA types rather than overall PA.[46,47] For example, different environmental variables can be related to walking for leisure or transportation and to moderate PA for household, occupation, recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to understanding the domain specific nature of ecological models research in the African region. One additional strength was the exploration of PA patterns by gender, educational level and employment status, the findings of which were consistent with general hypothesis on social patterns of inactivity in low-income countries.[20,48]

However, the findings of this study should be interpreted in the light of some important limitations. Direct comparison of our validity findings with previous studies should be made with caution, because unlike in our study, the accelerometer or PA diary were utilized as a common objective criterion standard to validate the IPAQ in the majority of the studies.[5,7,8,24,30,33,39] Thus, examining the construct validity through the relationships of

PA with BMI and resting blood pressure was an important limitation of our study. The choice and availability of appropriate criterion measures are particular issues of concern for the validation of PA questionnaires in low-income countries of Africa [5,49,50]. Despite these issues, the validity coefficients in our study were remarkably similar to those reported in other studies, [5,7,8,24,30,33,39] and the consistency of items on IPAQ with variables known to be related to PA such as BMI, blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have previously been used as important construct validity measures.[7,10,21,24] Another limitation of the study is the use of non-probability sampling technique. The study finding may have limited generalizability to other samples of Nigerians that have different characteristics from this sample. In addition, the majority of participants have more than secondary school education with potentially higher comprehension and recall ability than may be found in the general population. Nevertheless, recruitment from diverse neighbourhoods and settings allowed for a sample with reasonable heterogeneity in age, occupational status, and ethnic backgrounds and made it possible to stratify the analyses by sociodemographic characteristics. However, because some of the participants in the present study required assistance to complete the survey, interview administration rather than self-administration of the IPAQ-LF should be encouraged in any future national studies in the African region. Administering the IPAQ through interview has been considered as a viable and preferred option in developing countries.[5]

Conclusions

Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could further contribute to our understanding of the impact of multiple levels of influence on PA behaviours of people in the African region.

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Contributors

ALO conceived and designed the study, contributed to cultural adaptation and acquisition of data, conducted the statistical analysis and interpretation of data and drafted the manuscript. UMB and STP managed participants' recruitment and data collection and contributed to cultural adaptation. HBN and RDM contributed to cultural adaptation and translations of the measure. AYO contributed to study design, acquisition of data and critically revised the manuscript for important intellectual contents. All authors read and approved the final manuscript.

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Competing interests

Authors declare there is no competing interest associated with this study.

Ethics approval

Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria (ADM/TH/EC/75).

Data sharing process

Dataset for this study available upon request from the corresponding author.

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Table 1. Descriptive characteristics of the participants (N=180)

Variables	Total sample (N=180)	Men (n=90, 50%)	Women (n=90, 50%)
Age (years)			
Mean (± SD)	35.6 ± 10.3	35.7 ± 8.3	35.5 ± 11.9
Marital status (n, %)*			
Not Married	74(41.1)	48(53.3)	26(28.9)
Married	106(58.9)	42(46.7)	64(71.1)
BMI (Kg/m^2)			
Mean (± SD)	23.8 ± 3.9	23.8 ± 3.5	23.8 ± 4.4
BMI Category (n, %)			
Underweight	14 (7.8)	4 (4.4)	10 (11.1)
Normal weight	107 (59.4)	58 (64.4)	49 (54.4)
Overweight/obese	59 (32.8)	28 (31.2)	31 (34.5)
Ethnicity (n, %)			
Hausa/Fulani	21(11.7)	10.1(11.1)	11(12.2)
Igbo	8(4.4)	5(5.6)	3(3.3)
Yoruba	10(5.6)	6(6.7)	4(4.4)
Kanuri/Shuwa Arab	44(24.4)	23(25.6)	21(23.3)
Others	97(53.9)	46 (51.1)	51(56.7)
Educational level (n, %)*			
> Secondary School	111 (62.7)	11 (12.2)	17(19.5)
Secondary	38 (21.5)	10 (11.1)	28(32.5)
<Secondary School	28 (15.8)	69 (76.7)	42(48.2)
Occupational Status (n, %)*			
Unemployed	63(35)	16(17.8)	47(52.2)
Blue Collar	45(25)	28(31.1)	17(18.9)
White Collar	72(40)	46(51.1)	26(28.9)

*- Significant difference between samples (p<0.05)
BMI- Body Mass Index

Table 2: Test-reliability based on intra-class correlation coefficient for Hausa IPAQ– LF, overall and by gender

	Total (N=180)			Women (n=90)	Men (n=90)
PA Measure (MET×min/wk)	**Test 1 (Mean (SD))**	**Test 2 (Mean (SD))**	**ICC (95%CI)**	**ICC (95%Cl)**	**ICC (95%Cl)**
Total PA, all domain	2160.6 (2691.1)	1612.8 (1612.8)	0.76 (0.65-0.82)	0.45 (0.08-0.67)	0.80 (0.69- 0.87)
Occupation	619.1(1671.5)	497.5 (1332.9)	0.77 (0.68-082)	0.64 (0.46-0.77)	0.78 (0.66 -0.85)
Active Transport	468.1 (684.7)	440.5 (605.7)	0.82 (0.75-0.87)	0.63 (0.40-0.77)	0.83 (0.73 - 0.89)
Domestic	597.6 (754.6)	473.4 (673.7)	0.50 (0.32-0.62)	0.38 (0.01-0.57)	0.33 (-0.01-0.56)
Leisure	377.0 (1096.3)	196.7 (920.2)	0.71 (0.60-0.78)	0.69 (0.53-0.79)	0.75 (0.63-0.84)
Sitting	2263.0 (715.8)	2235.4 (818.9)	0.62 (0.42-0.75)	0.71 (0.46-0.85)	0.48 (0.06-0.72)
PA by Intensity (MET×min/wk)					
Walking	613.6 (635.6)	534.6 (449.1)	0.63 (0.48-0.74)	0.57 (0.29-0.74)	0.65 (0.44-0.78)
Moderate	986.9 (1365.9)	716.1 (1164.6)	0.61 (0.46-0.71)	0.42 (0.11-0.62)	0.67 (0.49-0.78)
Vigorous	526.5 (1543.7)	394.1 (1431.1)	0.82 (0.76-0.87)	0.55 (0.30-0.71)	0.86 (0.78-0.91)

PA= Physical Activity
MET= Metabolic Energy Turnover

Table 3: Socioeconomic status differences in test- retest reliability of the Hausa IPAQ- LF (N= 180)

Socioeconomic Status	Overall PA	Active Transport	Occupation PA	Leisure PA	Domestic PA	Sitting
Educational Qualification						
More than secondary school (n=111)	0.42 (0.08-0.63)	0.67 (0.43-0.78)	0.32 (-0.06-0.57)	0.33 (-0.05-0.57)	0.58 (0.35-0.73)	0.23 (-0.63-0.63)
Secondary School (n=38)	0.55 (0.22-0.74)	0.28 (-0.21-0.57)	0.58 (0.33-0.74)	0.54 (0.25-0.71)	0.50 (0.19-0.69)	0.51 (-0.04-0.76)
Less than Secondary school (n=28)	0.89 (0.67-0.96)	0.90 (0.74-0.96)	0.82 (0.61-0.92)	0.92 (0.83-0.96)	0.90 (0.78-0.95)	0.77 (0.45-0.90)
Employment Category						
Employed (117)	0.80 (0.67-0.96)	0.83 (0.74-0.88)	0.79 (0.70-0.86)	0.79 (0.69-0.85)	0.36 (0.08-0.56)	0.56 (0.23-0.75)
Unemployed (63)	0.09 (-8.86-0.56)	0.68 (0.44-0.82)	0.16 (-0.39-0.49)	0.25 (-0.24-0.55)	0.65 (0.43-0.79)	0.68 (0.36-0.80)

PA= Physical Activity

Table 4: Differences in time spent in physical activity overall, and by gender and socioeconomic status sub groups

		Gender		Education			Employment	
	Total Mean ± SD	**Men** Mean ± SD	**Women** Mean ± SD	**>Secondary** Mean ± SD	**Secondary** Mean ± SD	**<Secondary** Mean ± SD	**Employed** Mean ± SD	**Unemployed** Mean ± SD
PA by domain (min/wk)								
Total PA, all domain								
IPAQ1	405.2 (507.8)	460.7 (582.9)	326.8 (367.8)	334.0 (400.8)	384.8 (514.8)	849.2 (764.1)**	441.1 (530.2)	285.1 (408.6)*
IPAQ2	308.4 (440.3)	319.7 (522.8)	291.9 (282.9)	285.1 (295.1)	184.8 (264.4)	803.0 (929.6)**	359.4 (481.6)	141.0 (185.2)*
Active Transport								
IPAQ1	35.8 (89.7)	52.4 (127.7)	19.5 (17.7)*	28.3 (47.7)	28.9 (45.02)	76.4 (198.7)*	43.8 (109.4)	21.1 (21.9)*
IPAQ2	30.4 (76.7)	41.2 (106.3)	19.3 (17.5)*	23.6 (30.6)	20.3 (30.9)	74.3 (182.6)*	36.9 (94.1)	18.3 (14.7)*
Work								
IPAQ1	160.1 (380.8)	217.5 (466.8)	79.1 (179.9)*	114.8 (291.0)	122.9 (365.6)	546.7 (615.7)**	195.5 (418.8)	41.8 (162.2)*
IPAQ2	135.3 (310.3)	172.5 (372.8)	80.6 (171.9)*	104.1 (232.2)	160.9 (196.1)	531.6 (595.8)**	164.1 (341.7)	40.1 (133.0)*
Domestic								
IPAQ1	159.6 (202.2)	82.3 (120.6)	236.9 (235.8)**	141.2 (182.4)	173.3 (238.5)	165.4 (159.4)	132.1 (170.7)	210.6 (243.8)*
IPAQ2	123.9 (163.9)	52.4 (74.9)	195.5 (190.1)**	131.9 (182.5)	107.6 (130.4)	147.3 (189.1)	112.6 (163.9)	205.0 (163.3)*
Leisure								
IPAQ1	62.4 (159.1)	75.0 (211.1)	10.5 (27.3)**	47.0 (97.3)	92.7 (209.4)	38.2 (160.1)	69.7 (157.6)	48.7 (162.3)
IPAQ2	30.5 (118.2)	50.6 (160.7)	10.1 (38.5)**	23.4 (51.4)	24.7 (91.4)	71.5 (256.5)	43.1 (143.5)	17.0 (28.7)*
Sitting								
IPAQ1	2263.0 (715.8)	2188.8 (759.7)	2330.7 (674.8)	2280.0 (618.7)	2433.9 (693.7)	2180.9 (760.8)	2159.4 (775.9)	2337.6 (667.2)
IPAQ2	2235.4 (819.9)	2208.7 (916.9)	2259.6 (728.1)	2420.7 (638.7)	2215.3 (663.1)	2160.0 (1111.4)	2170.6 (870.5)	2282.0 (785.5)
PA by Intensity (min/wk)								
Walking								
IPAQ1	178.5 (221.5)	241.1 (271.9)	128.2 (100.8)*	194.4 (268.1)	133.4 (85.6)	266.9 (285.4)*	192.0 (245.7)	133.3 (96.2)*
IPAQ2	142.5 (141.8)	148.5 (137.9)	133.7 (147.9)	151.7 (138.4)	103.6(94.7)	200.3 (209.1)*	150.7 (146.6)	115.4 (122.7)
Moderate								
IPAQ1	201.9 (326.9)	193.0 (214.5)	214.5 (247.8)	187.3 (266.5)	194.9 (386.5)	309.7 (381.7)	221.2 (347.4)	137.7 (239.9)
IPAQ2	133.9 (238.5)	114.2 (276.9)	162.7 (165.6)	132.9 (177.8)	88.0 (197.2)	319.0 (482.1)*	153.9 (266.2)	68.0 (76.4)*
Vigorous								
IPAQ1	94.1 (211.8)	123.7 (249.6)	52.2 (133.2)*	32.9 (81.9)	129.5 (208.2)	268.0 (459.7)**	90.2 (214.6)	127.1 (204.6)
IPAQ2	78.4 (206.9)	86.8 (227.4)	46.2 (73.4)	52.2 (140.2)	55.2 (127.0)	292.8 (461.5)**	92.8 (226.9)	130.9 (107.8)

PA= Physical Activity
*=p<0.05
**=p<0.001

Table 5: Construct validity of Hausa IPAQ-LF: Spearman correlations between energy expenditure (MET×min/wk) from Hausa IPAQ– LF, and anthropometric and biological variables (N=180)

	Overall (N = 180)			Female (n = 90)			Male (n = 90)		
MET×min/wk	BMI	DBP	SBP	BMI	DBP	SBP	BMI	DBP	SBP
PA Domains									
Total PA	-0.29**	-0.17*	-0.09	-0.09	-0.23**	-0.04	-0.41**	-0.08	-0.14
Occupation PA	-0.12	-0.09	0.01	0.02	0.02	-0.05	-0.22**	-0.17	-0.08
Active transport PA	-0.05	-0.04	-0.01	-0.10	-0.13	-0.02	-0.04	-0.02	-0.80
Domestic PA	-0.07	-0.17*	-0.26**	-0.23**	-0.20*	-0.31**	0.04	-0.14	-0.04
Leisure PA	0.09	-0.08	-0.16*	-0.11	0.02	0.08	-0.39**	-0.12	-0.06
Sitting	0.16	-0.09	0.04	0.19	0.12	0.05	0.15	-0.09	0.05
PA Intensity									
Walking	0.90	-0.09	-0.03	0.19	-0.05	0.08	-0.05	-0.11	-0.15
Moderate	-0.02	0.21*	0.16*	0.02	-0.14	-0.08	0.02	-0.25**	-0.16
Vigorous	-0.11*	-0.06	0.03	-0.16	0.01	0.02	-0.13*	-0.12	-0.11

MET= Metabolic Energy Turnover
BMI= Body Mass Index
DBP= Diastolic Blood Pressure
SBP= Systolic Blood Pressure
PA= Physical activity
*=p<0.05,
**=p<0.01

Examining the reliability and validity of a modified version of the International Physical Activity Questionnaire, long form (IPAQ-L) in Nigeria: A cross-sectional study

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Key words: Physical activity, measurement, public health, IPAQ, Nigeria

Word counts: 4352

ABSTRACT

Objectives: To investigate the reliability and aspect of validity of a modified version of the long International Physical Activity Questionnaire (Hausa IPAQ-LF) in Nigeria.

Design: Cross-sectional study, examining the reliability and construct validity of the Hausa IPAQ-LF compared with anthropometric and biological variables.

Setting: Metropolitan Maiduguri, the capital city of Borno State in Nigeria.

Participants: 180 Nigerian adults (50% women) with a mean age of 35.6 (SD=10.3) years, recruited from neighbourhood with diverse socioeconomic status and walkability.

Outcome measures: Domains (domestic physical activity [PA], occupational PA, leisure-time PA, active transportation and sitting time) and intensities of PA (vigorous, moderate and walking) were measured with the Hausa IPAQ-LF on two different occasions, eight days apart. Outcomes for construct validity were measured BMI, SBP and DBP.

Results: The Hausa IPAQ-LF demonstrated good test-retest reliability (ICC>75) for total PA (ICC=0.79, 95% CI=0.65-0.82), occupational PA (ICC=0.77, 95% CI=0.68-0.82), active transportation (ICC=0.82, 95% CI=0.75-0.87) and vigorous intensity activities (ICC=0.82, 95% CI=0.76-0.87). Reliability was substantially higher for total PA (ICC=0.80), occupational PA (ICC=0.78), leisure-time PA (ICC=0.75) and active transportation (ICC=0.80) in men than women, but domestic PA (ICC=0.38) and sitting time (ICC=0.71) demonstrated substantial reliability coefficients in women than men. For the construct validity, domestic PA was significantly related mainly with SBP (ρ = -0.27) and DBP (ρ = -0.17), and leisure-time PA and total PA were significantly related only with SBP (ρ = -0.16) and BMI ((ρ = -0.29), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$).

Conclusions: The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria.

ARTICLE SUMMARY

Strengths and limitations of this study.

- Systematic adaptation and tailoring of items on the original IPAQ-LF to reflect the common PA behaviours of adults in Nigeria.
- The first study to describe the cultural adaptation and translations of the IPAQ-LF and explore its psychometric relevance in an African country.
- Findings establish evidence to support the feasibility of using a modified IPAQ-LF to reliably collect context specific PA behaviours of adults in the African region.
- Exploring construct validity through the relationships of PA with BMI and resting blood pressure was an important limitation of this study.
- The use of non-probability sampling technique may limit generalizability of findings to other samples of Nigerian adults with different characteristics from the study's sample.

INTRODUCTION

The importance of physical activity (PA) for promoting health and preventing disease is well established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it is important to have standardized, reliable and valid instruments that can be used to accurately describe population levels and patterns of PA within and across countries.[4, 5] In this context, the international physical activity questionnaire (IPAQ) was developed to obtain internationally comparable data on health-related PA of adults (18-65 years).[5, 6] Two versions of the IPAQ that could be administered by interview or self-completed were developed. The short form (SF) was designed for population surveillance of PA; while the long form (LF) was designed to be appropriate for use in research that requires detailed information on different PA domains, including PA at work, household, during leisure and transportation, and time spent in sedentary activities.[6]

The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts have been made to translate and adapt the IPAQ in many other countries, but most of the research in this context were from the Western developed countries.[7-14] In Africa, the psychometric properties of IPAQ have only been tested in South-Africa as part of the initial development process of the questionnaire,[5] and in older adults.[15] Because the largest increases and burden of non-communicable diseases (NCDs) are in the low-income countries where the understanding of evidence-based strategies for increasing PA remains poor,[16-19] improving PA research is a top priority for low-income countries.[20] However, to advance PA research in Africa, it is important to first develop or tailor standardized measures to be culturally sensitive to PA behaviours of people in the region countries. Because Nigeria is the most populous country in Africa with culture and languages similar to most of the other West African countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this country.

Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF in sub-Saharan African countries can impact PA research and surveillance in the African region where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the present study was to investigate the reliability and an aspect of validity of a modified version of the IPAQ-LF among adults in Nigeria.

METHODS

Participants

A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status and walkability in Maiduguri city were recruited for the study. The sampling and neighbourhood selection strategy have been described in details elsewhere.[26] Maiduguri with an estimated population of 749,123 people is the largest and capital city of Borno State in North-Eastern Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and Chad Republic, and Hausa language is the common means of communication for commercial activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this study if they were willing to self-complete a written survey twice in either Hausa or English Language. However, researchers (UMB and STP) were in attendance to provide translation and interpretation assistance to participants (n=11) who required help to complete the survey. Additional eligibility criteria included living within the identified neighbourhood categories in the last 12 months, being adults (18-65 years) and not having any disability that prevented independent walking. All participants were fully informed of the study protocol and provided signed informed consent. The study protocol was approved by the Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were collected between March and May, 2012.

Measures

The adapted international physical activity questionnaire- long Hausa version

The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly, interviews were conducted with public health experts, exercise scientists and not highly educated local people to identify the items and examples of PA on the original questionnaires that needed to be culturally adapted. Several cultural adaptations were made to the original items to reflect the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with words that are more representative of the language used in Nigeria, like 'very hard' and 'hard' respectively. Second, examples of various intensities of activity that were common in the Nigerian culture were added, and those already on the questionnaire but not common in the Nigerian context were replaced with culturally applicable examples that are equivalent in energy intensity (METs) with the original items and examples. Third, concepts like physical activity and walking for transportation that were misconstrued outside the health context were refined to indicate they were referring to health behaviours.

After adaptation, the questionnaire was independently translated from English into Hausa language by two native speakers of Hausa who also speaks English, and able to read and write in both languages. One of the translators was familiar with the questionnaire and the second was an expert in Hausa language. The translated questionnaires were mutually revised by the translators and the research team for consistency and then back translated into English language by a third bilingual person who was familiar with the construct measured by IPAQ. The back translated version was checked by the research team for any discrepancies and to ensure that the construct measures by IPAQ had not been lost during the adaptation and translation process.

The modified questionnaire (available in both Hausa and English language), hereafter referred to as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF), contains thirty-one questions that asked about physical activity done in the last 7-days in terms of frequency (days/week) and duration (minutes/day) spent in four activity domains (transportation,

occupation, domestic and leisure time), and included sections on walking, moderate- and vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and motorized transportation). The Hausa IPAQ-LF data were presented as the MET-minute/week for total walking, moderate, and vigorous intensity activity and overall physical activity across the four domains, and in each of the domains. The MET intensity values used to score the Hausa IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest reliability of the Hausa IPAQ-LF, participants self-completed all items on the measure twice, with an interval of one week between administrations.

Anthropometrical and biological measurements

Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO were used to create the categories: underweight (< 18.5 kg/m^2), normal weight (18.5– < 25 kg/m^2), overweight (25– <30kg/m^2) and obese (≥30 kg/m^2).[29] Resting blood pressure and heart rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study, construct validity was evaluated by investigating the relationship of outcomes from the Hausa IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also in part by comparing the differences in time spent in PA and sitting across sociodemograpic subgroups. These types of validation for PA measures have been referred as indirect or construct validity in previous studies.[7,24,30]

Sociodemographic Characteristics

Information on age, gender, marital status, religion, income, educational level and employment status were elicited from the participants. Marital status was classified as married or not married. Educational level was classified as more than secondary school education, secondary school

education and less than secondary school education. Employment status was classified into white collar (government or private employed), blue collar (self- employed, trader, artisan etc) and unemployed (homemaker, student, retired, or unable to find job).

Data Analysis

Descriptive data were reported as mean, standard deviation and percentages. Mean group differences for continuous variables by gender were examined by independent t-test, and for dichotomous variables by chi-square statistics. The reliability analyses were performed using 2 strategies. First, the two- way mixed model (single measure) intraclass correlation coefficient (ICC) with 95% confidence interval (CI) between the continuous scores obtained on 1st and 2nd administration of the Hausa IPAQ-LF was calculated. The ICCs were calculated overall, and by gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] Second, the Bland and Altman Method was used to assess agreement on scores of PA from the 1st and 2nd administrations.[32] Variables used for the Bland and Altman analysis were weekly time spent in moderate-to-vigorous activity (MVPA), total PA and sitting. MVPA was computed by summing the total minutes/week of reported physical activity of moderate and vigorous- intensities across all four domains. For total PA, the total minutes/week of activities in each domain were summed (total work + total transport + total domestic + total leisure-time min/week scores) to gain an overall estimate of physical activity in a week. Also, the independent t-test and one-Way ANOVA were used as appropriate to compare the time spent (minutes/week) in PA at both administrations across sociodemographic subgroups. To assess construct validity, the non-parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body mass index. Data were analyzed using Statistical Package for the Social Science (SPSS), version 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at $p<0.05$.

RESULTS

The socio-demographic characteristic of the participants are shown in Table 1. The participants comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of 23.8 ± 3.9kg/m^2. Majority of the participants were married (58.9%, n=106), had more than secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to men, the women were more likely to be married (71.1% vs 46.7%, p=0.001) and unemployed (52.2% vs 17.8%, p<0.001), but men were more likely to have more than secondary school education (76.7% vs 48.2%, p<0.001).

Reliability

Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients were good (ICC >75) for total PA, occupational PA, active transportation and vigorous intensity (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95% CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38, 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous intensity (very hard) activities were substantially greater in men than women.

Similarly, socioeconomic status differences were observed in the reliability coefficients of the modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were substantially higher among participants with less than secondary school education (ICC from 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and those with higher than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]). While reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and

leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95% CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were unemployed than in the employed subgroup.

Figures 1, 2 and 3 (Bland-Altman plots) illustrate the agreement in the scores (minutes/week) of total PA, MVPA and sitting between the first and second administrations of Hausa IPAQ-LF. For total PA, the mean difference was 106.7 minutes/week, with a wide 95% limits of agreement (-762.2 to 965.6 minutes/week). For MVPA, the mean difference was about one and half hour per week (91.6 minutes/week), and also demonstrating wide 95% limits of agreement (-744.5 to 927.7 minutes/week). For sitting time, the mean difference was small (26 minutes/week) and the 95% limits of agreement range from -2178.1 to 2230.9 minutes/week.

Table 4 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1) and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified variables, time spent in PA reported during the first administration tends to be higher than those reported during the second administration. At both time points, men reported significantly ($p<0.05$) higher mean time (minute/week) in active transportation, occupational PA, and leisure-time PA than women. However, women spent significantly ($p<0.001$) more time (minutes/week) in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status, participants that had lower than secondary school education compared to those with at least secondary school education reported statistically significant higher mean time (minutes/week) at both time points for total PA, active transport, occupational PA, walking and vigorous intensity activity compared to those with at least secondary school education. While participants that were employed reported statistically significant ($p<0.05$) more time (minutes/week) in total PA (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1, IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.

Construct Validity

Overall, correlations between energy expenditure (MET-Minutes/week) according to the modified IPAQ-LF and anthropometric and biological measures were statistically significant in the expected direction for all domains and intensities of PA, except for occupation and active transport domains and walking (table 5). In the full sample, domestic PA was mainly related with SBP (ρ = -0.27, $p< 0.01$) and DBP (ρ = -0.17, $p< 0.05$), while leisure PA and total PA were only related with SBP (ρ = -0.16, $p< 0.05$) and BMI (ρ = -0.29, $p< 0.01$), respectively. Similarly, moderate-intensity PA was mainly related with SBP (ρ = -0.16, $p< 0.05$) and DBP (ρ = -0.21, $p< 0.01$), but vigorous-intensity PA was only related with BMI (ρ = -0.11, $p< 0.05$). In the gender based analyses, total PA, domestic PA and sedentary time were more consistently related with anthropometric and biological variables. The strongest rho value (-0.41) was found for the relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was reached between total PA and DBP for the women subgroup. Only in women was domestic PA significantly related with BMI (ρ = -0.23), DBP (ρ = -0.20) and SBP (ρ = -0.31). Leisure-time PA (ρ = -0.39) and occupational PA (ρ = -0.22) were significantly related with BMI only in men. The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ = 0.19) than men (ρ = 0.15).

DISCUSSION

This study examined the reliability and an aspect of validity of a modified version of the IPAQ-LF in Nigeria. The findings generally indicated acceptable test-retest reliability and modest construct validity for items of the modified IPAQ-LF among Nigerian adults. To the best of our knowledge, the present study is the only one to examine the reliability and validity of the long version of IPAQ that has been modified specifically to an indigenous African culture and language.

We found evidence for good reliability with high correlations between the test-retest for total PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that except for domestic PA and sitting time, ICC values for domains of PA were consistently above 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[33,34]

Similar to a previous IPAQ-LF study in Hong Kong,[34] domestic activity demonstrated the lowest ICC value in our study. However, it is possible that the infrequent nature of household activities undertaken, especially by men may account for the low reliability reported for domestic PA in our study. In addition to the traditional African patriarchal norm that make most African men to rarely engage in indoor household activities, men in the high socioeconomic group in Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home, appliances and equipment maintenance because they are able to employ the services of domestic helpers and repair men. Our findings of lower reliability for domestic activity among men, those with more than secondary school education and those who were employed compared to their counterparts seem to support this assumption.

The highest and strongest reliability coefficients (0.82) were found for both active transportation and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and reproducible overtime than other PA domains because it is a common and ubiquitous PA behaviour in the African region. Mostly, the performance of active transportation especially walking is often out of necessity rather than choice within the African context. Our finding of higher ICC value for vigorous intensity PA is consistent with those of other studies that found the reliability of vigorous intensity activity to be higher compared to that of moderate intensity activity.[10,30,34,35] Compared to structured vigorous physical activities like sports and exercise that can be more easily recalled, moderate intensity PA are often of low salience, incidental and may not easily be remembered by people.[36,37] Further our finding that the reliability of vigorous intensity physical activity was meaningfully higher among men than women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria are more consistent than women when responding to PA items that pertained to intense vigorous PA than other intensities of activity. Overall, the moderate to good evidence of reliability found for all items indicate that the modified IPAQ-LF is reproducible, internally consistent and is promising for research in Nigeria.

Except for sitting time, the limits of agreement in the mean scores of total PA and MVPA between the first and second administrations were wide, suggesting an evidence of bias between

administrations. Large difference in PA scores between the 2 administrations would indicate that at least one of the two measurements is not accurate. However, similar to the finding of a Mexican study,[38] scores on the Hausa IPAQ-LF were consistently lower during the second administration of the questionnaire compared to the first administration. Because familiarity with the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that participants in our study might have over-reported their PA levels during the first administration of the Hausa IPAQ-LF. This kind of findings may have implication for the utility of IPAQ for surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA that has been associated with the IPAQ,[39,40] it may be necessary to start considering the need for multiple measurements when using the IPAQ for evaluating PA, especially in developing African countries. However, patterns of PA as measured by the modified IPAQ-LF during both administrations were consistently similar, and both administrations were able to discriminate PA in the expected direction between subgroups of our sample. For example, at both measurement time points, and consistent with hypothesis, men reported more time in active transportation, occupational PA and leisure PA than women, while women reported more time in domestic PA and sedentary activity than men.

In the absence of objective criterion standards for evaluating an absolute estimate of PA, the consistency of items on IPAQ with variables known to be related to PA such as body mass index (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have been used as important construct validity measures.[7,10,21,24] In the present study, the correlations of the PA domains and intensities with biological and anthropometric variables were mostly significant in the expected direction, but they were low suggesting a modest evidence of construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were comparable with the values in other studies that have evaluated the IPAQ-LF.[5,7,8,24,30,33,39] Because better validity coefficients have been reported for other PA measures above that of the IPAQ,[39,41] with the present African finding, it is possible that the IPAQ-LF only have modest evidence of construct validity. However, our findings on the relationships between physical activity and biological and anthropometric variables should be interpreted in the light of an important caution. Because hypertensive and obese people may get oriented to exercise,[3] cross-

sectional associations of physical activity and blood pressure or BMI could also occur in the opposite direction and may not represent much information as indicators of construct validity of physical activity measures.

Strengths and limitations

A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to reflect the common PA behaviours of people in Nigeria. This is the first study in an African country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse segment of the Nigerian population. In the Africa region, the importance of a valid and established PA scale like the modified IPAQ-LF is not only important to monitoring the domain in which activity is performed, but also very critical to understanding studies of ecological models of health behaviours, that emphasize the importance of multiple levels of influence on health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using ecological models indicate that favourable built environmental attributes are promising for improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45] However, built environment characteristics are expected to be strongly related to specific PA types rather than overall PA.[46,47] For example, different environmental variables can be related to walking for leisure or transportation and to moderate PA for household, occupation, recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to understanding the domain specific nature of ecological models research in the African region. One additional strength was the exploration of PA patterns by gender, educational level and employment status, the findings of which were consistent with general hypothesis on social patterns of inactivity in low-income countries.[20,48]

However, the findings of this study should be interpreted in the light of some important limitations. Direct comparison of our validity findings with previous studies should be made with caution, because unlike in our study, the accelerometer or PA diary were utilized as a common objective criterion standard to validate the IPAQ in the majority of the studies.[5,7,8,24,30,33,39] Thus, examining the construct validity through the relationships of

PA with BMI and resting blood pressure was an important limitation of our study. The choice and availability of appropriate criterion measures are particular issues of concern for the validation of PA questionnaires in low-income countries of Africa [5,49,50]. Despite these issues, the validity coefficients in our study were remarkably similar to those reported in other studies, [5,7,8,24,30,33,39] and the consistency of items on IPAQ with variables known to be related to PA such as BMI, blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index have previously been used as important construct validity measures.[7,10,21,24] Another limitation of the study is the use of non-probability sampling technique. The study finding may have limited generalizability to other samples of Nigerians that have different characteristics from this sample. In addition, the majority of participants have more than secondary school education with potentially higher comprehension and recall ability than may be found in the general population. Nevertheless, recruitment from diverse neighbourhoods and settings allowed for a sample with reasonable heterogeneity in age, occupational status, and ethnic backgrounds and made it possible to stratify the analyses by sociodemographic characteristics. However, because some of the participants in the present study required assistance to complete the survey, interview administration rather than self-administration of the IPAQ-LF should be encouraged in any future national studies in the African region. Administering the IPAQ through interview has been considered as a viable and preferred option in developing countries.[5]

Conclusions

Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence of test-retest reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could further contribute to our understanding of the impact of multiple levels of influence on PA behaviours of people in the African region.

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Contributors

ALO conceived and designed the study, contributed to cultural adaptation and acquisition of data, conducted the statistical analysis and interpretation of data and drafted the manuscript. UMB and STP managed participants' recruitment and data collection and contributed to cultural adaptation. HBN and RDM contributed to cultural adaptation and translations of the measure. AYO contributed to study design, acquisition of data and critically revised the manuscript for important intellectual contents. All authors read and approved the final manuscript.

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Competing interests

Authors declare there is no competing interest associated with this study.

Ethics approval

Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria (ADM/TH/EC/75).

Data sharing process

Dataset for this study available upon request from the corresponding author.

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Table 1. Descriptive characteristics of the participants (N=180)

Variables	Total sample (N=180)	Men (n=90, 50%)	Women (n=90, 50%)
Age (years)			
Mean (± SD)	35.6 ± 10.3	35.7 ± 8.3	35.5 ± 11.9
Marital status (n, %)*			
Not Married	74(41.1)	48(53.3)	26(28.9)
Married	106(58.9)	42(46.7)	64(71.1)
BMI (Kg/m^2)			
Mean (± SD)	23.8 ± 3.9	23.8 ± 3.5	23.8 ± 4.4
BMI Category (n, %)			
Underweight	14 (7.8)	4 (4.4)	10 (11.1)
Normal weight	107 (59.4)	58 (64.4)	49 (54.4)
Overweight/obese	59 (32.8)	28 (31.2)	31 (34.5)
Ethnicity (n, %)			
Hausa/Fulani	21(11.7)	10.1(11.1)	11(12.2)
Igbo	8(4.4)	5(5.6)	3(3.3)
Yoruba	10(5.6)	6(6.7)	4(4.4)
Kanuri/Shuwa Arab	44(24.4)	23(25.6)	21(23.3)
Others	97(53.9)	46 (51.1)	51(56.7)
Educational level (n, %)*			
> Secondary School	111 (62.7)	11 (12.2)	17(19.5)
Secondary	38 (21.5)	10 (11.1)	28(32.5)
<Secondary School	28 (15.8)	69 (76.7)	42(48.2)
Occupational Status (n, %)*			
Unemployed	63(35)	16(17.8)	47(52.2)
Blue Collar	45(25)	28(31.1)	17(18.9)
White Collar	72(40)	46(51.1)	26(28.9)

*- Significant difference between samples (p<0.05)
BMI- Body Mass Index

Table 2: Test-reliability based on intra-class correlation coefficient for Hausa IPAQ– LF, overall and by gender

	Total (N=180)			Women (n=90)	Men (n=90)
PA Measure (MET×min/wk)	**Test 1 (Mean (SD))**	**Test 2 (Mean (SD))**	**ICC (95%CI)**	**ICC (95%Cl)**	**ICC (95%Cl)**
Total PA, all domain	2160.6 (2691.1)	1612.8 (1612.8)	0.76 (0.65-0.82)	0.45 (0.08-0.67)	0.80 (0.69- 0.87)
Occupation	619.1(1671.5)	497.5 (1332.9)	0.77 (0.68-082)	0.64 (0.46-0.77)	0.78 (0.66 -0.85)
Active Transport	468.1 (684.7)	440.5 (605.7)	0.82 (0.75-0.87)	0.63 (0.40-0.77)	0.83 (0.73 - 0.89)
Domestic	597.6 (754.6)	473.4 (673.7)	0.50 (0.32-0.62)	0.38 (0.01-0.57)	0.33 (-0.01-0.56)
Leisure	377.0 (1096.3)	196.7 (920.2)	0.71 (0.60-0.78)	0.69 (0.53-0.79)	0.75 (0.63-0.84)
Sitting	2263.0 (715.8)	2235.4 (818.9)	0.62 (0.42-0.75)	0.71 (0.46-0.85)	0.48 (0.06-0.72)
PA by Intensity (MET×min/wk)					
Walking	613.6 (635.6)	534.6 (449.1)	0.63 (0.48-0.74)	0.57 (0.29-0.74)	0.65 (0.44-0.78)
Moderate	986.9 (1365.9)	716.1 (1164.6)	0.61 (0.46-0.71)	0.42 (0.11-0.62)	0.67 (0.49-0.78)
Vigorous	526.5 (1543.7)	394.1 (1431.1)	0.82 (0.76-0.87)	0.55 (0.30-0.71)	0.86 (0.78-0.91)

PA= Physical Activity
MET= Metabolic Energy Turnover

Table 3: Socioeconomic status differences in test- retest reliability of the Hausa IPAQ- LF (N= 180)

Socioeconomic Status	Overall PA	Active Transport	Occupation PA	Leisure PA	Domestic PA	Sitting
Educational Qualification						
More than secondary school (n=111)	0.42 (0.08-0.63)	0.67 (0.43-0.78)	0.32 (-0.06-0.57)	0.33 (-0.05-0.57)	0.58 (0.35-0.73)	0.23 (-0.63-0.63)
Secondary School (n=38)	0.55 (0.22-0.74)	0.28 (-0.21-0.57)	0.58 (0.33-0.74)	0.54 (0.25-0.71)	0.50 (0.19-0.69)	0.51 (-0.04-0.76)
Less than Secondary school (n=28)	0.89 (0.67-0.96)	0.90 (0.74-0.96)	0.82 (0.61-0.92)	0.92 (0.83-0.96)	0.90 (0.78-0.95)	0.77 (0.45-0.90)
Employment Category						
Employed (117)	0.80 (0.67-0.96)	0.83 (0.74-0.88)	0.79 (0.70-0.86)	0.79 (0.69-0.85)	0.36 (0.08-0.56)	0.56 (0.23-0.75)
Unemployed (63)	0.09 (-8.86-0.56)	0.68 (0.44-0.82)	0.16 (-0.39-0.49)	0.25 (-0.24-0.55)	0.65 (0.43-0.79)	0.68 (0.36-0.80)

PA= Physical Activity

Table 4: Differences in time spent in physical activity overall, and by gender and socioeconomic status sub groups

		Gender		Education			Employment	
	Total Mean ± SD	**Men** Mean ± SD	**Women** Mean ± SD	**>Secondary** Mean ± SD	**Secondary** Mean ± SD	**<Secondary** Mean ± SD	**Employed** Mean ± SD	**Unemployed** Mean ± SD
PA by domain (min/wk)								
Total PA, all domain								
IPAQ1	405.2 (507.8)	460.7 (582.9)	326.8 (367.8)	334.0 (400.8)	384.8 (514.8)	849.2 (764.1)**	441.1 (530.2)	285.1 (408.6)*
IPAQ2	308.4 (440.3)	319.7 (522.8)	291.9 (282.9)	285.1 (295.1)	184.8 (264.4)	803.0 (929.6)**	359.4 (481.6)	141.0 (185.2)*
Active Transport								
IPAQ1	35.8 (89.7)	52.4 (127.7)	19.5 (17.7)*	28.3 (47.7)	28.9 (45.02)	76.4 (198.7)*	43.8 (109.4)	21.1 (21.9)*
IPAQ2	30.4 (76.7)	41.2 (106.3)	19.3 (17.5)*	23.6 (30.6)	20.3 (30.9)	74.3 (182.6)*	36.9 (94.1)	18.3 (14.7)*
Work								
IPAQ1	160.1 (380.8)	217.5 (466.8)	79.1 (179.9)*	114.8 (291.0)	122.9 (365.6)	546.7 (615.7)**	195.5 (418.8)	41.8 (162.2)*
IPAQ2	135.3 (310.3)	172.5 (372.8)	80.6 (171.9)*	104.1 (232.2)	160.9 (196.1)	531.6 (595.8)**	164.1 (341.7)	40.1 (133.0)*
Domestic								
IPAQ1	159.6 (202.2)	82.3 (120.6)	236.9 (235.8)**	141.2 (182.4)	173.3 (238.5)	165.4 (159.4)	132.1 (170.7)	210.6 (243.8)*
IPAQ2	123.9 (163.9)	52.4 (74.9)	195.5 (190.1)**	131.9 (182.5)	107.6 (130.4)	147.3 (189.1)	112.6 (163.9)	205.0 (163.3)*
Leisure								
IPAQ1	62.4 (159.1)	75.0 (211.1)	10.5 (27.3)**	47.0 (97.3)	92.7 (209.4)	38.2 (160.1)	69.7 (157.6)	48.7 (162.3)
IPAQ2	30.5 (118.2)	50.6 (160.7)	10.1 (38.5)**	23.4 (51.4)	24.7 (91.4)	71.5 (256.5)	43.1 (143.5)	17.0 (28.7)*
Sitting								
IPAQ1	2263.0 (715.8)	2188.8 (759.7)	2330.7 (674.8)	2280.0 (618.7)	2433.9 (693.7)	2180.9 (760.8)	2159.4 (775.9)	2337.6 (667.2)
IPAQ2	2235.4 (819.9)	2208.7 (916.9)	2259.6 (728.1)	2420.7 (638.7)	2215.3 (663.1)	2160.0 (1111.4)	2170.6 (870.5)	2282.0 (785.5)
PA by Intensity (min/wk)								
Walking								
IPAQ1	178.5 (221.5)	241.1 (271.9)	128.2 (100.8)*	194.4 (268.1)	133.4 (85.6)	266.9 (285.4)*	192.0 (245.7)	133.3 (96.2)*
IPAQ2	142.5 (141.8)	148.5 (137.9)	133.7 (147.9)	151.7 (138.4)	103.6(94.7)	200.3 (209.1)*	150.7 (146.6)	115.4 (122.7)
Moderate								
IPAQ1	201.9 (326.9)	193.0 (214.5)	214.5 (247.8)	187.3 (266.5)	194.9 (386.5)	309.7 (381.7)	221.2 (347.4)	137.7 (239.9)
IPAQ2	133.9 (238.5)	114.2 (276.9)	162.7 (165.6)	132.9 (177.8)	88.0 (197.2)	319.0 (482.1)*	153.9 (266.2)	68.0 (76.4)*
Vigorous								
IPAQ1	94.1 (211.8)	123.7 (249.6)	52.2 (133.2)*	32.9 (81.9)	129.5 (208.2)	268.0 (459.7)**	90.2 (214.6)	127.1 (204.6)
IPAQ2	78.4 (206.9)	86.8 (227.4)	46.2 (73.4)	52.2 (140.2)	55.2 (127.0)	292.8 (461.5)**	92.8 (226.9)	130.9 (107.8)

PA= Physical Activity
*=p<0.05
**=p<0.001

Table 5: Construct validity of Hausa IPAQ-LF: Spearman correlations between energy expenditure (MET×min/wk) from Hausa IPAQ– LF, and anthropometric and biological variables (N=180)

	Overall (N = 180)			Female (n = 90)			Male (n = 90)		
MET×min/wk	BMI	DBP	SBP	BMI	DBP	SBP	BMI	DBP	SBP
PA Domains									
Total PA	-0.29**	-0.17*	-0.09	-0.09	-0.23**	-0.04	-0.41**	-0.08	-0.14
Occupation PA	-0.12	-0.09	0.01	0.02	0.02	-0.05	-0.22**	-0.17	-0.08
Active transport PA	-0.05	-0.04	-0.01	-0.10	-0.13	-0.02	-0.04	-0.02	-0.80
Domestic PA	-0.07	-0.17*	-0.26**	-0.23**	-0.20*	-0.31**	0.04	-0.14	-0.04
Leisure PA	0.09	-0.08	-0.16*	-0.11	0.02	0.08	-0.39**	-0.12	-0.06
Sitting	0.16	-0.09	0.04	0.19	0.12	0.05	0.15	-0.09	0.05
PA Intensity									
Walking	0.90	-0.09	-0.03	0.19	-0.05	0.08	-0.05	-0.11	-0.15
Moderate	-0.02	0.21*	0.16*	0.02	-0.14	-0.08	0.02	-0.25**	-0.16
Vigorous	-0.11*	-0.06	0.03	-0.16	0.01	0.02	-0.13*	-0.12	-0.11

MET= Metabolic Energy Turnover
BMI= Body Mass Index
DBP= Diastolic Blood Pressure
SBP= Systolic Blood Pressure
PA= Physical activity
*=p<0.05,
**=p<0.01

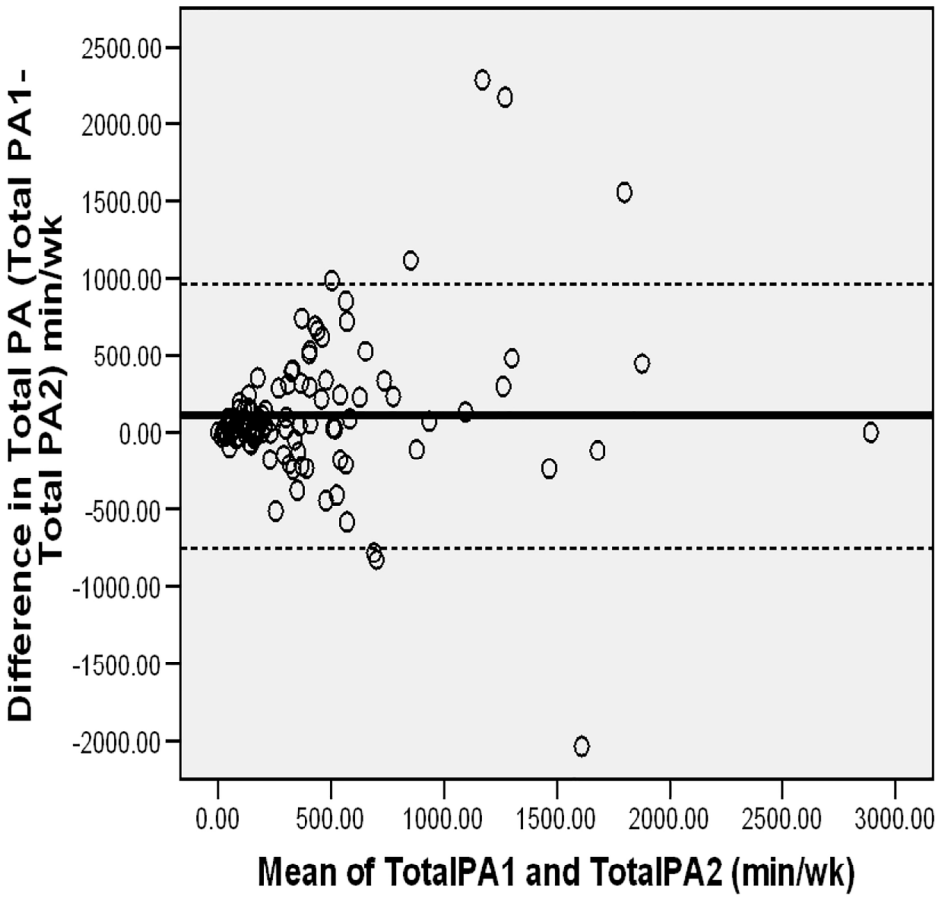

Figure 1: Bland-Altman plot min/wk reported in total physical activity (PA for the first and second administrations of Hausa IPAQ-LF. Mean difference:106.7 +/- 2SD (Standard deviation)= -762.2 to 965.6

238x265mm (300 x 300 DPI)

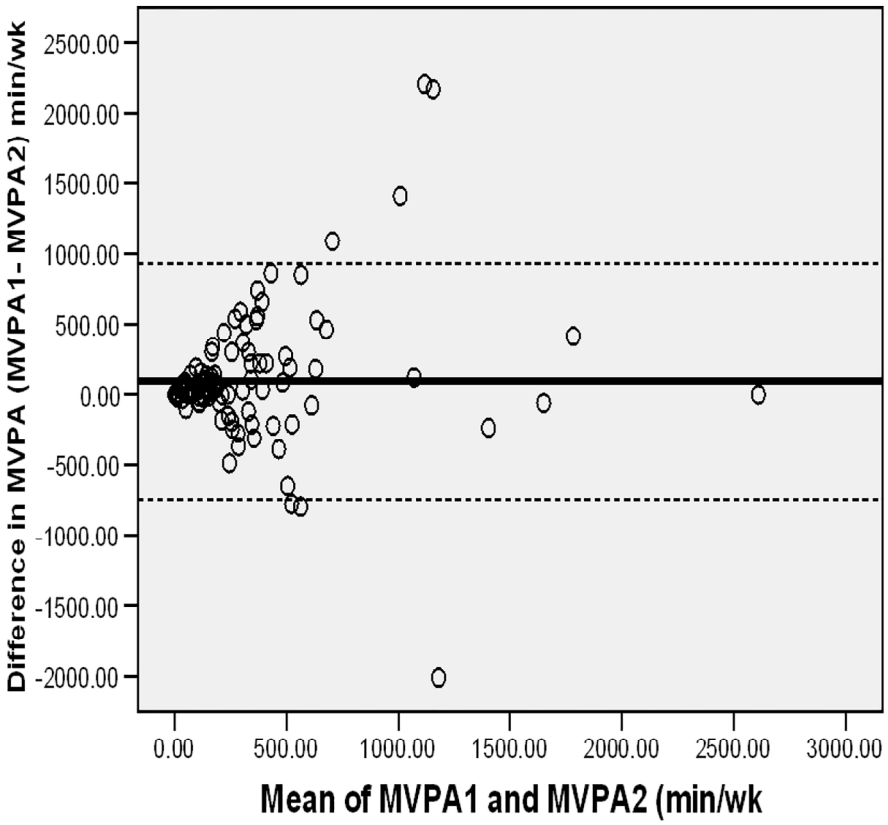

Figure 2: Bland-Altman plot for min/wk reported in moderate-to-vigorous physical activity (MVPA) for the first and second administrations of Hausa IPAQ-LF: Mean difference: 91.6 +/- 2SD (Standard Deviation)=-744.5 to 927

239x287mm (300 x 300 DPI)

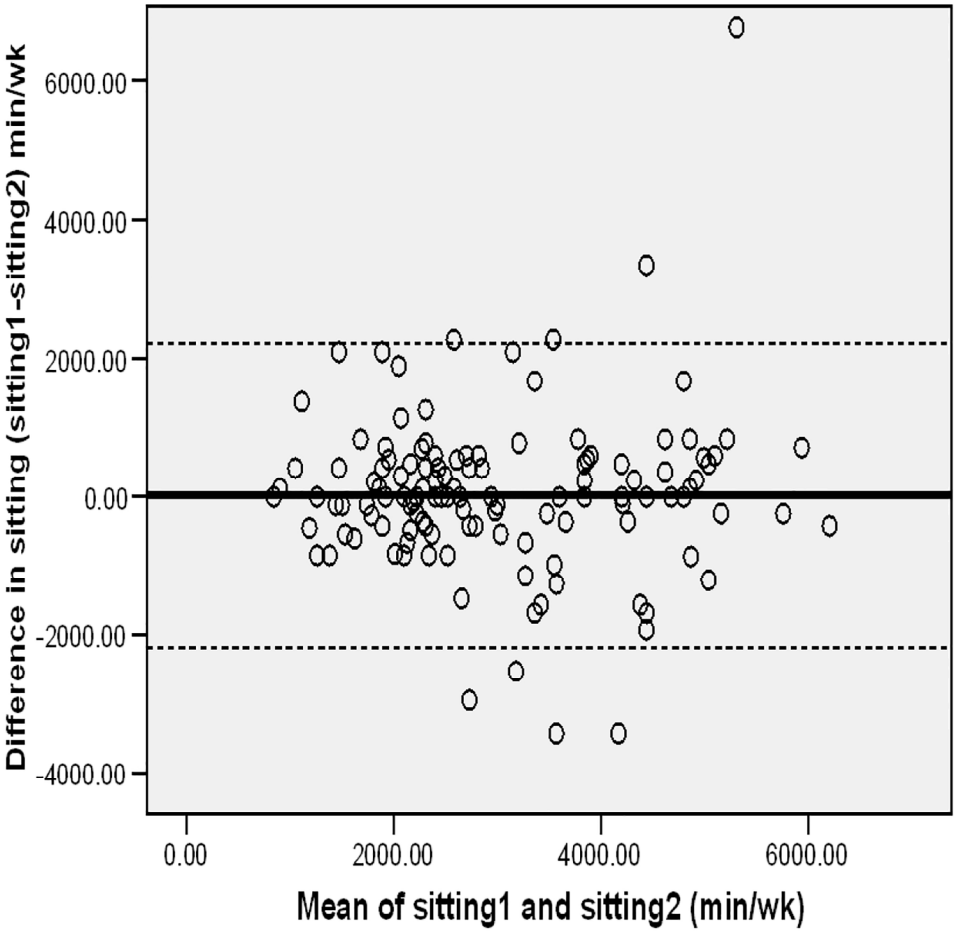

Figure 3: Bland-Altman plot min/wk reported in sitting for the first and second administration of Hausa IPAQ-LF. Mean difference: 26.4 =+/- 2SD (Standard Deviation)= -2178.1 to 2230.9

236x259mm (300 x 300 DPI)