

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2014-005820
Article Type:	Research
Date Submitted by the Author:	29-May-2014
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Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Sports and exercise medicine
Keywords:	PUBLIC HEALTH, SOCIAL MEDICINE, EPIDEMIOLOGY

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3 1 **Examining the reliability and validity of a modified version of the International Physical**
4 **Activity Questionnaire, long form (IPAQ-L) in Nigeria**
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31 18 **Key words:** Physical activity, measurements, public health, IPAQ, Nigeria
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20 **Word counts:** 4153

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33 ABSTRACT

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

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

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

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

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

45 **Results:** The Hausa IPAQ-LF demonstrated good test-retest reliability ($ICC > 0.75$) for total PA
46 ($ICC = 0.79$, 95% CI=0.65-0.82), occupational PA ($ICC = 0.77$, 95% CI=0.68-0.82), active
47 transportation ($ICC = 0.82$, 95% CI=0.75-0.87) and vigorous intensity activities ($ICC = 0.82$, 95%
48 CI=0.76-0.87). Reliability was substantially higher for total PA ($ICC = 0.80$), occupational PA
49 ($ICC = 0.78$), leisure-time PA ($ICC = 0.75$) and active transportation ($ICC = 0.80$) in men than
50 women, but domestic PA ($ICC = 0.38$) and sitting time ($ICC = 0.71$) demonstrated substantial
51 reliability coefficients in women than men. For the construct validity, domestic PA was
52 significantly related mainly with SBP ($\rho = -0.27$) and DBP ($\rho = -0.17$), and leisure-time PA and
53 total PA were significantly related only with SBP ($\rho = -0.16$) and BMI ($\rho = -0.29$), respectively.
54 Similarly, moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP (ρ
55 = -0.21 , $p < 0.01$), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$).

56 **Conclusions:** The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest
57 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.

106 INTRODUCTION

107
108 The importance of physical activity (PA) for promoting health and preventing disease is well
109 established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it
110 is important to have standardized, reliable and valid instruments that can be used to accurately
111 describe population levels and patterns of PA within and across countries.[4, 5] In this context,
112 the international physical activity questionnaire (IPAQ) was developed to obtain internationally
113 comparable data on health-related physical activity of adults (18-65 years).[5, 6] Two versions of
114 the IPAQ that could be administered by interview or self-completed were developed. The short
115 form (SF) was designed for population surveillance of PA; while the long form (LF) was
116 designed to be appropriate for use in research that requires detailed information on different PA
117 domains, including PA at work, household, during leisure and transportation, and time spent in
118 sedentary activities.[6]

119
120 The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of
121 reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in
122 order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts
123 have been made to translate and adapt the IPAQ in many other countries, but most of the
124 research in this context were from the Western developed countries.[7-14] In Africa, the
125 psychometric properties of IPAQ have only been tested in South-Africa as part of the initial
126 development process of the questionnaire,[5] and in older adults.[15] Because the largest
127 increases and burden of non-communicable diseases (NCDs) are in the low-income countries
128 where the understanding of evidence-based strategies for increasing PA remains poor,[16-19]
129 improving PA research is a top priority for low-income countries.[20] However, to advance PA
130 research in Africa, it is important to first develop or tailor standardized measures to be culturally
131 sensitive to PA behaviours of people in the region countries. Because Nigeria is the most
132 populous country in Africa with culture and languages similar to most of the other West African
133 countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this
134 country.

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3 136 Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in
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5 137 Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other
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7 138 studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide
8
9 139 context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for
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11 140 relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF
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13 141 in sub-Saharan African countries can impact PA research and surveillance in the African region
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15 142 where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the
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17 143 present study was to investigate the test-retest reliability and construct validity of a modified
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19 144 version of the IPAQ-LF among adults in Nigeria.
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21 146 **METHODS**

24 148 **Participants**

26 149 A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status
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28 150 and walkability in Maiduguri city were recruited for the study. The neighbourhood selection
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30 151 strategy has been described in details elsewhere.[26] Maiduguri with an estimated population of
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32 152 749,123 people is the largest and capital city of Borno State in North-Eastern Nigeria.[27] The
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34 153 city attracts immigrants from neighbouring countries of Cameroon, Niger and Chad Republic,
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36 154 and Hausa language is the common means of communication for commercial activities among
37
38 155 the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this study if they were
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40 156 willing to complete a written survey twice in English Language, the official language in Nigeria.
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42 157 Additional eligibility criteria included living within the identified neighbourhood categories in
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44 158 the last 12 months, being adults (18-65 years) and not having any disability that prevented
45
46 159 independent walking. All participants were fully informed of the study protocol and provided
47
48 160 written informed consent. The study protocol was approved by the Research and Ethic
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50 161 Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were
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52 162 collected between March and May, 2012.
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53 164 **Measures**

55 165 *The adapted international physical activity questionnaire- long Hausa version*

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3 166 The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is
4
5 167 similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly,
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7 168 interviews were conducted with public health experts, exercise scientists and not highly educated
8
9 169 local people to identify the items and examples of PA on the original questionnaires that needed
10
11 170 to be culturally adapted. Several cultural adaptations were made to the original items to reflect
12
13 171 the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity
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15 172 that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with
16
17 173 words that are more representative of the language used in Nigeria, like 'very hard' and 'hard'
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19 174 respectively. Second, examples of various intensities of activity that were common in the
20
21 175 Nigerian culture were added, and those already on the questionnaire but not common in the
22
23 176 Nigerian context were replaced with culturally applicable examples that are equivalent in energy
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25 177 intensity (METs) with the original items and examples. Third, concepts like physical activity and
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27 178 walking for transportation that were misconstrued outside the health context were refined to
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29 179 indicate they were referring to health behaviours.

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31 181 After adaptation, the questionnaire was independently translated from English into Hausa
32
33 182 language by two native speakers of Hausa who also speaks English, and able to read and write in
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35 183 both languages. One of the translators was familiar with the questionnaire and the second was an
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37 184 expert in Hausa language. The translated questionnaires were mutually revised by the translators
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39 185 and the research team for consistency and then back translated into English language by a third
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41 186 bilingual person who was familiar with the construct measured by IPAQ. The back translated
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43 187 version was checked by the research team for any discrepancies and to ensure that the construct
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45 188 measures by IPAQ had not been lost during the adaptation and translation process.

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47 190 The modified questionnaire, hereafter referred to as the Hausa version of the long international
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49 191 physical activity questionnaire (Hausa IPAQ-LF), contains thirty-one questions that asked about
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51 192 physical activity done in the last 7-days in terms of frequency (days/week) and duration
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53 193 (min/day) spent in four activity domains (transportation, occupation, domestic and leisure time),
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55 194 and included sections on walking, moderate- and vigorous- intensity activities, and time spent in
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57 195 sedentary behaviours (sitting during leisure and motorized transportation). The Hausa IPAQ-LF

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3 196 data were presented as the MET-min/week for total walking, moderate, and vigorous intensity
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5 197 activity and overall physical activity across the four domains, and in each of the domains. The
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7 198 MET intensity values used to score the Hausa IPAQ-LF questions in this study were 8 METs for
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9 199 vigorous activity, 4 METs for moderate activity and 3.3 METs for walking,[2, 6] One MET
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11 200 represents the energy expended while sitting quietly at rest and is equivalent to 3.5 ml/kg/min of
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13 201 VO₂ Max.[3] To assess the test-retest reliability of the Hausa IPAQ-LF, participants completed
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15 202 all items on the measure twice, with an interval of one week between administrations.
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18 204 *Anthropometrical and biological measurements*

19 205 Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing
20
21 206 using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight
22
23 207 divided by the square of height (kg/m²). The principal cutoff points as recommended by WHO
24
25 208 were used to create the categories: underweight (< 18.5 kg/m²), normal weight (18.5– < 25
26
27 209 kg/m²), overweight (25– <30kg/m²) and obese (≥30 kg/m²).[28] Resting blood pressure and heart
28
29 210 rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood
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31 211 Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure
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33 212 (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study,
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35 213 construct validity was evaluated by investigating the relationship of outcomes from the Hausa
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37 214 IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also by
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39 215 comparing the differences in time spent in PA and sitting across sociodemographic subgroups.
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41 216 These types of validation for PA measures have been referred as indirect or construct validity in
42
43 217 previous studies.[7,24,30]
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45 219 *Sociodemographic Characteristics*

46 220 Information on age, gender, marital status, religion, income, educational level and employment
47
48 221 status were elicited from the participants. Marital status was classified as married or not married.
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50 222 Educational level was classified as more than secondary school education, secondary school
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52 223 education and less than secondary school education. Employment status was classified into white
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54 224 collar (government or private employed), blue collar (self- employed, trader, artisan etc) and
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56 225 unemployed (homemaker, student, retired, or unable to find job).
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227 **Data Analysis**

228 Descriptive data were reported as mean, standard deviation and percentages. Mean group
229 differences for continuous variables by gender were examined by independent t-test, and for
230 dichotomous variables by chi-square statistics. The two- way mixed model (single measure)
231 intraclass correlation coefficient (ICC) with 95% confidence interval (CI) was utilized to
232 evaluate test-retest reliability of the instrument. The reliability analyses were conducted overall,
233 and by gender and socioeconomic status. ICC estimates >0.75 were considered as good
234 reliability scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31]
235 To assess construct validity, the non-parametric Spearman correlation coefficients (ρ) were
236 utilized to explore the relationship between MET-min/week of PA from the Hausa IPAQ- LF,
237 and resting blood pressure and body mass index. Independent t-test and one-Way ANOVA were
238 used as appropriate to compare the time spent (minutes/week) in PA across sociodemographic
239 subgroups. Data were analyzed using Statistical Package for the Social Science (SPSS), version
240 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at
241 $p<0.05$.

242

243 **RESULTS**

244 The socio-demographic characteristic of the participants are shown in Table 1. The participants
245 comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of
246 $23.8 \pm 3.9\text{kg/m}^2$. Majority of the participants were married (58.9%, $n=106$), had more than
247 secondary school education (62.7%, $n=111$) and were employed (75%, $n=117$). Compared to
248 men, the women were more likely to be married (71.1% vs 46.7%, $p=0.001$) and unemployed
249 (52.2% vs 17.8%, $p<0.001$), but men were more likely to have more than secondary school
250 education (76.7% vs 48.2%, $p<0.001$).

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252 **Test-retest Reliability**

253 Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients
254 were good (ICC >0.75) for total PA, occupational PA, active transportation and vigorous intensity
255 (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability

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3 256 (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95%
4 CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA
5 257 (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were
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7 258 substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38,
8 259 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women
9 260 than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest
10 261 value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity
11 262 (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous
12 263 intensity (very hard) activities were substantially greater in men than women.
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21 266 Similarly, socioeconomic status differences were observed in the reliability coefficients of the
22 267 modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were
23 268 substantially higher among participants with less than secondary school education (ICC from
24 269 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school
25 270 education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and higher than
26 271 secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]). While
27 272 reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active
28 273 transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and
29 274 leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed
30 275 compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95%
31 276 CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were
32 277 unemployed than in the employed subgroup.
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279 **Construct Validity**

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46 280 Overall, correlations between energy expenditure (MET-Min/wk) according to the modified
47 281 IPAQ-LF and anthropometric and biological measures were statistically significant in the
48 282 expected direction for all domains and intensities of PA, except for occupation and active
49 283 transport domains and walking (table 4). In the full sample, domestic PA was mainly related with
50 284 SBP ($\rho = -0.27$, $p < 0.01$) and DBP ($\rho = -0.17$, $p < 0.05$), while leisure PA and total PA were only
51 285 related with SBP ($\rho = -0.16$, $p < 0.05$) and BMI ($\rho = -0.29$, $p < 0.01$), respectively. Similarly,
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3 286 moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP ($\rho = -0.21$, $p <$
4 287 0.01), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$). In the gender
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6 288 based analyses, total PA, domestic PA and sedentary time were more consistently related with
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8 289 anthropometric and biological variables. The strongest rho value (-0.41) was found for the
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10 290 relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was
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12 291 reached between total PA and DBP for the women subgroup. Only in women was domestic PA
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14 292 significantly related with BMI ($\rho = -0.23$), DBP ($\rho = -0.20$) and SBP ($\rho = -0.31$). Leisure-time
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16 293 PA ($\rho = -0.39$) and occupational PA ($\rho = -0.22$) were significantly related with BMI only in men.
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18 294 The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ
19 295 $= 0.19$) than men ($\rho = 0.15$).
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23 297 Table 5 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1)
24 298 and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified
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26 299 variables, time spent in PA reported during the first administration tends to be higher than those
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28 300 reported during the second administration. At both time points, men reported significantly
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30 301 ($p < 0.05$) higher mean time (Min week⁻¹) in active transportation, occupational PA, and leisure-
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32 302 time PA than women. However, women spent significantly ($p < 0.001$) more time (Min week⁻¹) in
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34 303 domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status,
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36 304 participants that had lower than secondary school education compared to those with at least
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38 305 secondary school education reported statistically significant higher mean time (Min week⁻¹) at
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40 306 both time points for total PA, active transport, occupational PA, walking and vigorous intensity
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42 307 activity compared to those with at least secondary school education. While participants that were
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44 308 employed reported statistically significant ($p < 0.05$) more time (Min week⁻¹) in total PA
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46 309 (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1,
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48 310 IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those
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50 311 who were unemployed, the unemployed reported statistically significant ($p < 0.05$) higher time in
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52 312 domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.
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53 314 **DISCUSSION**

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3 315 This study examined aspects of reliability and validity of a modified version of the IPAQ-LF in
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5 316 Nigeria. The findings generally indicated acceptable test-retest reliability and construct validity
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7 317 for items of the modified IPAQ-LF among Nigerian adults. To the best of our knowledge, the
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9 318 present study is the only one to examine the reliability and validity of the long version of IPAQ
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11 319 that has been modified specifically to an indigenous African culture and language.
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14 321 We found evidence for good reliability with high correlations between the test-retest for total
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16 322 PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that
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18 323 except for domestic PA and sitting time, ICC values for domains of PA were consistently above
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20 324 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[32,33]
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22 325 Similar to a previous IPAQ-LF study in Hong Kong,[33] domestic activity demonstrated the
23
24 326 lowest ICC value in our study. However, it is possible that the infrequent nature of household
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26 327 activities undertaken, especially by men may account for the low reliability reported for domestic
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28 328 PA in our study. In addition to the traditional African patriarchal belief that make most African
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30 329 men to rarely engage in indoor household activities, men in the high socioeconomic group in
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32 330 Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home,
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34 331 appliances and equipment maintenance because they are able to employ the services of domestic
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36 332 helpers and repair men. Our findings of lower reliability for domestic activity among men, those
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38 333 with more than secondary school education and those who were employed compared to their
39
40 334 counterparts seem to support this assumption.
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43 336 The highest and strongest reliability coefficients (0.82) were found for both active transportation
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45 337 and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and
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47 338 reproducible overtime than other PA domains because it is a common and ubiquitous PA
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49 339 behaviour in the African region. Mostly, the performance of active transportation especially
50
51 340 walking is often out of necessity rather than choice within the African context. Our finding of
52
53 341 higher ICC value for vigorous intensity PA is consistent with those of other studies that found
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55 342 the reliability of vigorous intensity activity to be higher compared to that of moderate intensity
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57 343 activity.[10, 30, 33, 34] Compared to structured vigorous physical activities like sports and
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59 344 exercise that can be more easily recalled, moderate intensity PA are often of low salience,
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3 345 incidental and may not easily be remembered by people.[35, 36] Further our finding that the
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5 346 reliability of vigorous intensity physical activity was meaningfully higher among men than
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7 347 women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria
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9 348 are more consistent than women when responding to PA items that pertained to intense vigorous
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11 349 PA than other intensities of activity. Overall, the moderate to good evidence of reliability found
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13 350 for all items indicates that the modified IPAQ-LF is reproducible, internally consistent and is
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15 351 promising for research in Nigeria.

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18 353 In the absence of objective criterion standards for evaluating an absolute estimate of PA, the
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20 354 consistency of items on IPAQ with variables known to be related to PA such as body mass index
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22 355 (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index
23
24 356 have been used as important construct validity measures.[7, 10, 21, 24] In the present study, the
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26 357 correlations of the PA domains and intensities with biological and anthropometric variables were
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28 358 mostly significant in the expected direction, but they were low suggesting a modest evidence of
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30 359 construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were
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32 360 comparable with the values in other studies that have evaluated the IPAQ-LF.[5, 7, 8, 24, 30, 33,
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34 361 37] Because better validity coefficients have been reported for other PA measures above that of
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36 362 the IPAQ,[37, 38] with the present African finding, it is possible that the IPAQ-LF only have
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38 363 modest evidence of construct validity Worldwide.

39 364
40 365 One interesting finding was that total PA was strongly and inversely related with BMI of men
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42 366 and women. This is biologically plausible because total energy expenditure would be expected to
43
44 367 have the strongest effects on BMI. Similarly, domestic PA was related with resting blood
45
46 368 pressure and BMI in the expected direction, and this was mainly among women. Contrarily, no
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48 369 such gender based associations of domestic PA with health variables were found in previous
49
50 370 studies of the western developed countries.[10, 24] It is possible that African women are
51
52 371 accumulating domestic related PA at sufficient intensities needed to circumvent deleterious
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54 372 health outcomes. This kind of finding has implications for intervention strategies formulation,
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56 373 considering that domestic activities are common and dominant PA behaviour among women in
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58 374 Africa. In the present study, only in the domains of sitting and domestic PA did women

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3 375 accumulate more time than men. Perhaps, promotion of the typical domestic related activities
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5 376 like households chores, sweeping of compound and pounding of grains as integral components of
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7 377 health enhancing PA (HEPA) of women in Nigeria could be an important public health strategy
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9 378 for controlling the rising incidence of NCDs in this country, where current estimates indicate the
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11 379 prevalence of overweight/obesity as 33.3% (37.7% women and 28.8% men) and that NCDs
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13 380 already account for 27% (28.5% in women; 25.45 in men) of all deaths.[39]

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16 382 Similar to the finding of a Mexican study,[40] we found scores on the modified IPAQ-LF to be
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18 383 consistently lower during the second administration of the questionnaire compared to the first
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20 384 administration. Because familiarity with the IPAQ questions may improve over multiple
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22 385 exposures to the questionnaire, it is possible that participants in our study might have over-
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24 386 reported their PA levels during the first administration of the IPAQ. This kind of findings may
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26 387 have implication for the utility of IPAQ for surveillance. Generally, due to issues of social
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28 388 desirability phenomenon and over reporting of PA that has been associated with the
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30 389 IPAQ,[37,41] it may be necessary to start considering the need for multiple measurements when
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32 390 using the IPAQ for evaluating PA, especially in developing African countries. However, patterns
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34 391 of PA as measured by the modified IPAQ-LF during both administrations were consistently
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36 392 similar, and both administrations were able to discriminate PA in the expected direction between
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38 393 subgroups of our sample. For example, at both measurement time points, and consistent with
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40 394 hypothesis, men reported more time in active transportation, occupational PA and leisure PA
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42 395 than women, while women reported more time in domestic PA and sedentary activity than men.
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44 396 These suggest an additional support for evidence of construct validity for the modified IPAQ-LF
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46 397 in Nigerian adults.

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48 399 **Strengths and limitations**

49 400 A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to
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51 401 reflect the common PA behaviours of people in Nigeria. This is the first study in an African
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53 402 country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings
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55 403 demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse
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57 404 segment of the Nigerian population. In the Africa region, the importance of a valid and

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3 405 established PA scale like the modified IPAQ-LF is not only important to monitoring the domain
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5 406 in which activity is performed, but also very critical to understanding studies of ecological
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7 407 models of health behaviours, that emphasize the importance of multiple levels of influence on
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9 408 health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using
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11 409 ecological models indicate that favourable built environmental attributes are promising for
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13 410 improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45]
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15 411 However, built environment characteristics are expected to be strongly related to specific PA
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17 412 types rather than overall PA.[46, 47] For example, different environmental variables can be
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19 413 related to walking for leisure or transportation and to moderate PA for household, occupation,
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21 414 recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to
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23 415 understanding the domain specific nature of ecological model research in the African region.
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25 416 One additional strength was the exploration of PA patterns by gender, educational level and
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27 417 employment status, the findings of which were consistent with general hypothesis on social
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29 418 patterns of inactivity in low-income countries.[20, 48]

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31 419
32 420 However, the findings of this study should be interpreted in the light of some important
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34 421 limitations. Direct comparison of our validity findings with previous studies should be made with
35
36 422 caution, because unlike in our study, the accelerometer or PA diary were utilized as a common
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38 423 objective criterion standard to validate the IPAQ in the majority of the studies.[5, 7, 8, 24, 30, 33,
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40 424 37] Despite this issue, the validity coefficients in our study were remarkably similar to those
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42 425 reported in these other studies. Because the choice and availability of appropriate criterion
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44 426 measures are particular issues of concern for the validation of PA questionnaires in low-income
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46 427 countries of Africa,[5, 49, 50] the use of simple and less expensive measures like biological and
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48 428 anthropometric variables may represent a useful alternative. Another limitation of the study is
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50 429 the use of non-probability sampling technique. The study finding may have limited
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52 430 generalizability to other samples of Nigerians that have different characteristics from this
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54 431 sample. In addition, the majority of participants have more than secondary school education with
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56 432 potentially higher comprehension and recall ability than may be found in the general population.
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58 433 However, recruitment from diverse neighbourhoods and settings allowed for a sample with
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3 434 reasonable heterogeneity in age, occupational status, and ethnic backgrounds and made it
4 possible to stratify the analyses by sociodemographic characteristics.
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9 437 **Conclusions**

10 438 Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence
11 of test-retest reliability and may be valid for assessing context specific PA behaviours of adults
12 in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could
13 further contribute to our understanding of the impact of multiple levels of influence on physical
14 activity behaviours of people in the African region.
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23 445 **Acknowledgments**

24 446 The authors are grateful to Mrs. Salamatu U Aliyu and Mr. Sa'adu Inusa Kiriri for their help
25 with questionnaire translations, and to the participants for their help \for taking part in the study.
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29
30 449 **Contributors**

31 450 ALO conceived and designed the study, conducted the statistical analysis and interpretation of
32 data and drafted the manuscript. UMB and STP managed participants' recruitment and data
33 collection and revised the manuscript for important intellectual contents. HBN and RDM
34 contributed to cultural adaptation and translations of the measure and revised the manuscript for
35 important intellectual contents. AYO contributed to study design, acquisition and interpretation
36 of data and critically revised the manuscript for important intellectual contents. All authors read
37 and approved the final manuscript.
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45
46 458 **Funding**

47 459 This research received no specific grant from any funding agency in the public, commercial or
48 not-for-profit sectors.
49 460
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53 462 **Competing interests**

54 463 Authors declare there is no competing interest associated with this study.
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5 465 **Ethics approval**

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7 466 Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria
8
9 467 (ADM/TH/EC/75).

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12 469 **Data sharing process**

13
14 470 Dataset for this study available upon request from the corresponding author.
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For peer review only

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 (\pm SD)	35.6 \pm 10.3	35.7 \pm 8.3	35.5 \pm 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/m²)			
Mean (\pm SD)	23.8 \pm 3.9	23.8 \pm 3.5	23.8 \pm 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)			Women (n=90)	Men (n=90)
	Test 1 (Mean (SD))	Test 2 (Mean (SD))	ICC (95%CI)	ICC (95%CI)	ICC (95%CI)
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 (0.68-0.82)	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)

MET×min/wk	Overall (N = 180)			Female (n = 90)			Male (n = 90)		
	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)

1 PA= Physical Activity
2 *=p<0.05
3 **=p<0.001
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BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2014-005820.R1
Article Type:	Research
Date Submitted by the Author:	04-Oct-2014
Complete List of Authors:	Oyeyemi, Adewale; University of Maiduguri, Physiotherapy Bello, Umar; University of Maiduguri, Physiotherapy Philemon, Saratu; Jos University Teaching Hospital, Physiotherapy Aliyu, Habibu; University of Maiduguri, Physiotherapy Majidadi, Rebecca; University of Maiduguri, Physiotherapy Oyeyemi, Adetoyeje; University of Maiduguri, Physiotherapy
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Sports and exercise medicine
Keywords:	PUBLIC HEALTH, SOCIAL MEDICINE, EPIDEMIOLOGY

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

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

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20 **Word counts:** 4338

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33 ABSTRACT

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

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

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

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

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

45 **Results:** The Hausa IPAQ-LF demonstrated good test-retest reliability ($ICC > 0.75$) for total PA
46 ($ICC = 0.79$, 95% $CI = 0.65-0.82$), occupational PA ($ICC = 0.77$, 95% $CI = 0.68-0.82$), active
47 transportation ($ICC = 0.82$, 95% $CI = 0.75-0.87$) and vigorous intensity activities ($ICC = 0.82$, 95%
48 $CI = 0.76-0.87$). Reliability was substantially higher for total PA ($ICC = 0.80$), occupational PA
49 ($ICC = 0.78$), leisure-time PA ($ICC = 0.75$) and active transportation ($ICC = 0.80$) in men than
50 women, but domestic PA ($ICC = 0.38$) and sitting time ($ICC = 0.71$) demonstrated substantial
51 reliability coefficients in women than men. For the construct validity, domestic PA was
52 significantly related mainly with SBP ($\rho = -0.27$) and DBP ($\rho = -0.17$), and leisure-time PA and
53 total PA were significantly related only with SBP ($\rho = -0.16$) and BMI ($\rho = -0.29$), respectively.
54 Similarly, moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP (ρ
55 $= -0.21$, $p < 0.01$), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$).

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

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3 66 **ARTICLE SUMMARY**
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5 68 **Strengths and limitations of this study.**
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- 7 69
- 8 70 ▪ Systematic adaptation and tailoring of items on the original IPAQ-LF to reflect the common
9 71 PA behaviours of adults in Nigeria.
 - 10 71
 - 11 72 ▪ The first study to describe the cultural adaptation and translations of the IPAQ-LF and
12 72 explore its psychometric relevance in an African country.
13 73
 - 14 73
 - 15 74 ▪ Findings establish evidence to support the feasibility of using a modified IPAQ-LF to
16 74 reliably collect context specific PA behaviours of adults in the African region.
17 75
 - 18 75
 - 19 76 ▪ Exploring construct validity through the relationships of PA with BMI and resting blood
20 76 pressure was an important limitation of this study.
21 77
 - 22 77
 - 23 78 ▪ The use of non-probability sampling technique may limit generalizability of findings to other
24 78 samples of Nigerian adults with different characteristics from the study's sample.
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106 INTRODUCTION

107
108 The importance of physical activity (PA) for promoting health and preventing disease is well
109 established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it
110 is important to have standardized, reliable and valid instruments that can be used to accurately
111 describe population levels and patterns of PA within and across countries.[4, 5] In this context,
112 the international physical activity questionnaire (IPAQ) was developed to obtain internationally
113 comparable data on health-related PA of adults (18-65 years).[5, 6] Two versions of the IPAQ
114 that could be administered by interview or self-completed were developed. The short form (SF)
115 was designed for population surveillance of PA; while the long form (LF) was designed to be
116 appropriate for use in research that requires detailed information on different PA domains,
117 including PA at work, household, during leisure and transportation, and time spent in sedentary
118 activities.[6]

119
120 The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of
121 reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in
122 order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts
123 have been made to translate and adapt the IPAQ in many other countries, but most of the
124 research in this context were from the Western developed countries.[7-14] In Africa, the
125 psychometric properties of IPAQ have only been tested in South-Africa as part of the initial
126 development process of the questionnaire,[5] and in older adults.[15] Because the largest
127 increases and burden of non-communicable diseases (NCDs) are in the low-income countries
128 where the understanding of evidence-based strategies for increasing PA remains poor,[16-19]
129 improving PA research is a top priority for low-income countries.[20] However, to advance PA
130 research in Africa, it is important to first develop or tailor standardized measures to be culturally
131 sensitive to PA behaviours of people in the region countries. Because Nigeria is the most
132 populous country in Africa with culture and languages similar to most of the other West African
133 countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this
134 country.

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3 136 Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in
4
5 137 Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other
6
7 138 studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide
8
9 139 context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for
10
11 140 relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF
12
13 141 in sub-Saharan African countries can impact PA research and surveillance in the African region
14
15 142 where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the
16
17 143 present study was to investigate the reliability and an aspect of validity of a modified version of
18
19 144 the IPAQ-LF among adults in Nigeria.
20

21 146 **METHODS**

24 148 **Participants**

26 149 A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status
27
28 150 and walkability in Maiduguri city were recruited for the study. The sampling and neighbourhood
29
30 151 selection strategy have been described in details elsewhere.[26] Maiduguri with an estimated
31
32 152 population of 749,123 people is the largest and capital city of Borno State in North-Eastern
33
34 153 Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and
35
36 154 Chad Republic, and Hausa language is the common means of communication for commercial
37
38 155 activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this
39
40 156 study if they were willing to self-complete a written survey twice in either Hausa or English
41
42 157 Language. However, researchers (UMB and STP) were in attendance to provide translation and
43
44 158 interpretation assistance to participants (n=11) who were unable to independently complete the
45
46 159 survey. Additional eligibility criteria included living within the identified neighbourhood
47
48 160 categories in the last 12 months, being adults (18-65 years) and not having any disability that
49
50 161 prevented independent walking. All participants were fully informed of the study protocol and
51
52 162 provided signed informed consent. The study protocol was approved by the Research and Ethic
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54 163 Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were
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56 164 collected between March and May, 2012.
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3 166 **Measures**

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5 167 *The adapted international physical activity questionnaire- long Hausa version*

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7 168 The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is
8
9 169 similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly,
10
11 170 interviews were conducted with public health experts, exercise scientists and not highly educated
12
13 171 local people to identify the items and examples of PA on the original questionnaires that needed
14
15 172 to be culturally adapted. Several cultural adaptations were made to the original items to reflect
16
17 173 the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity
18
19 174 that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with
20
21 175 words that are more representative of the language used in Nigeria, like ‘very hard’ and ‘hard’
22
23 176 respectively. Second, examples of various intensities of activity that were common in the
24
25 177 Nigerian culture were added, and those already on the questionnaire but not common in the
26
27 178 Nigerian context were replaced with culturally applicable examples that are equivalent in energy
28
29 179 intensity (METs) with the original items and examples. Third, concepts like physical activity and
30
31 180 walking for transportation that were misconstrued outside the health context were refined to
32
33 181 indicate they were referring to health behaviours.

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37 183 After adaptation, the questionnaire was independently translated from English into Hausa
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39 184 language by two native speakers of Hausa who also speaks English, and able to read and write in
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41 185 both languages. One of the translators was familiar with the questionnaire and the second was an
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43 186 expert in Hausa language. The translated questionnaires were mutually revised by the translators
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45 187 and the research team for consistency and then back translated into English language by a third
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47 188 bilingual person who was familiar with the construct measured by IPAQ. The back translated
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49 189 version was checked by the research team for any discrepancies and to ensure that the construct
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51 190 measures by IPAQ had not been lost during the adaptation and translation process.

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55 192 The modified questionnaire (available in both Hausa and English language), hereafter referred to
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57 193 as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF),
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59 194 contains thirty-one questions that asked about physical activity done in the last 7-days in terms of
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195 frequency (days/week) and duration (minutes/day) spent in four activity domains (transportation,

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3 196 occupation, domestic and leisure time), and included sections on walking, moderate- and
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5 197 vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and
6
7 198 motorized transportation). The Hausa IPAQ-LF data were presented as the MET-minute/week
8
9 199 for total walking, moderate, and vigorous intensity activity and overall physical activity across
10
11 200 the four domains, and in each of the domains. The MET intensity values used to score the Hausa
12
13 201 IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate
14
15 202 activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting
16
17 203 quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest
18
19 204 reliability of the Hausa IPAQ-LF, participants self-completed all items on the measure twice,
20
21 205 with an interval of one week between administrations.

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23 207 *Anthropometrical and biological measurements*

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25 208 Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing
26
27 209 using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight
28
29 210 divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO
30
31 211 were used to create the categories: underweight ($< 18.5 kg/m^2$), normal weight ($18.5- < 25$
32
33 212 kg/m^2), overweight ($25- < 30 kg/m^2$) and obese ($\geq 30 kg/m^2$).[29] Resting blood pressure and heart
34
35 213 rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood
36
37 214 Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure
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39 215 (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study,
40
41 216 construct validity was evaluated by investigating the relationship of outcomes from the Hausa
42
43 217 IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also in
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45 218 part by comparing the differences in time spent in PA and sitting across sociodemographic
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47 219 subgroups. These types of validation for PA measures have been referred as indirect or construct
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49 220 validity in previous studies.[7,24,30]

221

222 222 *Sociodemographic Characteristics*

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224 Information on age, gender, marital status, religion, income, educational level and employment
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226 status were elicited from the participants. Marital status was classified as married or not married.
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228 Educational level was classified as more than secondary school education, secondary school
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3 226 education and less than secondary school education. Employment status was classified into white
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5 227 collar (government or private employed), blue collar (self- employed, trader, artisan etc) and
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7 228 unemployed (homemaker, student, retired, or unable to find job).
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11 230 **Data Analysis**

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13 231 Descriptive data were reported as mean, standard deviation and percentages. Mean group
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15 232 differences for continuous variables by gender were examined by independent t-test, and for
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17 233 dichotomous variables by chi-square statistics. The reliability analyses were performed using 2
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19 234 strategies. First, the two- way mixed model (single measure) intraclass correlation coefficient
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21 235 (ICC) with 95% confidence interval (CI) between the continuous scores obtained on 1st and 2nd
22
23 236 administration of the Hausa IPAQ-LF was calculated. The ICCs were calculated overall, and by
24
25 237 gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability
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27 238 scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] Second,
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29 239 the Bland and Altman Method was used to assess agreement on scores of PA from the 1st and 2nd
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31 240 administrations.[32] Variables used for the Bland and Altman analysis were weekly time spent in
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33 241 moderate-to-vigorous activity (MVPA), total PA and sitting. MVPA was computed by summing
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35 242 the total minutes/week of reported physical activity of moderate and vigorous- intensities across
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37 243 all four domains. For total PA, the total minutes/week of activities in each domain were summed
38
39 244 (total work + total transport + total domestic + total leisure-time min/week scores) to gain an
40
41 245 overall estimate of physical activity in a week. Also, the independent t-test and one-Way
42
43 246 ANOVA were used as appropriate to compare the time spent (minutes/week) in PA at both
44
45 247 administrations across sociodemographic subgroups. To assess construct validity, the non-
46
47 248 parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship
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49 249 between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body
50
51 250 mass index. Data were analyzed using Statistical Package for the Social Science (SPSS), version
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53 251 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at
54
55 252 $p < 0.05$.
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57 253

54 254 **RESULTS**

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3 255 The socio-demographic characteristic of the participants are shown in Table 1. The participants
4
5 256 comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of
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7 257 $23.8 \pm 3.9\text{kg/m}^2$. Majority of the participants were married (58.9%, n=106), had more than
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9 258 secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to
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11 259 men, the women were more likely to be married (71.1% vs 46.7%, $p=0.001$) and unemployed
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13 260 (52.2% vs 17.8%, $p<0.001$), but men were more likely to have more than secondary school
14
15 261 education (76.7% vs 48.2%, $p<0.001$).
16

17 263 **Reliability**

18
19 264 Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients
20
21 265 were good (ICC >0.75) for total PA, occupational PA, active transportation and vigorous intensity
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23 266 (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability
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25 267 (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95%
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27 268 CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA
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29 269 (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were
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31 270 substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38,
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33 271 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women
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35 272 than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest
36
37 273 value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity
38
39 274 (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous
40
41 275 intensity (very hard) activities were substantially greater in men than women.
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43 276
44 277 Similarly, socioeconomic status differences were observed in the reliability coefficients of the
45
46 278 modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were
47
48 279 substantially higher among participants with less than secondary school education (ICC from
49
50 280 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school
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52 281 education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and those with higher
53
54 282 than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]).
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56 283 While reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active
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58 284 transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and
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3 285 leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed
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5 286 compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95%
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7 287 CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were
8
9 288 unemployed than in the employed subgroup.
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11 289

12 290 Figures 1, 2 and 3 (Bland-Altman plots) illustrate the agreement in the scores (minutes/week) of
13
14 291 total PA, MVPA and sitting between the first and second administrations of Hausa IPAQ-LF. For
15
16 292 total PA, the mean difference was 106.7 minutes/week, with a wide 95% limits of agreement (-
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18 293 762.2 to 965.6 minutes/week). For MVPA, the mean difference was about one and half hour per
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20 294 week (91.6 minutes/week), and also demonstrating a wide 95% limits of agreement (-744.5 to
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22 295 927.7 minutes/week). For sitting time, the mean difference was small (26 minutes/week) and the
23
24 296 95% limits of agreement range from -2178.1 to 2230.9 minutes/week.
25
26 297

27 298 Table 4 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1)
28
29 299 and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified
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31 300 variables, time spent in PA reported during the first administration tends to be higher than those
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33 301 reported during the second administration. At both time points, men reported significantly
34
35 302 ($p<0.05$) higher mean time (minute/week) in active transportation, occupational PA, and leisure-
36
37 303 time PA than women. However, women spent significantly ($p<0.001$) more time (minutes/week)
38
39 304 in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status,
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41 305 participants that had lower than secondary school education compared to those with at least
42
43 306 secondary school education reported statistically significant higher mean time (minutes/week) at
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45 307 both time points for total PA, active transport, occupational PA, walking and vigorous intensity
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47 308 activity compared to those with at least secondary school education. While participants that were
48
49 309 employed reported statistically significant ($p<0.05$) more time (minutes/week) in total PA
50
51 310 (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1,
52
53 311 IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those
54
55 312 who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in
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57 313 domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.
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315 **Construct Validity**

316 Overall, correlations between energy expenditure (MET-Minutes/week) according to the
317 modified IPAQ-LF and anthropometric and biological measures were statistically significant in
318 the expected direction for all domains and intensities of PA, except for occupation and active
319 transport domains and walking (table 5). In the full sample, domestic PA was mainly related with
320 SBP ($\rho = -0.27, p < 0.01$) and DBP ($\rho = -0.17, p < 0.05$), while leisure PA and total PA were only
321 related with SBP ($\rho = -0.16, p < 0.05$) and BMI ($\rho = -0.29, p < 0.01$), respectively. Similarly,
322 moderate-intensity PA was mainly related with SBP ($\rho = -0.16, p < 0.05$) and DBP ($\rho = -0.21, p <$
323 0.01), but vigorous-intensity PA was only related with BMI ($\rho = -0.11, p < 0.05$). In the gender
324 based analyses, total PA, domestic PA and sedentary time were more consistently related with
325 anthropometric and biological variables. The strongest rho value (-0.41) was found for the
326 relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was
327 reached between total PA and DBP for the women subgroup. Only in women was domestic PA
328 significantly related with BMI ($\rho = -0.23$), DBP ($\rho = -0.20$) and SBP ($\rho = -0.31$). Leisure-time
329 PA ($\rho = -0.39$) and occupational PA ($\rho = -0.22$) were significantly related with BMI only in men.
330 The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ
331 $= 0.19$) than men ($\rho = 0.15$).

332

333 **DISCUSSION**

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

340

341 We found evidence for good reliability with high correlations between the test-retest for total
342 PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that
343 except for domestic PA and sitting time, ICC values for domains of PA were consistently above
344 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[33,34]

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3 345 Similar to a previous IPAQ-LF study in Hong Kong,[34] domestic activity demonstrated the
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5 346 lowest ICC value in our study. However, it is possible that the infrequent nature of household
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7 347 activities undertaken, especially by men may account for the low reliability reported for domestic
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9 348 PA in our study. In addition to the traditional African patriarchal belief that make most African
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11 349 men to rarely engage in indoor household activities, men in the high socioeconomic group in
12
13 350 Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home,
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15 351 appliances and equipment maintenance because they are able to employ the services of domestic
16
17 352 helpers and repair men. Our findings of lower reliability for domestic activity among men, those
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19 353 with more than secondary school education and those who were employed compared to their
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21 354 counterparts seem to support this assumption.
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23 355
24 356 The highest and strongest reliability coefficients (0.82) were found for both active transportation
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26 357 and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and
27
28 358 reproducible overtime than other PA domains because it is a common and ubiquitous PA
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30 359 behaviour in the African region. Mostly, the performance of active transportation especially
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32 360 walking is often out of necessity rather than choice within the African context. Our finding of
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34 361 higher ICC value for vigorous intensity PA is consistent with those of other studies that found
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36 362 the reliability of vigorous intensity activity to be higher compared to that of moderate intensity
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38 363 activity.[10,30,34,35] Compared to structured vigorous physical activities like sports and
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40 364 exercise that can be more easily recalled, moderate intensity PA are often of low salience,
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42 365 incidental and may not easily be remembered by people.[36,37] Further our finding that the
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44 366 reliability of vigorous intensity physical activity was meaningfully higher among men than
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46 367 women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria
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48 368 are more consistent than women when responding to PA items that pertained to intense vigorous
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50 369 PA than other intensities of activity. Overall, the moderate to good evidence of reliability found
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52 370 for all items indicates that the modified IPAQ-LF is reproducible, internally consistent and is
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54 371 promising for research in Nigeria.
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57 373 Except for sitting time, the limits of agreement in the mean scores of total PA and MVPA
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59 374 between the first and second administrations were wide, suggesting an evidence of bias between
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3 375 administrations. Large difference in PA scores between the 2 administrations would indicate that
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5 376 at least one of two measurements is not accurate. However, similar to the finding of a Mexican
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7 377 study,[38] scores on the Hausa IPAQ-LF were consistently lower during the second
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9 378 administration of the questionnaire compared to the first administration. Because familiarity with
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11 379 the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that
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13 380 participants in our study might have over-reported their PA levels during the first administration
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15 381 of the Hausa IPAQ-LF. This kind of findings may have implication for the utility of IPAQ for
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17 382 surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA
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19 383 that has been associated with the IPAQ,[39,40] it may be necessary to start considering the need
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21 384 for multiple measurements when using the IPAQ for evaluating PA, especially in developing
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23 385 African countries. However, patterns of PA as measured by the modified IPAQ-LF during both
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25 386 administrations were consistently similar, and both administrations were able to discriminate PA
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27 387 in the expected direction between subgroups of our sample. For example, at both measurement
28
29 388 time points, and consistent with hypothesis, men reported more time in active transportation,
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31 389 occupational PA and leisure PA than women, while women reported more time in domestic PA
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33 390 and sedentary activity than men.

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37 392 In the absence of objective criterion standards for evaluating an absolute estimate of PA, the
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39 393 consistency of items on IPAQ with variables known to be related to PA such as body mass index
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41 394 (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index
42
43 395 have been used as important construct validity measures.[7,10,21,24] In the present study, the
44
45 396 correlations of the PA domains and intensities with biological and anthropometric variables were
46
47 397 mostly significant in the expected direction, but they were low suggesting a modest evidence of
48
49 398 construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were
50
51 399 comparable with the values in other studies that have evaluated the IPAQ-LF.[5,7,8,24,30,33,39]
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53 400 Because better validity coefficients have been reported for other PA measures above that of the
54
55 401 IPAQ,[39,41] with the present African finding, it is possible that the IPAQ-LF only have modest
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57 402 evidence of construct validity. However, our findings on the relationships between physical
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59 403 activity and biological and anthropometric variables should be interpreted in the light of an
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404 important caution. Because hypertensive and obese people may get oriented to exercise,[3] cross-

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3 405 sectional associations of physical activity and blood pressure or BMI could also occur in the
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5 406 opposite direction and may not represent much information as indicators of construct validity of
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7 407 physical activity measures.
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10 409 **Strengths and limitations**

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13 410 A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to
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15 411 reflect the common PA behaviours of people in Nigeria. This is the first study in an African
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17 412 country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings
18
19 413 demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse
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21 414 segment of the Nigerian population. In the Africa region, the importance of a valid and
22
23 415 established PA scale like the modified IPAQ-LF is not only important to monitoring the domain
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25 416 in which activity is performed, but also very critical to understanding studies of ecological
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27 417 models of health behaviours, that emphasize the importance of multiple levels of influence on
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29 418 health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using
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31 419 ecological models indicate that favourable built environmental attributes are promising for
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33 420 improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45]
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35 421 However, built environment characteristics are expected to be strongly related to specific PA
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37 422 types rather than overall PA.[46,47] For example, different environmental variables can be
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39 423 related to walking for leisure or transportation and to moderate PA for household, occupation,
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41 424 recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to
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43 425 understanding the domain specific nature of ecological model research in the African region.
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45 426 One additional strength was the exploration of PA patterns by gender, educational level and
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47 427 employment status, the findings of which were consistent with general hypothesis on social
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49 428 patterns of inactivity in low-income countries.[20,48]
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52
53 430 However, the findings of this study should be interpreted in the light of some important
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55 431 limitations. Direct comparison of our validity findings with previous studies should be made with
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57 432 caution, because unlike in our study, the accelerometer or PA diary were utilized as a common
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59 433 objective criterion standard to validate the IPAQ in the majority of the
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434 studies.[5,7,8,24,30,33,39] Thus, examining the construct validity through the relationships of

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3 435 PA with BMI and resting blood pressure was an important limitation of our study. The choice
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5 436 and availability of appropriate criterion measures are particular issues of concern for the
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7 437 validation of PA questionnaires in low-income countries of Africa [5,49,50]. Despite these
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9 438 issues, the validity coefficients in our study were remarkably similar to those reported in other
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11 439 studies, [5,7,8,24,30,33,39] and the consistency of items on IPAQ with variables known to be
12
13 440 related to PA such as BMI, blood pressure, heart rate, indicators of lipid and glucose metabolism,
14
15 441 and fitness index have previously been used as important construct validity
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17 442 measures.[7,10,21,24] Another limitation of the study is the use of non-probability sampling
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19 443 technique. The study finding may have limited generalizability to other samples of Nigerians that
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21 444 have different characteristics from this sample. In addition, the majority of participants have
22
23 445 more than secondary school education with potentially higher comprehension and recall ability
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25 446 than may be found in the general population. Nevertheless, recruitment from diverse
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27 447 neighbourhoods and settings allowed for a sample with reasonable heterogeneity in age,
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29 448 occupational status, and ethnic backgrounds and made it possible to stratify the analyses by
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31 449 sociodemographic characteristics. However, because some of the participants in the present
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33 450 study required assistance to complete the survey, interview administration rather than self-
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35 451 administration of the IPAQ-LF should be encouraged in any future national studies in the
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37 452 African region.

38 453

39 454 **Conclusions**

40 455 Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence
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42 456 of test-retest reliability and may be valid for assessing context specific PA behaviours of adults
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44 457 in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could
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46 458 further contribute to our understanding of the impact of multiple levels of influence on PA
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48 459 behaviours of people in the African region.

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3 465 **Acknowledgments**

466 The authors are grateful to Mrs. Salamatu U Aliyu and Mr. Sa'adu Inusa Kiriri for their help
467 with questionnaire translations, and to the participants for their help for taking part in the study.
468

9 469 **Contributors**

10 470 ALO conceived and designed the study, contributed to cultural adaptation and acquisition of
11 data, conducted the statistical analysis and interpretation of data and drafted the manuscript.
12 471 UMB and STP managed participants' recruitment and data collection and contributed to cultural
13 adaptation. HBN and RDM contributed to cultural adaptation and translations of the measure.
14 472 AYO contributed to study design, acquisition of data and critically revised the manuscript for
15 important intellectual contents. All authors read and approved the final manuscript.
16 473
17 474
18 475
19 476

20 477 **Funding**

21 478 This research received no specific grant from any funding agency in the public, commercial or
22 not-for-profit sectors.
23 479
24 480

25 481 **Competing interests**

26 482 Authors declare there is no competing interest associated with this study.
27 483
28 484

29 485 **Ethics approval**

30 486 Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria
31 (ADM/TH/EC/75).
32 487

33 488 **Data sharing process**

34 489 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 (\pm SD)	35.6 \pm 10.3	35.7 \pm 8.3	35.5 \pm 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/m²)			
Mean (\pm SD)	23.8 \pm 3.9	23.8 \pm 3.5	23.8 \pm 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)			Women (n=90)	Men (n=90)
	Test 1 (Mean (SD))	Test 2 (Mean (SD))	ICC (95%CI)	ICC (95%CI)	ICC (95%CI)
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 (0.68-0.82)	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)

1 PA= Physical Activity
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3 **=p<0.001
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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)

MET×min/wk	Overall (N = 180)			Female (n = 90)			Male (n = 90)		
	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

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3 1 **Examining the reliability and validity of a modified version of the International Physical**
4 **Activity Questionnaire, long form (IPAQ-L) in Nigeria: A cross-sectional study**
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31 18 **Key words:** Physical activity, measurements, public health, IPAQ, Nigeria
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35 20 **Word counts:** 4338
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3 33 **ABSTRACT**
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5 34 **Objectives:** To investigate the reliability and **aspect of** validity of a modified version of the long
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7 35 International Physical Activity Questionnaire (Hausa IPAQ-LF) in Nigeria.

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9 36 **Design:** Cross-sectional study, examining the reliability and construct validity of the Hausa
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11 37 IPAQ-LF compared with anthropometric and biological variables.

12 38 **Setting:** Metropolitan Maiduguri, the capital city of Borno State in Nigeria.

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14 39 **Participants:** 180 Nigerian adults (50% women) with a mean age of 35.6 (SD=10.3) years,
15
16 40 purposively selected from neighbourhood with diverse socioeconomic status and walkability.

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18 41 **Outcome measures:** Domains (domestic **physical activity** [PA], occupational PA, leisure-time
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20 42 PA, active transportation and sitting time) and intensities of PA (vigorous, moderate and
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22 43 walking) were measured with the Hausa IPAQ-LF on two different occasions, eight days apart.
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24 44 Outcomes for construct validity were measured BMI, SBP and DBP.

25 45 **Results:** The Hausa IPAQ-LF demonstrated good test-retest reliability (ICC>75) for total PA
26
27 46 (ICC=0.79, 95% CI=0.65-0.82), occupational PA (ICC=0.77, 95% CI=0.68-0.82), active
28
29 47 transportation (ICC=0.82, 95% CI=0.75-0.87) and vigorous intensity activities (ICC=0.82, 95%
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31 48 CI=0.76-0.87). Reliability was substantially higher for total PA (ICC=0.80), occupational PA
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33 49 (ICC=0.78), leisure-time PA (ICC=0.75) and active transportation (ICC=0.80) in men than
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35 50 women, but domestic PA (ICC=0.38) and sitting time (ICC=0.71) demonstrated substantial
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37 51 reliability coefficients in women than men. For the construct validity, domestic PA was
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39 52 significantly related mainly with SBP ($\rho = -0.27$) and DBP ($\rho = -0.17$), and leisure-time PA and
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41 53 total PA were significantly related only with SBP ($\rho = -0.16$) and BMI ($\rho = -0.29$), respectively.
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43 54 Similarly, moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP (ρ
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45 55 = -0.21 , $p < 0.01$), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$).

46 56 **Conclusions:** The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest
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48 57 reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria.
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3 66 **ARTICLE SUMMARY**
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5 68 **Strengths and limitations of this study.**
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- 7 70
- 8 70 ■ Systematic adaptation and tailoring of items on the original IPAQ-LF to reflect the common
9 71 PA behaviours of adults in Nigeria.
 - 10 71
 - 11 72 ■ The first study to describe the cultural adaptation and translations of the IPAQ-LF and
12 72 explore its psychometric relevance in an African country.
 - 13 73
 - 14 73
 - 15 74 ■ Findings establish evidence to support the feasibility of using a modified IPAQ-LF to
16 74 reliably collect context specific PA behaviours of adults in the African region.
 - 17 75
 - 18 75
 - 19 76 ■ Exploring construct validity through the relationships of PA with BMI and resting blood
20 76 pressure was an important limitation of this study.
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 - 22 77
 - 23 78 ■ The use of non-probability sampling technique may limit generalizability of findings to other
24 78 samples of Nigerian adults with different characteristics from the study's sample.
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106 INTRODUCTION

107
108 The importance of physical activity (PA) for promoting health and preventing disease is well
109 established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it
110 is important to have standardized, reliable and valid instruments that can be used to accurately
111 describe population levels and patterns of PA within and across countries.[4, 5] In this context,
112 the international physical activity questionnaire (IPAQ) was developed to obtain internationally
113 comparable data on health-related PA of adults (18-65 years).[5, 6] Two versions of the IPAQ
114 that could be administered by interview or self-completed were developed. The short form (SF)
115 was designed for population surveillance of PA; while the long form (LF) was designed to be
116 appropriate for use in research that requires detailed information on different PA domains,
117 including PA at work, household, during leisure and transportation, and time spent in sedentary
118 activities.[6]

119
120 The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of
121 reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in
122 order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts
123 have been made to translate and adapt the IPAQ in many other countries, but most of the
124 research in this context were from the Western developed countries.[7-14] In Africa, the
125 psychometric properties of IPAQ have only been tested in South-Africa as part of the initial
126 development process of the questionnaire,[5] and in older adults.[15] Because the largest
127 increases and burden of non-communicable diseases (NCDs) are in the low-income countries
128 where the understanding of evidence-based strategies for increasing PA remains poor,[16-19]
129 improving PA research is a top priority for low-income countries.[20] However, to advance PA
130 research in Africa, it is important to first develop or tailor standardized measures to be culturally
131 sensitive to PA behaviours of people in the region countries. Because Nigeria is the most
132 populous country in Africa with culture and languages similar to most of the other West African
133 countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this
134 country.

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3 136 Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in
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5 137 Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other
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7 138 studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide
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9 139 context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for
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11 140 relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF
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13 141 in sub-Saharan African countries can impact PA research and surveillance in the African region
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15 142 where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the
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17 143 present study was to investigate the reliability and an aspect of validity of a modified version of
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19 144 the IPAQ-LF among adults in Nigeria.
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21 146 **METHODS**

24 148 **Participants**

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26 149 A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status
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28 150 and walkability in Maiduguri city were recruited for the study. The **sampling and** neighbourhood
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30 151 selection strategy **have** been described in details elsewhere.[26] Maiduguri with an estimated
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32 152 population of 749,123 people is the largest and capital city of Borno State in North-Eastern
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34 153 Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and
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36 154 Chad Republic, and Hausa language is the common means of communication for commercial
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38 155 activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this
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40 156 study if they were willing to **self-complete** a written survey twice in **either Hausa or** English
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42 157 Language. **However, researchers (UMB and STP) were in attendance to provide translation and**
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44 158 **interpretation assistance to participants (n=11) who were unable to independently complete the**
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46 159 **survey.** Additional eligibility criteria included living within the identified neighbourhood
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48 160 categories in the last 12 months, being adults (18-65 years) and not having any disability that
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50 161 prevented independent walking. All participants were fully informed of the study protocol and
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52 162 provided **signed** informed consent. The study protocol was approved by the Research and Ethic
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54 163 Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were
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56 164 collected between March and May, 2012.
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3 166 **Measures**

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5 167 *The adapted international physical activity questionnaire- long Hausa version*

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7 168 The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is
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9 169 similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly,
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11 170 interviews were conducted with public health experts, exercise scientists and not highly educated
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13 171 local people to identify the items and examples of PA on the original questionnaires that needed
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15 172 to be culturally adapted. Several cultural adaptations were made to the original items to reflect
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17 173 the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity
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19 174 that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with
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21 175 words that are more representative of the language used in Nigeria, like ‘very hard’ and ‘hard’
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23 176 respectively. Second, examples of various intensities of activity that were common in the
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25 177 Nigerian culture were added, and those already on the questionnaire but not common in the
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27 178 Nigerian context were replaced with culturally applicable examples that are equivalent in energy
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29 179 intensity (METs) with the original items and examples. Third, concepts like physical activity and
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31 180 walking for transportation that were misconstrued outside the health context were refined to
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33 181 indicate they were referring to health behaviours.

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37 183 After adaptation, the questionnaire was independently translated from English into Hausa
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39 184 language by two native speakers of Hausa who also speaks English, and able to read and write in
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41 185 both languages. One of the translators was familiar with the questionnaire and the second was an
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43 186 expert in Hausa language. The translated questionnaires were mutually revised by the translators
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45 187 and the research team for consistency and then back translated into English language by a third
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47 188 bilingual person who was familiar with the construct measured by IPAQ. The back translated
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49 189 version was checked by the research team for any discrepancies and to ensure that the construct
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51 190 measures by IPAQ had not been lost during the adaptation and translation process.

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55 192 The modified questionnaire (**available in both Hausa and English language**), hereafter referred to
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57 193 as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF),
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59 194 contains thirty-one questions that asked about physical activity done in the last 7-days in terms of
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195 frequency (days/week) and duration (minutes/day) spent in four activity domains (transportation,

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3 196 occupation, domestic and leisure time), and included sections on walking, moderate- and
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5 197 vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and
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7 198 motorized transportation). The Hausa IPAQ-LF data were presented as the MET-minute/week
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9 199 for total walking, moderate, and vigorous intensity activity and overall physical activity across
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11 200 the four domains, and in each of the domains. The MET intensity values used to score the Hausa
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13 201 IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate
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15 202 activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting
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17 203 quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest
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19 204 reliability of the Hausa IPAQ-LF, participants self-completed all items on the measure twice,
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21 205 with an interval of one week between administrations.

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23 207 *Anthropometrical and biological measurements*

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25 208 Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing
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27 209 using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight
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29 210 divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO
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31 211 were used to create the categories: underweight ($< 18.5 kg/m^2$), normal weight ($18.5- < 25$
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33 212 kg/m^2), overweight ($25- < 30 kg/m^2$) and obese ($\geq 30 kg/m^2$).[29] Resting blood pressure and heart
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35 213 rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood
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37 214 Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure
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39 215 (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study,
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41 216 construct validity was evaluated by investigating the relationship of outcomes from the Hausa
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43 217 IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also in
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45 218 part by comparing the differences in time spent in PA and sitting across sociodemographic
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47 219 subgroups. These types of validation for PA measures have been referred as indirect or construct
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49 220 validity in previous studies.[7,24,30]

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222 222 *Sociodemographic Characteristics*

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

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3 226 education and less than secondary school education. Employment status was classified into white
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5 227 collar (government or private employed), blue collar (self- employed, trader, artisan etc) and
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7 228 unemployed (homemaker, student, retired, or unable to find job).
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230 **Data Analysis**

13 231 Descriptive data were reported as mean, standard deviation and percentages. Mean group
14 232 differences for continuous variables by gender were examined by independent t-test, and for
15 233 dichotomous variables by chi-square statistics. **The reliability analyses were performed using 2**
16 234 **strategies. First, the two- way mixed model (single measure) intraclass correlation coefficient**
17 235 **(ICC) with 95% confidence interval (CI) between the continuous scores obtained on 1st and 2nd**
18 236 **administration of the Hausa IPAQ-LF was calculated.** The ICCs were **calculated** overall, and by
19 237 gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability
20 238 scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] **Second,**
21 239 **the Bland and Altman Method was used to assess agreement on scores of PA from the 1st and 2nd**
22 240 **administrations.[32] Variables used for the Bland and Altman analysis were weekly time spent in**
23 241 **moderate-to-vigorous activity (MVPA), total PA and sitting. MVPA was computed by summing**
24 242 **the total minutes/week of reported physical activity of moderate and vigorous- intensities across**
25 243 **all four domains. For total PA, the total minutes/week of activities in each domain were summed**
26 244 **(total work + total transport + total domestic + total leisure-time min/week scores) to gain an**
27 245 **overall estimate of physical activity in a week. Also, the independent t-test and one-Way**
28 246 **ANOVA were used as appropriate to compare the time spent (minutes/week) in PA at both**
29 247 **administrations** across sociodemographic subgroups. To assess construct validity, the non-
30 248 parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship
31 249 between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body
32 250 mass index. Data were analyzed using Statistical Package for the Social Science (SPSS), version
33 251 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at
34 252 $p < 0.05$.
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54 **RESULTS**

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3 255 The socio-demographic characteristic of the participants are shown in Table 1. The participants
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5 256 comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of
6
7 257 $23.8 \pm 3.9\text{kg/m}^2$. Majority of the participants were married (58.9%, n=106), had more than
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9 258 secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to
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11 259 men, the women were more likely to be married (71.1% vs 46.7%, $p=0.001$) and unemployed
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13 260 (52.2% vs 17.8%, $p<0.001$), but men were more likely to have more than secondary school
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15 261 education (76.7% vs 48.2%, $p<0.001$).
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17 262 18 263 **Reliability**

19 264 Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients
20
21 265 were good (ICC >0.75) for total PA, occupational PA, active transportation and vigorous intensity
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23 266 (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability
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25 267 (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95%
26
27 268 CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA
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29 269 (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were
30
31 270 substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38,
32
33 271 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women
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35 272 than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest
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37 273 value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity
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39 274 (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous
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41 275 intensity (very hard) activities were substantially greater in men than women.
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43 276
44 277 Similarly, socioeconomic status differences were observed in the reliability coefficients of the
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46 278 modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were
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48 279 substantially higher among participants with less than secondary school education (ICC from
49
50 280 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school
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52 281 education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and those with higher
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54 282 than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]).
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56 283 While reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active
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58 284 transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and
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3 285 leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed
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5 286 compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95%
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7 287 CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were
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9 288 unemployed than in the employed subgroup.
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11 289

12 290 **Figures 1, 2 and 3 (Bland-Altman plots) illustrate the agreement in the scores (minutes/week) of**
13 **total PA, MVPA and sitting between the first and second administrations of Hausa IPAQ-LF. For**
14 **total PA, the mean difference was 106.7 minutes/week, with a wide 95% limits of agreement (-**
15 **762.2 to 965.6 minutes/week). For MVPA, the mean difference was about one and half hour per**
16 **week (91.6 minutes/week), and also demonstrating a wide 95% limits of agreement (-744.5 to**
17 **927.7 minutes/week). For sitting time, the mean difference was small (26 minutes/week) and the**
18 **95% limits of agreement range from -2178.1 to 2230.9 minutes/week.**
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26 298 Table 4 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1)
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28 299 and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified
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30 300 variables, time spent in PA reported during the first administration tends to be higher than those
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32 301 reported during the second administration. At both time points, men reported significantly
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34 302 ($p<0.05$) higher mean time (minute/week) in active transportation, occupational PA, and leisure-
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36 303 time PA than women. However, women spent significantly ($p<0.001$) more time (minutes/week)
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38 304 in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status,
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40 305 participants that had lower than secondary school education compared to those with at least
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42 306 secondary school education reported statistically significant higher mean time (minutes/week) at
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44 307 both time points for total PA, active transport, occupational PA, walking and vigorous intensity
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46 308 activity compared to those with at least secondary school education. While participants that were
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48 309 employed reported statistically significant ($p<0.05$) more time (minutes/week) in total PA
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50 310 (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1,
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52 311 IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those
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54 312 who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in
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56 313 domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.
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315 **Construct Validity**

316 Overall, correlations between energy expenditure (MET-Minutes/week) according to the
317 modified IPAQ-LF and anthropometric and biological measures were statistically significant in
318 the expected direction for all domains and intensities of PA, except for occupation and active
319 transport domains and walking (table 5). In the full sample, domestic PA was mainly related with
320 SBP ($\rho = -0.27$, $p < 0.01$) and DBP ($\rho = -0.17$, $p < 0.05$), while leisure PA and total PA were only
321 related with SBP ($\rho = -0.16$, $p < 0.05$) and BMI ($\rho = -0.29$, $p < 0.01$), respectively. Similarly,
322 moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP ($\rho = -0.21$, $p <$
323 0.01), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$). In the gender
324 based analyses, total PA, domestic PA and sedentary time were more consistently related with
325 anthropometric and biological variables. The strongest rho value (-0.41) was found for the
326 relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was
327 reached between total PA and DBP for the women subgroup. Only in women was domestic PA
328 significantly related with BMI ($\rho = -0.23$), DBP ($\rho = -0.20$) and SBP ($\rho = -0.31$). Leisure-time
329 PA ($\rho = -0.39$) and occupational PA ($\rho = -0.22$) were significantly related with BMI only in men.
330 The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ
331 $= 0.19$) than men ($\rho = 0.15$).

332

333 **DISCUSSION**

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

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341 We found evidence for good reliability with high correlations between the test-retest for total
342 PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that
343 except for domestic PA and sitting time, ICC values for domains of PA were consistently above
344 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[33,34]

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3 345 Similar to a previous IPAQ-LF study in Hong Kong,[34] domestic activity demonstrated the
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5 346 lowest ICC value in our study. However, it is possible that the infrequent nature of household
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7 347 activities undertaken, especially by men may account for the low reliability reported for domestic
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9 348 PA in our study. In addition to the traditional African patriarchal belief that make most African
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11 349 men to rarely engage in indoor household activities, men in the high socioeconomic group in
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13 350 Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home,
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15 351 appliances and equipment maintenance because they are able to employ the services of domestic
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17 352 helpers and repair men. Our findings of lower reliability for domestic activity among men, those
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19 353 with more than secondary school education and those who were employed compared to their
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21 354 counterparts seem to support this assumption.
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23 356 The highest and strongest reliability coefficients (0.82) were found for both active transportation
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25 357 and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and
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27 358 reproducible overtime than other PA domains because it is a common and ubiquitous PA
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29 359 behaviour in the African region. Mostly, the performance of active transportation especially
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31 360 walking is often out of necessity rather than choice within the African context. Our finding of
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33 361 higher ICC value for vigorous intensity PA is consistent with those of other studies that found
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35 362 the reliability of vigorous intensity activity to be higher compared to that of moderate intensity
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37 363 activity.[10,30,34,35] Compared to structured vigorous physical activities like sports and
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39 364 exercise that can be more easily recalled, moderate intensity PA are often of low salience,
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41 365 incidental and may not easily be remembered by people.[36,37] Further our finding that the
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43 366 reliability of vigorous intensity physical activity was meaningfully higher among men than
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45 367 women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria
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47 368 are more consistent than women when responding to PA items that pertained to intense vigorous
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49 369 PA than other intensities of activity. Overall, the moderate to good evidence of reliability found
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51 370 for all items indicates that the modified IPAQ-LF is reproducible, internally consistent and is
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53 371 promising for research in Nigeria.
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57 373 **Except for sitting time, the limits of agreement in the mean scores of total PA and MVPA**
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59 374 **between the first and second administrations were wide, suggesting an evidence of bias between**
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3 375 administrations. Large difference in PA scores between the 2 administrations would indicate that
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5 376 at least one of two measurements is not accurate. However, similar to the finding of a Mexican
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7 377 study,[38] scores on the Hausa IPAQ-LF were consistently lower during the second
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9 378 administration of the questionnaire compared to the first administration. Because familiarity with
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11 379 the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that
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13 380 participants in our study might have over-reported their PA levels during the first administration
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15 381 of the Hausa IPAQ-LF. This kind of findings may have implication for the utility of IPAQ for
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17 382 surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA
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19 383 that has been associated with the IPAQ,[39,40] it may be necessary to start considering the need
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21 384 for multiple measurements when using the IPAQ for evaluating PA, especially in developing
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23 385 African countries. However, patterns of PA as measured by the modified IPAQ-LF during both
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25 386 administrations were consistently similar, and both administrations were able to discriminate PA
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27 387 in the expected direction between subgroups of our sample. For example, at both measurement
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29 388 time points, and consistent with hypothesis, men reported more time in active transportation,
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31 389 occupational PA and leisure PA than women, while women reported more time in domestic PA
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33 390 and sedentary activity than men.

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37 392 In the absence of objective criterion standards for evaluating an absolute estimate of PA, the
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39 393 consistency of items on IPAQ with variables known to be related to PA such as body mass index
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41 394 (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index
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43 395 have been used as important construct validity measures.[7,10,21,24] In the present study, the
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45 396 correlations of the PA domains and intensities with biological and anthropometric variables were
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47 397 mostly significant in the expected direction, but they were low suggesting a modest evidence of
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49 398 construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were
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51 399 comparable with the values in other studies that have evaluated the IPAQ-LF.[5,7,8,24,30,33,39]
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53 400 Because better validity coefficients have been reported for other PA measures above that of the
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55 401 IPAQ,[39,41] with the present African finding, it is possible that the IPAQ-LF only have modest
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57 402 evidence of construct validity. However, our findings on the relationships between physical
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59 403 activity and biological and anthropometric variables should be interpreted in the light of an
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404 important caution. Because hypertensive and obese people may get oriented to exercise,[3] cross-

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3 405 sectional associations of physical activity and blood pressure or BMI could also occur in the
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5 406 opposite direction and may not represent much information as indicators of construct validity of
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7 407 physical activity measures.
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10 409 **Strengths and limitations**

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13 410 A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to
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15 411 reflect the common PA behaviours of people in Nigeria. This is the first study in an African
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17 412 country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings
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19 413 demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse
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21 414 segment of the Nigerian population. In the Africa region, the importance of a valid and
22
23 415 established PA scale like the modified IPAQ-LF is not only important to monitoring the domain
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25 416 in which activity is performed, but also very critical to understanding studies of ecological
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27 417 models of health behaviours, that emphasize the importance of multiple levels of influence on
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29 418 health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using
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31 419 ecological models indicate that favourable built environmental attributes are promising for
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33 420 improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45]
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35 421 However, built environment characteristics are expected to be strongly related to specific PA
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37 422 types rather than overall PA.[46,47] For example, different environmental variables can be
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39 423 related to walking for leisure or transportation and to moderate PA for household, occupation,
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41 424 recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to
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43 425 understanding the domain specific nature of ecological model research in the African region.
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45 426 One additional strength was the exploration of PA patterns by gender, educational level and
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47 427 employment status, the findings of which were consistent with general hypothesis on social
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49 428 patterns of inactivity in low-income countries.[20,48]
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51 429

52 430 However, the findings of this study should be interpreted in the light of some important
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54 431 limitations. Direct comparison of our validity findings with previous studies should be made with
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56 432 caution, because unlike in our study, the accelerometer or PA diary were utilized as a common
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58 433 objective criterion standard to validate the IPAQ in the majority of the
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60 434 studies.[5,7,8,24,30,33,39] Thus, examining the construct validity through the relationships of

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3 435 PA with BMI and resting blood pressure was an important limitation of our study. The choice
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5 436 and availability of appropriate criterion measures are particular issues of concern for the
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7 437 validation of PA questionnaires in low-income countries of Africa [5,49,50]. Despite these
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9 438 issues, the validity coefficients in our study were remarkably similar to those reported in other
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11 439 studies, [5,7,8,24,30,33,39] and the consistency of items on IPAQ with variables known to be
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13 440 related to PA such as BMI, blood pressure, heart rate, indicators of lipid and glucose metabolism,
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15 441 and fitness index have previously been used as important construct validity
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17 442 measures.[7,10,21,24] Another limitation of the study is the use of non-probability sampling
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19 443 technique. The study finding may have limited generalizability to other samples of Nigerians that
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21 444 have different characteristics from this sample. In addition, the majority of participants have
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23 445 more than secondary school education with potentially higher comprehension and recall ability
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25 446 than may be found in the general population. Nevertheless, recruitment from diverse
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27 447 neighbourhoods and settings allowed for a sample with reasonable heterogeneity in age,
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29 448 occupational status, and ethnic backgrounds and made it possible to stratify the analyses by
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31 449 sociodemographic characteristics. However, because some of the participants in the present
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33 450 study required assistance to complete the survey, interview administration rather than self-
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35 451 administration of the IPAQ-LF should be encouraged in any future national studies in the
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37 452 African region.

37 454 **Conclusions**

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39 455 Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence
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41 456 of test-retest reliability and may be valid for assessing context specific PA behaviours of adults
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43 457 in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could
44
45 458 further contribute to our understanding of the impact of multiple levels of influence on PA
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47 459 behaviours of people in the African region.

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3 465 **Acknowledgments**

4 466 The authors are grateful to Mrs. Salamatu U Aliyu and Mr. Sa'adu Inusa Kiriri for their help
5 467 with questionnaire translations, and to the participants for their help for taking part in the study.
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9
10 469 **Contributors**

11 470 ALO conceived and designed the study, contributed to cultural adaptation and acquisition of
12 471 data, conducted the statistical analysis and interpretation of data and drafted the manuscript.
13 472 UMB and STP managed participants' recruitment and data collection and contributed to cultural
14 473 adaptation. HBN and RDM contributed to cultural adaptation and translations of the measure.
15 474 AYO contributed to study design, acquisition of data and critically revised the manuscript for
16 475 important intellectual contents. All authors read and approved the final manuscript.
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20
21 477 **Funding**

22 478 This research received no specific grant from any funding agency in the public, commercial or
23 479 not-for-profit sectors.
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25 480

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27
28 481 **Competing interests**

29 482 Authors declare there is no competing interest associated with this study.
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31 483

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33 484 **Ethics approval**

34 485 Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria
35 486 (ADM/TH/EC/75).
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39 488 **Data sharing process**

40 489 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 (\pm SD)	35.6 \pm 10.3	35.7 \pm 8.3	35.5 \pm 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/m²)			
Mean (\pm SD)	23.8 \pm 3.9	23.8 \pm 3.5	23.8 \pm 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)			Women (n=90)	Men (n=90)
	Test 1 (Mean (SD))	Test 2 (Mean (SD))	ICC (95%CI)	ICC (95%CI)	ICC (95%CI)
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 (0.68-0.82)	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)

1 PA= Physical Activity
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3 **=p<0.001
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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

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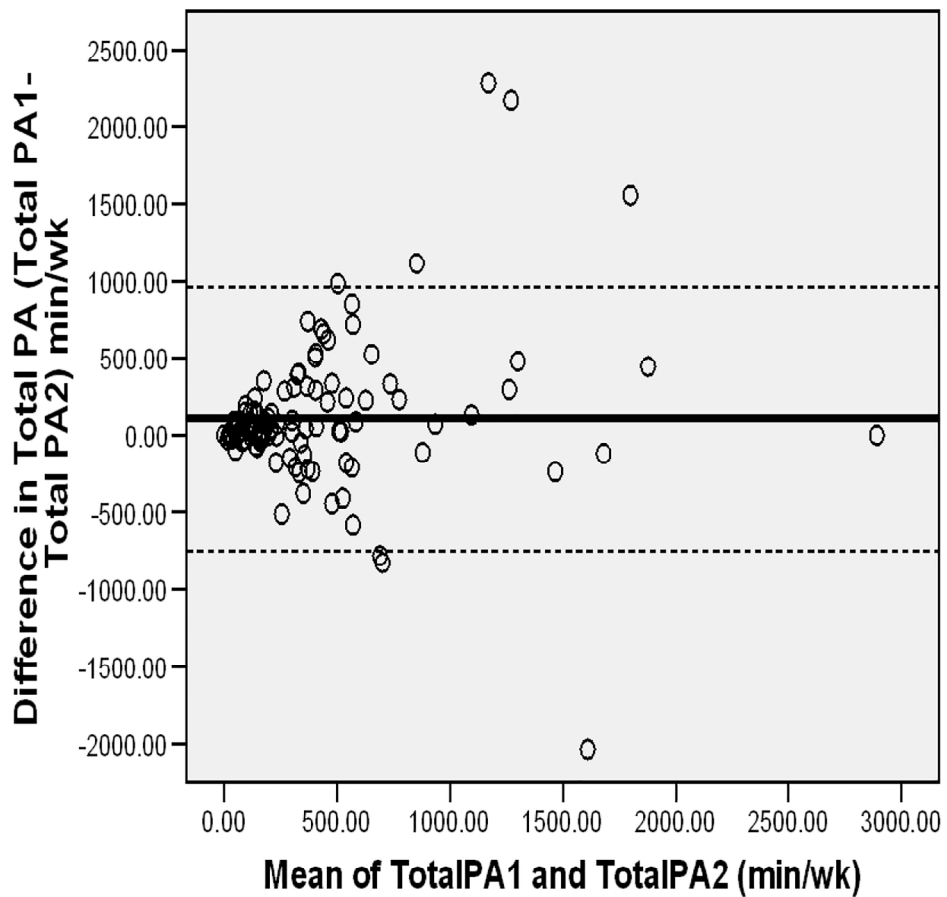


Figure 1: Bland-Altman plot min/wk reported in total physical activity (PA for the first and second administrations of Hausa IPAQ-LF. Mean difference: 106.7 +/- 2SD (Standard deviation) = -762.2 to 965.6

238x265mm (300 x 300 DPI)



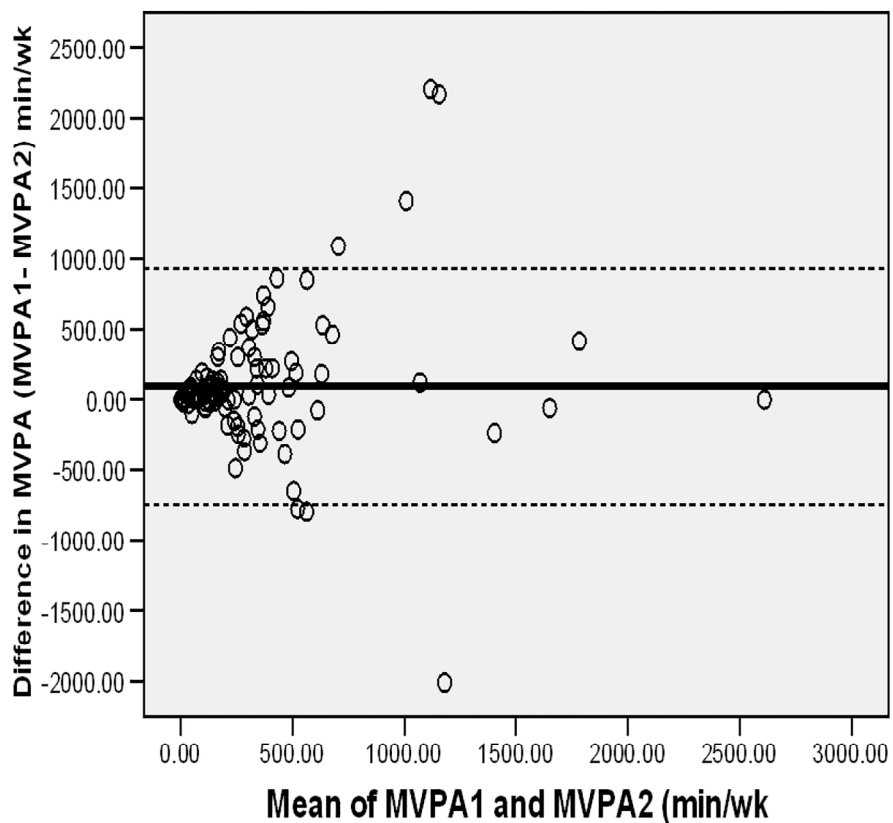


Figure 2: Bland-Altman plot for min/wk reported in moderate-to-vigorous physical activity (MVPA) for the first and second administrations of Hausa IPAQ-LF: Mean difference: 91.6 +/- 2SD (Standard Deviation)=-744.5 to 927

239x287mm (300 x 300 DPI)

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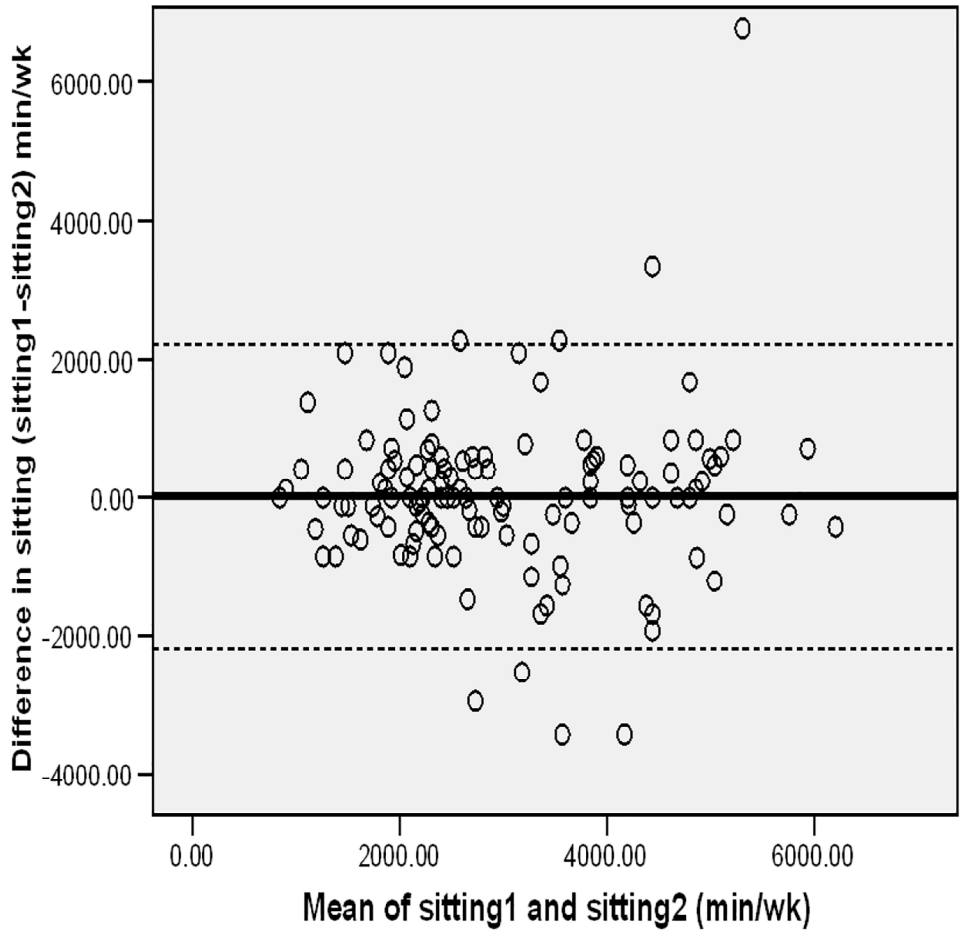


Figure 3: Bland-Altman plot min/wk reported in sitting for the first and second administration of Hausa IPAQ-LF. Mean difference: 26.4 \pm 2SD (Standard Deviation) = -2178.1 to 2230.9

236x259mm (300 x 300 DPI)



BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2014-005820.R2
Article Type:	Research
Date Submitted by the Author:	07-Nov-2014
Complete List of Authors:	Oyeyemi, Adewale; University of Maiduguri, Physiotherapy Bello, Umar; University of Maiduguri, Physiotherapy Philemon, Saratu; Jos University Teaching Hospital, Physiotherapy Aliyu, Habibu; University of Maiduguri, Physiotherapy Majidadi, Rebecca; University of Maiduguri, Physiotherapy Oyeyemi, Adetoyeje; University of Maiduguri, Physiotherapy
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology, Sports and exercise medicine
Keywords:	PUBLIC HEALTH, SOCIAL MEDICINE, EPIDEMIOLOGY

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3 1 **Examining the reliability and validity of a modified version of the International Physical**
4 **Activity Questionnaire, long form (IPAQ-L) in Nigeria: A cross-sectional study**
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9 4 Adewale L. Oyeyemi*¹, Umar M. Bello¹, Saratu T. Philemon², Habeeb N. Aliyu¹, Rebecca W.
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31 18 **Key words:** Physical activity, measurement, public health, IPAQ, Nigeria
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35 20 **Word counts:** 4352
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33 ABSTRACT

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

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

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

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

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

45 **Results:** The Hausa IPAQ-LF demonstrated good test-retest reliability ($ICC > 0.75$) for total PA
46 ($ICC = 0.79$, 95% $CI = 0.65-0.82$), occupational PA ($ICC = 0.77$, 95% $CI = 0.68-0.82$), active
47 transportation ($ICC = 0.82$, 95% $CI = 0.75-0.87$) and vigorous intensity activities ($ICC = 0.82$, 95%
48 $CI = 0.76-0.87$). Reliability was substantially higher for total PA ($ICC = 0.80$), occupational PA
49 ($ICC = 0.78$), leisure-time PA ($ICC = 0.75$) and active transportation ($ICC = 0.80$) in men than
50 women, but domestic PA ($ICC = 0.38$) and sitting time ($ICC = 0.71$) demonstrated substantial
51 reliability coefficients in women than men. For the construct validity, domestic PA was
52 significantly related mainly with SBP ($\rho = -0.27$) and DBP ($\rho = -0.17$), and leisure-time PA and
53 total PA were significantly related only with SBP ($\rho = -0.16$) and BMI ($\rho = -0.29$), respectively.
54 Similarly, moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP (ρ
55 $= -0.21$, $p < 0.01$), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$).

56 **Conclusions:** The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest
57 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.

106 INTRODUCTION

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

119
120 The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of
121 reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in
122 order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts
123 have been made to translate and adapt the IPAQ in many other countries, but most of the
124 research in this context were from the Western developed countries.[7-14] In Africa, the
125 psychometric properties of IPAQ have only been tested in South-Africa as part of the initial
126 development process of the questionnaire,[5] and in older adults.[15] Because the largest
127 increases and burden of non-communicable diseases (NCDs) are in the low-income countries
128 where the understanding of evidence-based strategies for increasing PA remains poor,[16-19]
129 improving PA research is a top priority for low-income countries.[20] However, to advance PA
130 research in Africa, it is important to first develop or tailor standardized measures to be culturally
131 sensitive to PA behaviours of people in the region countries. Because Nigeria is the most
132 populous country in Africa with culture and languages similar to most of the other West African
133 countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this
134 country.

135

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3 136 Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in
4
5 137 Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other
6
7 138 studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide
8
9 139 context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for
10
11 140 relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF
12
13 141 in sub-Saharan African countries can impact PA research and surveillance in the African region
14
15 142 where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the
16
17 143 present study was to investigate the reliability and an aspect of validity of a modified version of
18
19 144 the IPAQ-LF among adults in Nigeria.
20

21 146 **METHODS**

24 148 **Participants**

26 149 A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status
27
28 150 and walkability in Maiduguri city were recruited for the study. The sampling and neighbourhood
29
30 151 selection strategy have been described in details elsewhere.[26] Maiduguri with an estimated
31
32 152 population of 749,123 people is the largest and capital city of Borno State in North-Eastern
33
34 153 Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and
35
36 154 Chad Republic, and Hausa language is the common means of communication for commercial
37
38 155 activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this
39
40 156 study if they were willing to self-complete a written survey twice in either Hausa or English
41
42 157 Language. However, researchers (UMB and STP) were in attendance to provide translation and
43
44 158 interpretation assistance to participants (n=11) who required help to complete the survey.
45
46 159 Additional eligibility criteria included living within the identified neighbourhood categories in
47
48 160 the last 12 months, being adults (18-65 years) and not having any disability that prevented
49
50 161 independent walking. All participants were fully informed of the study protocol and provided
51
52 162 signed informed consent. The study protocol was approved by the Research and Ethic
53
54 163 Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were
55
56 164 collected between March and May, 2012.
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58
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1
2
3 166 **Measures**

4
5 167 *The adapted international physical activity questionnaire- long Hausa version*

6
7 168 The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is
8
9 169 similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly,
10
11 170 interviews were conducted with public health experts, exercise scientists and not highly educated
12
13 171 local people to identify the items and examples of PA on the original questionnaires that needed
14
15 172 to be culturally adapted. Several cultural adaptations were made to the original items to reflect
16
17 173 the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity
18
19 174 that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with
20
21 175 words that are more representative of the language used in Nigeria, like ‘very hard’ and ‘hard’
22
23 176 respectively. Second, examples of various intensities of activity that were common in the
24
25 177 Nigerian culture were added, and those already on the questionnaire but not common in the
26
27 178 Nigerian context were replaced with culturally applicable examples that are equivalent in energy
28
29 179 intensity (METs) with the original items and examples. Third, concepts like physical activity and
30
31 180 walking for transportation that were misconstrued outside the health context were refined to
32
33 181 indicate they were referring to health behaviours.

34
35 182
36
37 183 After adaptation, the questionnaire was independently translated from English into Hausa
38
39 184 language by two native speakers of Hausa who also speaks English, and able to read and write in
40
41 185 both languages. One of the translators was familiar with the questionnaire and the second was an
42
43 186 expert in Hausa language. The translated questionnaires were mutually revised by the translators
44
45 187 and the research team for consistency and then back translated into English language by a third
46
47 188 bilingual person who was familiar with the construct measured by IPAQ. The back translated
48
49 189 version was checked by the research team for any discrepancies and to ensure that the construct
50
51 190 measures by IPAQ had not been lost during the adaptation and translation process.

52
53 191
54
55 192 The modified questionnaire (available in both Hausa and English language), hereafter referred to
56
57 193 as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF),
58
59 194 contains thirty-one questions that asked about physical activity done in the last 7-days in terms of
60
195 frequency (days/week) and duration (minutes/day) spent in four activity domains (transportation,

1
2
3 196 occupation, domestic and leisure time), and included sections on walking, moderate- and
4
5 197 vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and
6
7 198 motorized transportation). The Hausa IPAQ-LF data were presented as the MET-minute/week
8
9 199 for total walking, moderate, and vigorous intensity activity and overall physical activity across
10
11 200 the four domains, and in each of the domains. The MET intensity values used to score the Hausa
12
13 201 IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate
14
15 202 activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting
16
17 203 quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest
18
19 204 reliability of the Hausa IPAQ-LF, participants self-completed all items on the measure twice,
20
21 205 with an interval of one week between administrations.

22

23 207 *Anthropometrical and biological measurements*

24
25 208 Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing
26
27 209 using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight
28
29 210 divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO
30
31 211 were used to create the categories: underweight ($< 18.5 kg/m^2$), normal weight ($18.5- < 25$
32
33 212 kg/m^2), overweight ($25- < 30 kg/m^2$) and obese ($\geq 30 kg/m^2$).[29] Resting blood pressure and heart
34
35 213 rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood
36
37 214 Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure
38
39 215 (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study,
40
41 216 construct validity was evaluated by investigating the relationship of outcomes from the Hausa
42
43 217 IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also in
44
45 218 part by comparing the differences in time spent in PA and sitting across sociodemographic
46
47 219 subgroups. These types of validation for PA measures have been referred as indirect or construct
48
49 220 validity in previous studies.[7,24,30]

221

222 222 *Sociodemographic Characteristics*

223
224 Information on age, gender, marital status, religion, income, educational level and employment
225
226 status were elicited from the participants. Marital status was classified as married or not married.
227
228 Educational level was classified as more than secondary school education, secondary school

1
2
3 226 education and less than secondary school education. Employment status was classified into white
4
5 227 collar (government or private employed), blue collar (self- employed, trader, artisan etc) and
6
7 228 unemployed (homemaker, student, retired, or unable to find job).
8
9

10 229

11 230 **Data Analysis**

12
13 231 Descriptive data were reported as mean, standard deviation and percentages. Mean group
14
15 232 differences for continuous variables by gender were examined by independent t-test, and for
16
17 233 dichotomous variables by chi-square statistics. The reliability analyses were performed using 2
18
19 234 strategies. First, the two- way mixed model (single measure) intraclass correlation coefficient
20
21 235 (ICC) with 95% confidence interval (CI) between the continuous scores obtained on 1st and 2nd
22
23 236 administration of the Hausa IPAQ-LF was calculated. The ICCs were calculated overall, and by
24
25 237 gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability
26
27 238 scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] Second,
28
29 239 the Bland and Altman Method was used to assess agreement on scores of PA from the 1st and 2nd
30
31 240 administrations.[32] Variables used for the Bland and Altman analysis were weekly time spent in
32
33 241 moderate-to-vigorous activity (MVPA), total PA and sitting. MVPA was computed by summing
34
35 242 the total minutes/week of reported physical activity of moderate and vigorous- intensities across
36
37 243 all four domains. For total PA, the total minutes/week of activities in each domain were summed
38
39 244 (total work + total transport + total domestic + total leisure-time min/week scores) to gain an
40
41 245 overall estimate of physical activity in a week. Also, the independent t-test and one-Way
42
43 246 ANOVA were used as appropriate to compare the time spent (minutes/week) in PA at both
44
45 247 administrations across sociodemographic subgroups. To assess construct validity, the non-
46
47 248 parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship
48
49 249 between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body
50
51 250 mass index. Data were analyzed using Statistical Package for the Social Science (SPSS), version
52
53 251 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at
54
55 252 $p < 0.05$.
56
57 253

54 254 **RESULTS**

1
2
3 255 The socio-demographic characteristic of the participants are shown in Table 1. The participants
4
5 256 comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of
6
7 257 $23.8 \pm 3.9\text{kg/m}^2$. Majority of the participants were married (58.9%, n=106), had more than
8
9 258 secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to
10
11 259 men, the women were more likely to be married (71.1% vs 46.7%, $p=0.001$) and unemployed
12
13 260 (52.2% vs 17.8%, $p<0.001$), but men were more likely to have more than secondary school
14
15 261 education (76.7% vs 48.2%, $p<0.001$).
16

17 263 **Reliability**

18
19 264 Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients
20
21 265 were good (ICC >0.75) for total PA, occupational PA, active transportation and vigorous intensity
22
23 266 (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability
24
25 267 (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA (ICC=0.80, 95%
26
27 268 CI=0.69-0.87), active transportation (ICC=0.83, 95% CI=0.73-0.89), occupational PA
28
29 269 (ICC=0.78, 95% CI=0.66-0.85) and leisure time PA (ICC=0.75, 95% CI=0.63-0.84) were
30
31 270 substantially higher among men than women, reliability coefficients for domestic PA (ICC=0.38,
32
33 271 95%, CI=0.01-0.57) and sitting time (ICC=0.71, 95% CI=0.46-0.85) were higher among women
34
35 272 than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest
36
37 273 value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity
38
39 274 (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous
40
41 275 intensity (very hard) activities were substantially greater in men than women.
42

43 276
44 277 Similarly, socioeconomic status differences were observed in the reliability coefficients of the
45
46 278 modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were
47
48 279 substantially higher among participants with less than secondary school education (ICC from
49
50 280 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school
51
52 281 education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and those with higher
53
54 282 than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]).
55
56 283 While reliability coefficients were higher for overall PA (ICC=0.80, 95% CI=0.71- 0.86), active
57
58 284 transport (ICC=0.83, 95% CI=0.74- 0.88), occupational PA (ICC=0.79, 95% CI=0.70- 0.86) and
59
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1
2
3 285 leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed
4
5 286 compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95%
6
7 287 CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were
8
9 288 unemployed than in the employed subgroup.

10 289
11
12 290 Figures 1, 2 and 3 (Bland-Altman plots) illustrate the agreement in the scores (minutes/week) of
13
14 291 total PA, MVPA and sitting between the first and second administrations of Hausa IPAQ-LF. For
15
16 292 total PA, the mean difference was 106.7 minutes/week, with a wide 95% limits of agreement (-
17
18 293 762.2 to 965.6 minutes/week). For MVPA, the mean difference was about one and half hour per
19
20 294 week (91.6 minutes/week), and also demonstrating wide 95% limits of agreement (-744.5 to
21
22 295 927.7 minutes/week). For sitting time, the mean difference was small (26 minutes/week) and the
23
24 296 95% limits of agreement range from -2178.1 to 2230.9 minutes/week.

25 297
26 298 Table 4 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1)
27
28 299 and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified
29
30 300 variables, time spent in PA reported during the first administration tends to be higher than those
31
32 301 reported during the second administration. At both time points, men reported significantly
33
34 302 ($p<0.05$) higher mean time (minute/week) in active transportation, occupational PA, and leisure-
35
36 303 time PA than women. However, women spent significantly ($p<0.001$) more time (minutes/week)
37
38 304 in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status,
39
40 305 participants that had lower than secondary school education compared to those with at least
41
42 306 secondary school education reported statistically significant higher mean time (minutes/week) at
43
44 307 both time points for total PA, active transport, occupational PA, walking and vigorous intensity
45
46 308 activity compared to those with at least secondary school education. While participants that were
47
48 309 employed reported statistically significant ($p<0.05$) more time (minutes/week) in total PA
49
50 310 (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1,
51
52 311 IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those
53
54 312 who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in
55
56 313 domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.

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315 **Construct Validity**

316 Overall, correlations between energy expenditure (MET-Minutes/week) according to the
317 modified IPAQ-LF and anthropometric and biological measures were statistically significant in
318 the expected direction for all domains and intensities of PA, except for occupation and active
319 transport domains and walking (table 5). In the full sample, domestic PA was mainly related with
320 SBP ($\rho = -0.27$, $p < 0.01$) and DBP ($\rho = -0.17$, $p < 0.05$), while leisure PA and total PA were only
321 related with SBP ($\rho = -0.16$, $p < 0.05$) and BMI ($\rho = -0.29$, $p < 0.01$), respectively. Similarly,
322 moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP ($\rho = -0.21$, $p <$
323 0.01), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$). In the gender
324 based analyses, total PA, domestic PA and sedentary time were more consistently related with
325 anthropometric and biological variables. The strongest rho value (-0.41) was found for the
326 relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was
327 reached between total PA and DBP for the women subgroup. Only in women was domestic PA
328 significantly related with BMI ($\rho = -0.23$), DBP ($\rho = -0.20$) and SBP ($\rho = -0.31$). Leisure-time
329 PA ($\rho = -0.39$) and occupational PA ($\rho = -0.22$) were significantly related with BMI only in men.
330 The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ
331 $= 0.19$) than men ($\rho = 0.15$).

332

333 **DISCUSSION**

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

340

341 We found evidence for good reliability with high correlations between the test-retest for total
342 PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that
343 except for domestic PA and sitting time, ICC values for domains of PA were consistently above
344 0.70, a level of reproducibility that has been considered acceptably good for IPAQ data.[33,34]

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2
3 345 Similar to a previous IPAQ-LF study in Hong Kong,[34] domestic activity demonstrated the
4
5 346 lowest ICC value in our study. However, it is possible that the infrequent nature of household
6
7 347 activities undertaken, especially by men may account for the low reliability reported for domestic
8
9 348 PA in our study. In addition to the traditional African patriarchal norm that make most African
10
11 349 men to rarely engage in indoor household activities, men in the high socioeconomic group in
12
13 350 Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home,
14
15 351 appliances and equipment maintenance because they are able to employ the services of domestic
16
17 352 helpers and repair men. Our findings of lower reliability for domestic activity among men, those
18
19 353 with more than secondary school education and those who were employed compared to their
20
21 354 counterparts seem to support this assumption.
22

23 355
24 356 The highest and strongest reliability coefficients (0.82) were found for both active transportation
25
26 357 and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and
27
28 358 reproducible overtime than other PA domains because it is a common and ubiquitous PA
29
30 359 behaviour in the African region. Mostly, the performance of active transportation especially
31
32 360 walking is often out of necessity rather than choice within the African context. Our finding of
33
34 361 higher ICC value for vigorous intensity PA is consistent with those of other studies that found
35
36 362 the reliability of vigorous intensity activity to be higher compared to that of moderate intensity
37
38 363 activity.[10,30,34,35] Compared to structured vigorous physical activities like sports and
39
40 364 exercise that can be more easily recalled, moderate intensity PA are often of low salience,
41
42 365 incidental and may not easily be remembered by people.[36,37] Further our finding that the
43
44 366 reliability of vigorous intensity physical activity was meaningfully higher among men than
45
46 367 women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria
47
48 368 are more consistent than women when responding to PA items that pertained to intense vigorous
49
50 369 PA than other intensities of activity. Overall, the moderate to good evidence of reliability found
51
52 370 for all items indicate that the modified IPAQ-LF is reproducible, internally consistent and is
53
54 371 promising for research in Nigeria.
55

56 372
57 373 Except for sitting time, the limits of agreement in the mean scores of total PA and MVPA
58
59 374 between the first and second administrations were wide, suggesting an evidence of bias between
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1
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3 375 administrations. Large difference in PA scores between the 2 administrations would indicate that
4
5 376 at least one of the two measurements is not accurate. However, similar to the finding of a
6
7 377 Mexican study,[38] scores on the Hausa IPAQ-LF were consistently lower during the second
8
9 378 administration of the questionnaire compared to the first administration. Because familiarity with
10
11 379 the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that
12
13 380 participants in our study might have over-reported their PA levels during the first administration
14
15 381 of the Hausa IPAQ-LF. This kind of findings may have implication for the utility of IPAQ for
16
17 382 surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA
18
19 383 that has been associated with the IPAQ,[39,40] it may be necessary to start considering the need
20
21 384 for multiple measurements when using the IPAQ for evaluating PA, especially in developing
22
23 385 African countries. However, patterns of PA as measured by the modified IPAQ-LF during both
24
25 386 administrations were consistently similar, and both administrations were able to discriminate PA
26
27 387 in the expected direction between subgroups of our sample. For example, at both measurement
28
29 388 time points, and consistent with hypothesis, men reported more time in active transportation,
30
31 389 occupational PA and leisure PA than women, while women reported more time in domestic PA
32
33 390 and sedentary activity than men.

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35 391
36
37 392 In the absence of objective criterion standards for evaluating an absolute estimate of PA, the
38
39 393 consistency of items on IPAQ with variables known to be related to PA such as body mass index
40
41 394 (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index
42
43 395 have been used as important construct validity measures.[7,10,21,24] In the present study, the
44
45 396 correlations of the PA domains and intensities with biological and anthropometric variables were
46
47 397 mostly significant in the expected direction, but they were low suggesting a modest evidence of
48
49 398 construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were
50
51 399 comparable with the values in other studies that have evaluated the IPAQ-LF.[5,7,8,24,30,33,39]
52
53 400 Because better validity coefficients have been reported for other PA measures above that of the
54
55 401 IPAQ,[39,41] with the present African finding, it is possible that the IPAQ-LF only have modest
56
57 402 evidence of construct validity. However, our findings on the relationships between physical
58
59 403 activity and biological and anthropometric variables should be interpreted in the light of an
60
404 important caution. Because hypertensive and obese people may get oriented to exercise,[3] cross-

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2
3 405 sectional associations of physical activity and blood pressure or BMI could also occur in the
4
5 406 opposite direction and may not represent much information as indicators of construct validity of
6
7 407 physical activity measures.
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9 408

10 409 **Strengths and limitations**

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12
13 410 A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to
14
15 411 reflect the common PA behaviours of people in Nigeria. This is the first study in an African
16
17 412 country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings
18
19 413 demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse
20
21 414 segment of the Nigerian population. In the Africa region, the importance of a valid and
22
23 415 established PA scale like the modified IPAQ-LF is not only important to monitoring the domain
24
25 416 in which activity is performed, but also very critical to understanding studies of ecological
26
27 417 models of health behaviours, that emphasize the importance of multiple levels of influence on
28
29 418 health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using
30
31 419 ecological models indicate that favourable built environmental attributes are promising for
32
33 420 improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45]
34
35 421 However, built environment characteristics are expected to be strongly related to specific PA
36
37 422 types rather than overall PA.[46,47] For example, different environmental variables can be
38
39 423 related to walking for leisure or transportation and to moderate PA for household, occupation,
40
41 424 recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to
42
43 425 understanding the domain specific nature of ecological models research in the African region.
44
45 426 One additional strength was the exploration of PA patterns by gender, educational level and
46
47 427 employment status, the findings of which were consistent with general hypothesis on social
48
49 428 patterns of inactivity in low-income countries.[20,48]
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51 429

52
53 430 However, the findings of this study should be interpreted in the light of some important
54
55 431 limitations. Direct comparison of our validity findings with previous studies should be made with
56
57 432 caution, because unlike in our study, the accelerometer or PA diary were utilized as a common
58
59 433 objective criterion standard to validate the IPAQ in the majority of the
60
434 studies.[5,7,8,24,30,33,39] Thus, examining the construct validity through the relationships of

1
2
3 435 PA with BMI and resting blood pressure was an important limitation of our study. The choice
4
5 436 and availability of appropriate criterion measures are particular issues of concern for the
6
7 437 validation of PA questionnaires in low-income countries of Africa [5,49,50]. Despite these
8
9 438 issues, the validity coefficients in our study were remarkably similar to those reported in other
10
11 439 studies, [5,7,8,24,30,33,39] and the consistency of items on IPAQ with variables known to be
12
13 440 related to PA such as BMI, blood pressure, heart rate, indicators of lipid and glucose metabolism,
14
15 441 and fitness index have previously been used as important construct validity
16
17 442 measures.[7,10,21,24] Another limitation of the study is the use of non-probability sampling
18
19 443 technique. The study finding may have limited generalizability to other samples of Nigerians that
20
21 444 have different characteristics from this sample. In addition, the majority of participants have
22
23 445 more than secondary school education with potentially higher comprehension and recall ability
24
25 446 than may be found in the general population. Nevertheless, recruitment from diverse
26
27 447 neighbourhoods and settings allowed for a sample with reasonable heterogeneity in age,
28
29 448 occupational status, and ethnic backgrounds and made it possible to stratify the analyses by
30
31 449 sociodemographic characteristics. However, because some of the participants in the present
32
33 450 study required assistance to complete the survey, interview administration rather than self-
34
35 451 administration of the IPAQ-LF should be encouraged in any future national studies in the
36
37 452 African region. Administering the IPAQ through interview has been considered as a viable and
38
39 453 preferred option in developing countries.[5]
40
41 454

455 **Conclusions**

456 Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence
457
458 of test-retest reliability and may be valid for assessing context specific PA behaviours of adults
459
460 in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could
461
462 further contribute to our understanding of the impact of multiple levels of influence on PA
463
464 behaviours of people in the African region.

1
2
3 465**Acknowledgments**

467 The authors are grateful to Mrs. Salamatu U Aliyu and Mr. Sa'adu Inusa Kiriri for their help
468 with questionnaire translations, and to the participants for their help for taking part in the study.

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Contributors

470
471 ALO conceived and designed the study, contributed to cultural adaptation and acquisition of
472 data, conducted the statistical analysis and interpretation of data and drafted the manuscript.
473 UMB and STP managed participants' recruitment and data collection and contributed to cultural
474 adaptation. HBN and RDM contributed to cultural adaptation and translations of the measure.
475 AYO contributed to study design, acquisition of data and critically revised the manuscript for
476 important intellectual contents. All authors read and approved the final manuscript.

477

Funding

478
479 This research received no specific grant from any funding agency in the public, commercial or
480 not-for-profit sectors.

481

Competing interests

482
483 Authors declare there is no competing interest associated with this study.

484

Ethics approval

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

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Data sharing process

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490 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 (\pm SD)	35.6 \pm 10.3	35.7 \pm 8.3	35.5 \pm 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/m²)			
Mean (\pm SD)	23.8 \pm 3.9	23.8 \pm 3.5	23.8 \pm 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)			Women (n=90)	Men (n=90)
	Test 1 (Mean (SD))	Test 2 (Mean (SD))	ICC (95%CI)	ICC (95%CI)	ICC (95%CI)
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 (0.68-0.82)	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)

1 PA= Physical Activity
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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)

MET×min/wk	Overall (N = 180)			Female (n = 90)			Male (n = 90)		
	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

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**=p<0.01

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28 18 **Key words:** Physical activity, measurement, public health, IPAQ, Nigeria
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20 **Word counts:** 4352

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3 33 **ABSTRACT**
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5 34 **Objectives:** To investigate the reliability and aspect of validity of a modified version of the long
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7 35 International Physical Activity Questionnaire (Hausa IPAQ-LF) in Nigeria.

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9 36 **Design:** Cross-sectional study, examining the reliability and construct validity of the Hausa
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11 37 IPAQ-LF compared with anthropometric and biological variables.

12 38 **Setting:** Metropolitan Maiduguri, the capital city of Borno State in Nigeria.

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14 39 **Participants:** 180 Nigerian adults (50% women) with a mean age of 35.6 (SD=10.3) years,
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16 40 recruited from neighbourhood with diverse socioeconomic status and walkability.

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18 41 **Outcome measures:** Domains (domestic physical activity [PA], occupational PA, leisure-time
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20 42 PA, active transportation and sitting time) and intensities of PA (vigorous, moderate and
21
22 43 walking) were measured with the Hausa IPAQ-LF on two different occasions, eight days apart.
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24 44 Outcomes for construct validity were measured BMI, SBP and DBP.

25 45 **Results:** The Hausa IPAQ-LF demonstrated good test-retest reliability (ICC>75) for total PA
26
27 46 (ICC=0.79, 95% CI=0.65-0.82), occupational PA (ICC=0.77, 95% CI=0.68-0.82), active
28
29 47 transportation (ICC=0.82, 95% CI=0.75-0.87) and vigorous intensity activities (ICC=0.82, 95%
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31 48 CI=0.76-0.87). Reliability was substantially higher for total PA (ICC=0.80), occupational PA
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33 49 (ICC=0.78), leisure-time PA (ICC=0.75) and active transportation (ICC=0.80) in men than
34
35 50 women, but domestic PA (ICC=0.38) and sitting time (ICC=0.71) demonstrated substantial
36
37 51 reliability coefficients in women than men. For the construct validity, domestic PA was
38
39 52 significantly related mainly with SBP ($\rho = -0.27$) and DBP ($\rho = -0.17$), and leisure-time PA and
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41 53 total PA were significantly related only with SBP ($\rho = -0.16$) and BMI ($\rho = -0.29$), respectively.
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43 54 Similarly, moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP (ρ
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45 55 = -0.21 , $p < 0.01$), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$).

46 56 **Conclusions:** The modified Hausa IPAQ-LF demonstrated sufficient evidence of test-retest
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48 57 reliability and may be valid for assessing context specific PA behaviours of adults in Nigeria.
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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.

106 INTRODUCTION

107
108 The importance of physical activity (PA) for promoting health and preventing disease is well
109 established.[1-3] However, for effective health promotion and PA surveillance and monitoring, it
110 is important to have standardized, reliable and valid instruments that can be used to accurately
111 describe population levels and patterns of PA within and across countries.[4, 5] In this context,
112 the international physical activity questionnaire (IPAQ) was developed to obtain internationally
113 comparable data on health-related PA of adults (18-65 years).[5, 6] Two versions of the IPAQ
114 that could be administered by interview or self-completed were developed. The short form (SF)
115 was designed for population surveillance of PA; while the long form (LF) was designed to be
116 appropriate for use in research that requires detailed information on different PA domains,
117 including PA at work, household, during leisure and transportation, and time spent in sedentary
118 activities.[6]

119
120 The initial evaluation of the IPAQ across 12 countries produced acceptable evidence of
121 reliability and validity that are as good as other self-report measures of PA.[5] Consequently, in
122 order to enhance the utility of IPAQ and to further evaluate its psychometrics worldwide, efforts
123 have been made to translate and adapt the IPAQ in many other countries, but most of the
124 research in this context were from the Western developed countries.[7-14] In Africa, the
125 psychometric properties of IPAQ have only been tested in South-Africa as part of the initial
126 development process of the questionnaire,[5] and in older adults.[15] Because the largest
127 increases and burden of non-communicable diseases (NCDs) are in the low-income countries
128 where the understanding of evidence-based strategies for increasing PA remains poor,[16-19]
129 improving PA research is a top priority for low-income countries.[20] However, to advance PA
130 research in Africa, it is important to first develop or tailor standardized measures to be culturally
131 sensitive to PA behaviours of people in the region countries. Because Nigeria is the most
132 populous country in Africa with culture and languages similar to most of the other West African
133 countries, it is a good choice to evaluate the IPAQ for cultural and psychometric relevance in this
134 country.

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3 136 Recently, a cultural adaptation study of the IPAQ-SF was conducted among adults in
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5 137 Nigeria,[21] with good evidence of test-retest reliability similar to findings in some other
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7 138 studies.[10, 22-24] However, because the IPAQ-SF is not domain specific and does not provide
8
9 139 context specific information on PA behaviour, it is important to evaluate the IPAQ-LF for
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11 140 relevance in Nigeria. Psychometric evaluation of a culturally modified version of the IPAQ-LF
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13 141 in sub-Saharan African countries can impact PA research and surveillance in the African region
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15 142 where the prevalence of inactivity related NCDs is on the increase.[20, 25] The aim of the
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17 143 present study was to investigate the reliability and an aspect of validity of a modified version of
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19 144 the IPAQ-LF among adults in Nigeria.
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21 146 **METHODS**

24 148 **Participants**

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26 149 A purposive sample of 180 adults from eight neighbourhoods that varied in socioeconomic status
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28 150 and walkability in Maiduguri city were recruited for the study. The sampling and neighbourhood
29
30 151 selection strategy have been described in details elsewhere.[26] Maiduguri with an estimated
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32 152 population of 749,123 people is the largest and capital city of Borno State in North-Eastern
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34 153 Nigeria.[27] The city attracts immigrants from neighbouring countries of Cameroon, Niger and
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36 154 Chad Republic, and Hausa language is the common means of communication for commercial
37
38 155 activities among the diverse inhabitants of Maiduguri.[27, 28] Participants were eligible for this
39
40 156 study if they were willing to self-complete a written survey twice in either Hausa or English
41
42 157 Language. However, researchers (UMB and STP) were in attendance to provide translation and
43
44 158 interpretation assistance to participants (n=11) who required help to complete the survey.
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46 159 Additional eligibility criteria included living within the identified neighbourhood categories in
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48 160 the last 12 months, being adults (18-65 years) and not having any disability that prevented
49
50 161 independent walking. All participants were fully informed of the study protocol and provided
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52 162 signed informed consent. The study protocol was approved by the Research and Ethic
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54 163 Committee of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria. Data were
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56 164 collected between March and May, 2012.
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3 166 **Measures**

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5 167 *The adapted international physical activity questionnaire- long Hausa version*

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7 168 The cultural adaptation, translation and back translation of the Hausa version of IPAQ-LF is
8
9 169 similar to that of the Hausa IPAQ-SF that has been described in details elsewhere.[21] Briefly,
10
11 170 interviews were conducted with public health experts, exercise scientists and not highly educated
12
13 171 local people to identify the items and examples of PA on the original questionnaires that needed
14
15 172 to be culturally adapted. Several cultural adaptations were made to the original items to reflect
16
17 173 the reality in Nigeria. First, adjustments to English words like vigorous and moderate activity
18
19 174 that can be misunderstood and not associated with PA behaviours in Nigeria were replaced with
20
21 175 words that are more representative of the language used in Nigeria, like 'very hard' and 'hard'
22
23 176 respectively. Second, examples of various intensities of activity that were common in the
24
25 177 Nigerian culture were added, and those already on the questionnaire but not common in the
26
27 178 Nigerian context were replaced with culturally applicable examples that are equivalent in energy
28
29 179 intensity (METs) with the original items and examples. Third, concepts like physical activity and
30
31 180 walking for transportation that were misconstrued outside the health context were refined to
32
33 181 indicate they were referring to health behaviours.

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35 182
36 183 After adaptation, the questionnaire was independently translated from English into Hausa
37
38 184 language by two native speakers of Hausa who also speaks English, and able to read and write in
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40 185 both languages. One of the translators was familiar with the questionnaire and the second was an
41
42 186 expert in Hausa language. The translated questionnaires were mutually revised by the translators
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44 187 and the research team for consistency and then back translated into English language by a third
45
46 188 bilingual person who was familiar with the construct measured by IPAQ. The back translated
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48 189 version was checked by the research team for any discrepancies and to ensure that the construct
49
50 190 measures by IPAQ had not been lost during the adaptation and translation process.

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53 192 The modified questionnaire (available in both Hausa and English language), hereafter referred to
54
55 193 as the Hausa version of the long international physical activity questionnaire (Hausa IPAQ-LF),
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57 194 contains thirty-one questions that asked about physical activity done in the last 7-days in terms of
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59 195 frequency (days/week) and duration (minutes/day) spent in four activity domains (transportation,
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3 196 occupation, domestic and leisure time), and included sections on walking, moderate- and
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5 197 vigorous- intensity activities, and time spent in sedentary behaviours (sitting during leisure and
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7 198 motorized transportation). The Hausa IPAQ-LF data were presented as the MET-minute/week
8
9 199 for total walking, moderate, and vigorous intensity activity and overall physical activity across
10
11 200 the four domains, and in each of the domains. The MET intensity values used to score the Hausa
12
13 201 IPAQ-LF questions in this study were 8 METs for vigorous activity, 4 METs for moderate
14
15 202 activity and 3.3 METs for walking,[2, 6] One MET represents the energy expended while sitting
16
17 203 quietly at rest and is equivalent to 3.5 ml/kg/min of VO_2 Max.[3] To assess the test-retest
18
19 204 reliability of the Hausa IPAQ-LF, participants self-completed all items on the measure twice,
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21 205 with an interval of one week between administrations.

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23 207 *Anthropometrical and biological measurements*

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25 208 Body weight (to nearest 0.5 kg) and Height (to nearest 0.1 cm) were measured in light clothing
26
27 209 using a digital scale and stadiometer. Body mass index (BMI) was calculated as body weight
28
29 210 divided by the square of height (kg/m^2). The principal cutoff points as recommended by WHO
30
31 211 were used to create the categories: underweight ($< 18.5 kg/m^2$), normal weight ($18.5- < 25$
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33 212 kg/m^2), overweight ($25- < 30 kg/m^2$) and obese ($\geq 30 kg/m^2$).[29] Resting blood pressure and heart
34
35 213 rate were measured with Digital Sphygmomanometer (Diagnostic Advanced Wrist Blood
36
37 214 Pressure Monitor, Model 6016, USA). Body mass index and resting diastolic blood pressure
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39 215 (DBP) have previously been used for validating the IPAQ.[7,24] Similarly, for this study,
40
41 216 construct validity was evaluated by investigating the relationship of outcomes from the Hausa
42
43 217 IPAQ-LF with anthropometric (BMI) and biological (SBP and DBP) measurements, and also in
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45 218 part by comparing the differences in time spent in PA and sitting across sociodemographic
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47 219 subgroups. These types of validation for PA measures have been referred as indirect or construct
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49 220 validity in previous studies.[7,24,30]

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222 222 *Sociodemographic Characteristics*

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224 Information on age, gender, marital status, religion, income, educational level and employment
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226 status were elicited from the participants. Marital status was classified as married or not married.
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228 Educational level was classified as more than secondary school education, secondary school
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3 226 education and less than secondary school education. Employment status was classified into white
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5 227 collar (government or private employed), blue collar (self- employed, trader, artisan etc) and
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7 228 unemployed (homemaker, student, retired, or unable to find job).
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11 230 **Data Analysis**

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13 231 Descriptive data were reported as mean, standard deviation and percentages. Mean group
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15 232 differences for continuous variables by gender were examined by independent t-test, and for
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17 233 dichotomous variables by chi-square statistics. The reliability analyses were performed using 2
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19 234 strategies. First, the two- way mixed model (single measure) intraclass correlation coefficient
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21 235 (ICC) with 95% confidence interval (CI) between the continuous scores obtained on 1st and 2nd
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23 236 administration of the Hausa IPAQ-LF was calculated. The ICCs were calculated overall, and by
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25 237 gender and socioeconomic status. ICC estimates >0.75 were considered as good reliability
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27 238 scores, between 0.50 and 0.75 as moderate reliability and <0.50 as poor reliability.[31] Second,
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29 239 the Bland and Altman Method was used to assess agreement on scores of PA from the 1st and 2nd
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31 240 administrations.[32] Variables used for the Bland and Altman analysis were weekly time spent in
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33 241 moderate-to-vigorous activity (MVPA), total PA and sitting. MVPA was computed by summing
34
35 242 the total minutes/week of reported physical activity of moderate and vigorous- intensities across
36
37 243 all four domains. For total PA, the total minutes/week of activities in each domain were summed
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39 244 (total work + total transport + total domestic + total leisure-time min/week scores) to gain an
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41 245 overall estimate of physical activity in a week. Also, the independent t-test and one-Way
42
43 246 ANOVA were used as appropriate to compare the time spent (minutes/week) in PA at both
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45 247 administrations across sociodemographic subgroups. To assess construct validity, the non-
46
47 248 parametric Spearman correlation coefficients (ρ) were utilized to explore the relationship
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49 249 between MET-min/week of PA from the Hausa IPAQ- LF, and resting blood pressure and body
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51 250 mass index. Data were analyzed using Statistical Package for the Social Science (SPSS), version
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53 251 15.0 for windows (SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at
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55 252 $p<0.05$.
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54 254 **RESULTS**

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3 255 The socio-demographic characteristic of the participants are shown in Table 1. The participants
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5 256 comprised 50% women and men, with a mean age of 35.6 ± 10.3 years and body mass index of
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7 257 $23.8 \pm 3.9\text{kg/m}^2$. Majority of the participants were married (58.9%, n=106), had more than
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9 258 secondary school education (62.7%, n=111) and were employed (75%, n=117). Compared to
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11 259 men, the women were more likely to be married (71.1% vs 46.7%, $p=0.001$) and unemployed
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13 260 (52.2% vs 17.8%, $p<0.001$), but men were more likely to have more than secondary school
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15 261 education (76.7% vs 48.2%, $p<0.001$).
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18 263 **Reliability**

19 264 Table 2 shows the test-retest reliability of the modified IPAQ-LF. Overall, reliability coefficients
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21 265 were good ($\text{ICC} > 0.75$) for total PA, occupational PA, active transportation and vigorous intensity
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23 266 (very hard) PA. Domestic PA, sitting activity and leisure PA demonstrated moderate reliability
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25 267 (ICC ranges from 0.51- 0.71). While, the reliability coefficients of total PA ($\text{ICC}=0.80$, 95%
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27 268 $\text{CI}=0.69-0.87$), active transportation ($\text{ICC}=0.83$, 95% $\text{CI}=0.73-0.89$), occupational PA
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29 269 ($\text{ICC}=0.78$, 95% $\text{CI}=0.66-0.85$) and leisure time PA ($\text{ICC}=0.75$, 95% $\text{CI}=0.63-0.84$) were
30
31 270 substantially higher among men than women, reliability coefficients for domestic PA ($\text{ICC}=0.38$,
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33 271 95%, $\text{CI}=0.01-0.57$) and sitting time ($\text{ICC}=0.71$, 95% $\text{CI}=0.46-0.85$) were higher among women
34
35 272 than men. According to the intensity of PA, ICCs range between 0.61 and 0.82, with the lowest
36
37 273 value recorded for moderate intensity (hard) PA and the highest value for vigorous intensity
38
39 274 (very hard) PA. The reliability coefficients for walking, moderate-intensity (hard) and vigorous
40
41 275 intensity (very hard) activities were substantially greater in men than women.
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44 277 Similarly, socioeconomic status differences were observed in the reliability coefficients of the
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46 278 modified IPAQ-LF (Table 3). Across all domains of PA, reliability coefficients were
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48 279 substantially higher among participants with less than secondary school education (ICC from
49
50 280 0.77 [sitting activity] to 0.92 [leisure activity]) compared to those with secondary school
51
52 281 education (ICC from 0.28 [active transport] to 0.58 [occupational activity]) and those with higher
53
54 282 than secondary school education (ICC from 0.23 [sitting activity] to 0.67[active transport]).
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56 283 While reliability coefficients were higher for overall PA ($\text{ICC}=0.80$, 95% $\text{CI}=0.71- 0.86$), active
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58 284 transport ($\text{ICC}=0.83$, 95% $\text{CI}=0.74- 0.88$), occupational PA ($\text{ICC}=0.79$, 95% $\text{CI}=0.70- 0.86$) and
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3 285 leisure-time PA (ICC= 0.79, 95% CI= 0.69- 0.85) among participants that were employed
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5 286 compared to their unemployed counterparts, it was higher for domestic PA (ICC=0.65, 95%
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7 287 CI=0.43- 0.79) and sitting time (ICC= 0.68, 95% CI= 0.36- 0.83) among participants that were
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9 288 unemployed than in the employed subgroup.

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11
12 290 Figures 1, 2 and 3 (Bland-Altman plots) illustrate the agreement in the scores (minutes/week) of
13
14 291 total PA, MVPA and sitting between the first and second administrations of Hausa IPAQ-LF. For
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16 292 total PA, the mean difference was 106.7 minutes/week, with a wide 95% limits of agreement (-
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18 293 762.2 to 965.6 minutes/week). For MVPA, the mean difference was about one and half hour per
19
20 294 week (91.6 minutes/week), and also demonstrating wide 95% limits of agreement (-744.5 to
21
22 295 927.7 minutes/week). For sitting time, the mean difference was small (26 minutes/week) and the
23
24 296 95% limits of agreement range from -2178.1 to 2230.9 minutes/week.

25 297
26 298 Table 4 shows the patterns of PA across sociodemographic subgroups during the first (IPAQ1)
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28 299 and second (IPAQ2) administrations of the modified IPAQ-LF. Overall and across all stratified
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30 300 variables, time spent in PA reported during the first administration tends to be higher than those
31
32 301 reported during the second administration. At both time points, men reported significantly
33
34 302 ($p<0.05$) higher mean time (minute/week) in active transportation, occupational PA, and leisure-
35
36 303 time PA than women. However, women spent significantly ($p<0.001$) more time (minutes/week)
37
38 304 in domestic PA than men (IPAQ1=236.9 vs 82.3, IPAQ2=195.5 vs 52.4). For educational status,
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40 305 participants that had lower than secondary school education compared to those with at least
41
42 306 secondary school education reported statistically significant higher mean time (minutes/week) at
43
44 307 both time points for total PA, active transport, occupational PA, walking and vigorous intensity
45
46 308 activity compared to those with at least secondary school education. While participants that were
47
48 309 employed reported statistically significant ($p<0.05$) more time (minutes/week) in total PA
49
50 310 (IPAQ1=441.1 vs 285.1, IPAQ2=359.4 vs 141.0), active transportation (IPAQ1=43.8 vs 21.1,
51
52 311 IPAQ2=36.9 vs 18.3) and work PA (IPAQ1=195.5 vs 41.8, IPAQ2=164.1 vs 40.1) than those
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54 312 who were unemployed, the unemployed reported statistically significant ($p<0.05$) higher time in
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56 313 domestic activity (IPAQ1=210.6 vs 132.1, IPAQ2=205.0 vs 112.6) compared to the employed.

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315 **Construct Validity**

316 Overall, correlations between energy expenditure (MET-Minutes/week) according to the
317 modified IPAQ-LF and anthropometric and biological measures were statistically significant in
318 the expected direction for all domains and intensities of PA, except for occupation and active
319 transport domains and walking (table 5). In the full sample, domestic PA was mainly related with
320 SBP ($\rho = -0.27$, $p < 0.01$) and DBP ($\rho = -0.17$, $p < 0.05$), while leisure PA and total PA were only
321 related with SBP ($\rho = -0.16$, $p < 0.05$) and BMI ($\rho = -0.29$, $p < 0.01$), respectively. Similarly,
322 moderate-intensity PA was mainly related with SBP ($\rho = -0.16$, $p < 0.05$) and DBP ($\rho = -0.21$, $p <$
323 0.01), but vigorous-intensity PA was only related with BMI ($\rho = -0.11$, $p < 0.05$). In the gender
324 based analyses, total PA, domestic PA and sedentary time were more consistently related with
325 anthropometric and biological variables. The strongest rho value (-0.41) was found for the
326 relationship between total PA and BMI for the male subgroup. The rho values of -0.23 was
327 reached between total PA and DBP for the women subgroup. Only in women was domestic PA
328 significantly related with BMI ($\rho = -0.23$), DBP ($\rho = -0.20$) and SBP ($\rho = -0.31$). Leisure-time
329 PA ($\rho = -0.39$) and occupational PA ($\rho = -0.22$) were significantly related with BMI only in men.
330 The rho value for the relationship between sitting time and BMI was slightly higher in women (ρ
331 $= 0.19$) than men ($\rho = 0.15$).

332

333 **DISCUSSION**

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

340

341 We found evidence for good reliability with high correlations between the test-retest for total
342 PA, occupational PA, active transportation and vigorous intensity activity. Our results shows that
343 except for domestic PA and sitting time, ICC values for domains of PA were consistently above
344 0.70 , a level of reproducibility that has been considered acceptably good for IPAQ data.[33,34]

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3 345 Similar to a previous IPAQ-LF study in Hong Kong,[34] domestic activity demonstrated the
4
5 346 lowest ICC value in our study. However, it is possible that the infrequent nature of household
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7 347 activities undertaken, especially by men may account for the low reliability reported for domestic
8
9 348 PA in our study. In addition to the traditional African patriarchal norm that make most African
10
11 349 men to rarely engage in indoor household activities, men in the high socioeconomic group in
12
13 350 Nigeria may also not engage in outdoor domestic activities like gardening and outdoor home,
14
15 351 appliances and equipment maintenance because they are able to employ the services of domestic
16
17 352 helpers and repair men. Our findings of lower reliability for domestic activity among men, those
18
19 353 with more than secondary school education and those who were employed compared to their
20
21 354 counterparts seem to support this assumption.
22

23 356 The highest and strongest reliability coefficients (0.82) were found for both active transportation
24
25 357 and vigorous intensity activity. Perhaps, active transportation was more stable, consistent and
26
27 358 reproducible overtime than other PA domains because it is a common and ubiquitous PA
28
29 359 behaviour in the African region. Mostly, the performance of active transportation especially
30
31 360 walking is often out of necessity rather than choice within the African context. Our finding of
32
33 361 higher ICC value for vigorous intensity PA is consistent with those of other studies that found
34
35 362 the reliability of vigorous intensity activity to be higher compared to that of moderate intensity
36
37 363 activity.[10,30,34,35] Compared to structured vigorous physical activities like sports and
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39 364 exercise that can be more easily recalled, moderate intensity PA are often of low salience,
40
41 365 incidental and may not easily be remembered by people.[36,37] Further our finding that the
42
43 366 reliability of vigorous intensity physical activity was meaningfully higher among men than
44
45 367 women seem to confirm our previous findings with the IPAQ-SF.[21] Plausibly men in Nigeria
46
47 368 are more consistent than women when responding to PA items that pertained to intense vigorous
48
49 369 PA than other intensities of activity. Overall, the moderate to good evidence of reliability found
50
51 370 for all items indicate that the modified IPAQ-LF is reproducible, internally consistent and is
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53 371 promising for research in Nigeria.
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57 373 Except for sitting time, the limits of agreement in the mean scores of total PA and MVPA
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59 374 between the first and second administrations were wide, suggesting an evidence of bias between
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3 375 administrations. Large difference in PA scores between the 2 administrations would indicate that
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5 376 at least one of the two measurements is not accurate. However, similar to the finding of a
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7 377 Mexican study,[38] scores on the Hausa IPAQ-LF were consistently lower during the second
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9 378 administration of the questionnaire compared to the first administration. Because familiarity with
10
11 379 the IPAQ questions may improve over multiple exposures to the questionnaire, it is possible that
12
13 380 participants in our study might have over-reported their PA levels during the first administration
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15 381 of the Hausa IPAQ-LF. This kind of findings may have implication for the utility of IPAQ for
16
17 382 surveillance. Generally, due to issues of social desirability phenomenon and over reporting of PA
18
19 383 that has been associated with the IPAQ,[39,40] it may be necessary to start considering the need
20
21 384 for multiple measurements when using the IPAQ for evaluating PA, especially in developing
22
23 385 African countries. However, patterns of PA as measured by the modified IPAQ-LF during both
24
25 386 administrations were consistently similar, and both administrations were able to discriminate PA
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27 387 in the expected direction between subgroups of our sample. For example, at both measurement
28
29 388 time points, and consistent with hypothesis, men reported more time in active transportation,
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31 389 occupational PA and leisure PA than women, while women reported more time in domestic PA
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33 390 and sedentary activity than men.
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37 392 In the absence of objective criterion standards for evaluating an absolute estimate of PA, the
38
39 393 consistency of items on IPAQ with variables known to be related to PA such as body mass index
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41 394 (BMI), blood pressure, heart rate, indicators of lipid and glucose metabolism, and fitness index
42
43 395 have been used as important construct validity measures.[7,10,21,24] In the present study, the
44
45 396 correlations of the PA domains and intensities with biological and anthropometric variables were
46
47 397 mostly significant in the expected direction, but they were low suggesting a modest evidence of
48
49 398 construct validity for the modified IPAQ-LF in Nigeria. However, observed correlations were
50
51 399 comparable with the values in other studies that have evaluated the IPAQ-LF.[5,7,8,24,30,33,39]
52
53 400 Because better validity coefficients have been reported for other PA measures above that of the
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55 401 IPAQ,[39,41] with the present African finding, it is possible that the IPAQ-LF only have modest
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57 402 evidence of construct validity. However, our findings on the relationships between physical
58
59 403 activity and biological and anthropometric variables should be interpreted in the light of an
60
61 404 important caution. Because hypertensive and obese people may get oriented to exercise,[3] cross-

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3 405 sectional associations of physical activity and blood pressure or BMI could also occur in the
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5 406 opposite direction and may not represent much information as indicators of construct validity of
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7 407 physical activity measures.
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9 408

10 409 **Strengths and limitations**

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13 410 A strength of this study is the systematic adaptation and tailoring of items on the IPAQ-LF to
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15 411 reflect the common PA behaviours of people in Nigeria. This is the first study in an African
16
17 412 country to explore the cultural adaptation and translation of the IPAQ-LF, and its findings
18
19 413 demonstrated the feasibility of using the IPAQ-LF to reliably collect PA data in a diverse
20
21 414 segment of the Nigerian population. In the Africa region, the importance of a valid and
22
23 415 established PA scale like the modified IPAQ-LF is not only important to monitoring the domain
24
25 416 in which activity is performed, but also very critical to understanding studies of ecological
26
27 417 models of health behaviours, that emphasize the importance of multiple levels of influence on
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29 418 health behaviours including PA.[18,42] In Nigeria, emerging evidence from studies using
30
31 419 ecological models indicate that favourable built environmental attributes are promising for
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33 420 improving total and moderate-to-vigorous PA and controlling obesity among adults.[26, 43-45]
34
35 421 However, built environment characteristics are expected to be strongly related to specific PA
36
37 422 types rather than overall PA.[46,47] For example, different environmental variables can be
38
39 423 related to walking for leisure or transportation and to moderate PA for household, occupation,
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41 424 recreation or transportation. Thus, a study of adaptation of the IPAQ-LF is very important to
42
43 425 understanding the domain specific nature of ecological models research in the African region.
44
45 426 One additional strength was the exploration of PA patterns by gender, educational level and
46
47 427 employment status, the findings of which were consistent with general hypothesis on social
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49 428 patterns of inactivity in low-income countries.[20,48]
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51 429

52
53 430 However, the findings of this study should be interpreted in the light of some important
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55 431 limitations. Direct comparison of our validity findings with previous studies should be made with
56
57 432 caution, because unlike in our study, the accelerometer or PA diary were utilized as a common
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59 433 objective criterion standard to validate the IPAQ in the majority of the
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61 434 studies.[5,7,8,24,30,33,39] Thus, examining the construct validity through the relationships of

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2
3 435 PA with BMI and resting blood pressure was an important limitation of our study. The choice
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5 436 and availability of appropriate criterion measures are particular issues of concern for the
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7 437 validation of PA questionnaires in low-income countries of Africa [5,49,50]. Despite these
8
9 438 issues, the validity coefficients in our study were remarkably similar to those reported in other
10
11 439 studies, [5,7,8,24,30,33,39] and the consistency of items on IPAQ with variables known to be
12
13 440 related to PA such as BMI, blood pressure, heart rate, indicators of lipid and glucose metabolism,
14
15 441 and fitness index have previously been used as important construct validity
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17 442 measures.[7,10,21,24] Another limitation of the study is the use of non-probability sampling
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19 443 technique. The study finding may have limited generalizability to other samples of Nigerians that
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21 444 have different characteristics from this sample. In addition, the majority of participants have
22
23 445 more than secondary school education with potentially higher comprehension and recall ability
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25 446 than may be found in the general population. Nevertheless, recruitment from diverse
26
27 447 neighbourhoods and settings allowed for a sample with reasonable heterogeneity in age,
28
29 448 occupational status, and ethnic backgrounds and made it possible to stratify the analyses by
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31 449 sociodemographic characteristics. However, because some of the participants in the present
32
33 450 study required assistance to complete the survey, interview administration rather than self-
34
35 451 administration of the IPAQ-LF should be encouraged in any future national studies in the
36
37 452 African region. **Administering the IPAQ through interview has been considered as a viable and
38
39 453 preferred option in developing countries.[5]**
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41 454

455 **Conclusions**

456 Overall, the present study suggests that the modified IPAQ-LF demonstrated sufficient evidence
457
458 of test-retest reliability and may be valid for assessing context specific PA behaviours of adults
459
460 in Nigeria. Adaptation and criterion evaluation of the IPAQ-LF in other African countries could
461
462 further contribute to our understanding of the impact of multiple levels of influence on PA
463
464 behaviours of people in the African region.

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3 465**Acknowledgments**

467 The authors are grateful to Mrs. Salamatu U Aliyu and Mr. Sa'adu Inusa Kiriri for their help
468 with questionnaire translations, and to the participants for their help for taking part in the study.

469

Contributors

470
471 ALO conceived and designed the study, contributed to cultural adaptation and acquisition of
472 data, conducted the statistical analysis and interpretation of data and drafted the manuscript.
473 UMB and STP managed participants' recruitment and data collection and contributed to cultural
474 adaptation. HBN and RDM contributed to cultural adaptation and translations of the measure.
475 AYO contributed to study design, acquisition of data and critically revised the manuscript for
476 important intellectual contents. All authors read and approved the final manuscript.

477

Funding

478
479 This research received no specific grant from any funding agency in the public, commercial or
480 not-for-profit sectors.

481

Competing interests

482
483 Authors declare there is no competing interest associated with this study.

484

Ethics approval

485
486 Research and Ethic Committee of the University of Maiduguri Teaching Hospital, Nigeria
487 (ADM/TH/EC/75).

488

Data sharing process

489
490 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 (\pm SD)	35.6 \pm 10.3	35.7 \pm 8.3	35.5 \pm 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/m²)			
Mean (\pm SD)	23.8 \pm 3.9	23.8 \pm 3.5	23.8 \pm 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)			Women (n=90)	Men (n=90)
	Test 1 (Mean (SD))	Test 2 (Mean (SD))	ICC (95%CI)	ICC (95%CI)	ICC (95%CI)
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 (0.68-0.82)	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)

1 PA= Physical Activity
2 *=p<0.05
3 **=p<0.001
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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

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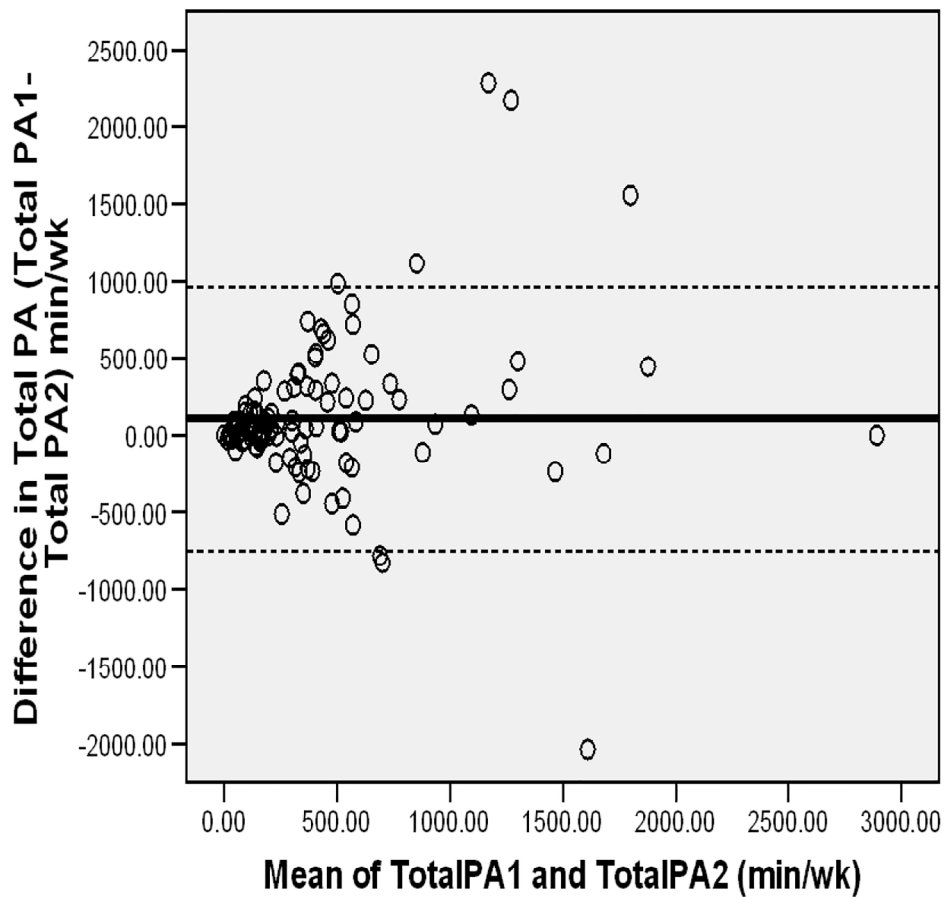


Figure 1: Bland-Altman plot min/wk reported in total physical activity (PA) for the first and second administrations of Hausa IPAQ-LF. Mean difference: 106.7 +/- 2SD (Standard deviation) = -762.2 to 965.6

238x265mm (300 x 300 DPI)

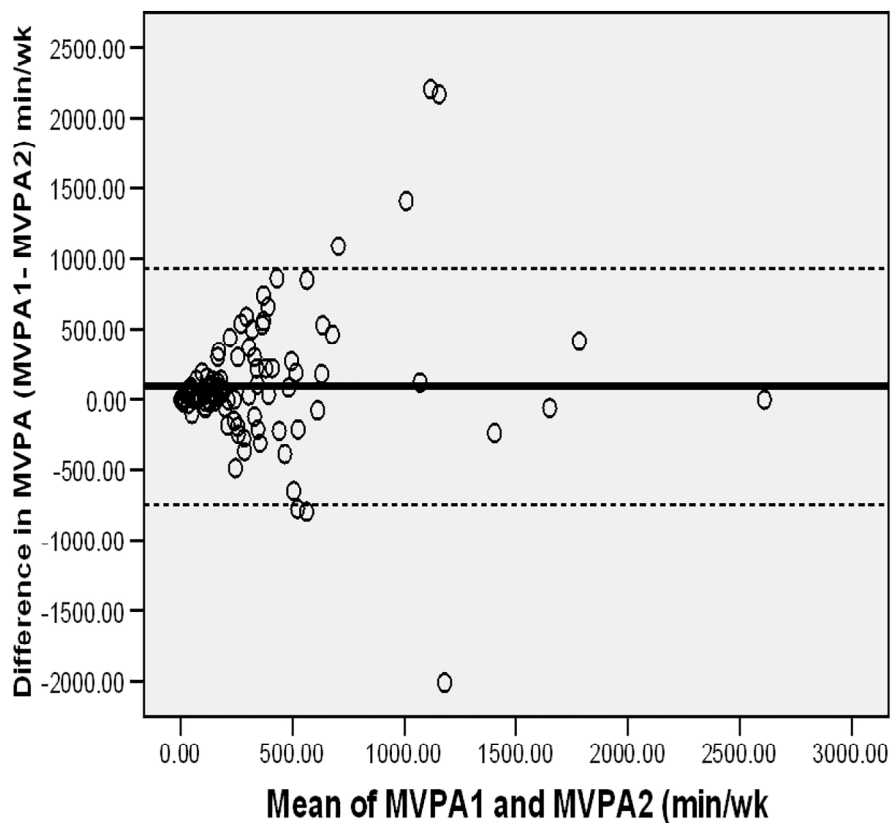


Figure 2: Bland-Altman plot for min/wk reported in moderate-to-vigorous physical activity (MVPA) for the first and second administrations of Hausa IPAQ-LF: Mean difference: 91.6 +/- 2SD (Standard Deviation)=-744.5 to 927

239x287mm (300 x 300 DPI)

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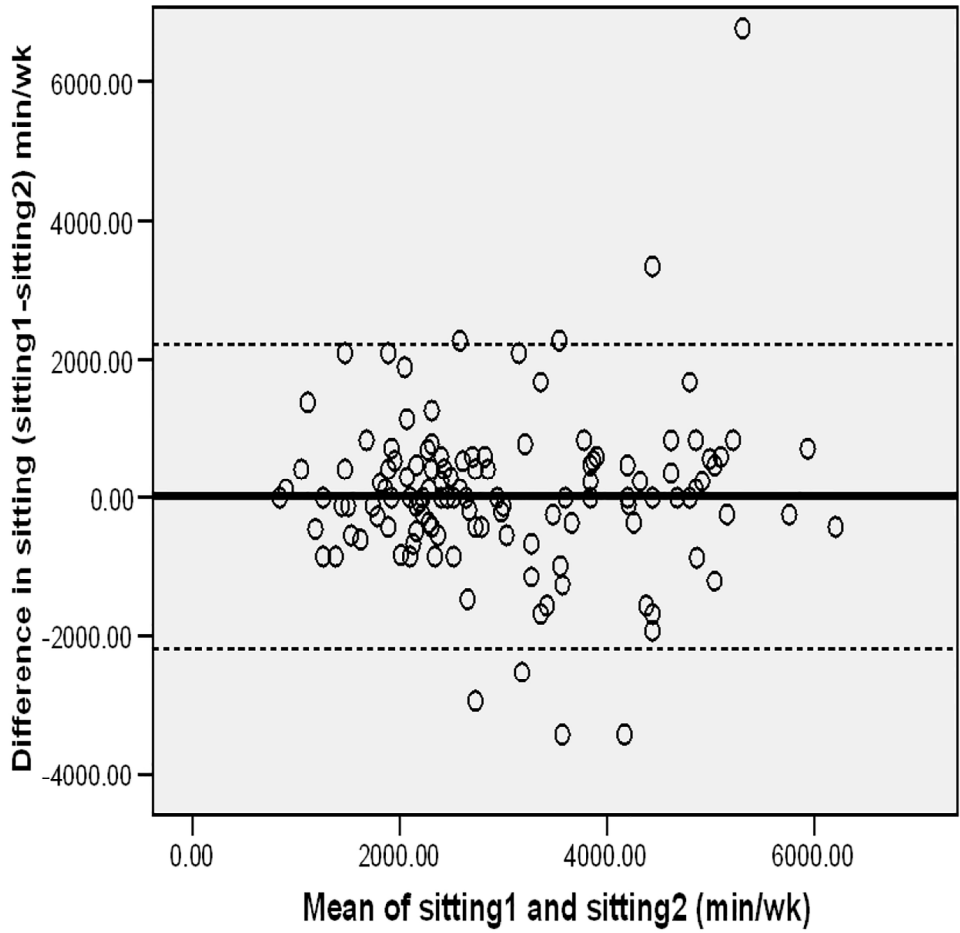


Figure 3: Bland-Altman plot min/wk reported in sitting for the first and second administration of Hausa IPAQ-LF. Mean difference: 26.4 \pm 2SD (Standard Deviation) = -2178.1 to 2230.9

236x259mm (300 x 300 DPI)

