

# Validity and reliability of the International Physical Activity Questionnaire (IPAQ) long-form in a subsample of female Mexican teachers

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## Abstract

**Objective.** To evaluate the test-retest reliability and validity of the long-form International Physical Activity Questionnaire (IPAQ-long form). **Materials and methods.** A subsample of 86 teachers underwent telephone interviews and clinic visits in Mexico City. Through 22 months, physical activity (PA) levels were obtained from accelerometers (months 6 and 22) and IPAQ long-form (months 1, 3, 6, 9 and 12). Minutes per week of moderate (MPA), walking (WPA), vigorous (VPA) and moderate-to-vigorous physical activity (MVPA) were calculated for each intensity and domain. Variables were logarithmically transformed. Intra-class and Pearson correlations were used to determine the relationship between instruments. **Results.** Test-retest reliability of the average IPAQs long-form varied across intensities and domains (ranged from  $r = 0.24$  to  $r = 0.65$ ). Minutes per week of VPA and MVPA accelerometer 1 (AC1) were fairly associated to International Physical Activity Questionnaire-long form 3 (IPAQ3) ( $r = 0.60$  and  $r = 0.31$ , respectively) one week apart. **Conclusions.**

## Resumen

**Objetivo.** Evaluar la confiabilidad y validez del Cuestionario Internacional de Actividad Física versión larga (por sus siglas en inglés IPAQ-long form). **Material y métodos.** Un total de 86 maestras realizaron entrevistas y visitas a clínicas en la Ciudad de México. En un periodo de 22 meses, se obtuvieron los niveles de actividad física (AF) por medio de un acelerómetro (AC) (meses 6 y 22) y autorreporte de actividad física por medio del IPAQ versión larga (meses 1, 3, 6, 9 y 12). Se estimaron los minutos por semana de actividad física moderada (AFM), caminando (AFC), vigorosa (AFV) y actividad física moderada-vigorosa (AFMV) para cada intensidad y dominio. Las variables se transformaron logaritmicamente. Se utilizaron correlaciones de intraclass y de Pearson para determinar la relación de los minutos por semana de AFM, AFC, AFMV entre instrumentos. **Resultados.** La confiabilidad entre el promedio de los IPAQs varió entre intensidades y dominios (de  $r = 0.24$  a  $r = 0.65$ ). Los minutos por semana de AFV y AFMV del acelerómetro 1

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IPAQ long-form is fairly reliable for MVPA and valid for assessing MVPA and VPA in a subsample of Mexican teachers.

Keywords: validity; women; measurement; questionnaire; accelerometer

(AC1) se asociaron con los del Cuestionario Internacional de Actividad Física 3 (IPAQ3) ( $r = 0.60$  y  $r = 0.31$ , respectivamente) reportado una semana después. **Conclusiones.** La versión larga del IPAQ es confiable para estimar AFMV y válido para evaluar AFMV y AFV en una submuestra de maestras mexicanas.

Palabras clave: validez; mujeres; mediciones; cuestionario; acelerómetro

Non-communicable chronic diseases (NCDs), including cancer, are the leading cause of death globally.<sup>1</sup> Among the main risk factors include the lack of physical activity (PA).<sup>2</sup> Measurement of physical activity levels is crucial to identify current levels of activity, to assess the effectiveness of intervention and/or prevention programs and to estimate its association with NCDs.<sup>3</sup>

Assessment of physical activity is possible through a variety of objective and subjective methods. Accelerometers (AC) have the advantage of measuring physical activity levels through acceleration, however, this instrument could underestimate some activities, specifically, aquatic and upper body movements.<sup>4,5</sup> Self-reported questionnaires are the most common, low-cost, and easy to apply method used to measure physical activity in population-based studies.<sup>3</sup> However, these instruments have the disadvantage of misclassifying physical activity levels and thus compromise the ability to detect true associations.<sup>3</sup>

One of the most commonly used questionnaires is the International Physical Activity Questionnaire (IPAQ), both the short and long version.<sup>6</sup> The short version has been validated in several settings including Mexico, with a test-retest reliability value of 0.55 and validity value of 0.31 when compared with accelerometer values.<sup>6,9</sup> However, there is a lack of information related to the reliability and validity of the long version within the Mexican context.

Therefore, the purposes of this study were to determine the test-retest reliability and validity of the IPAQ long-form in a subsample of female Mexican teachers from the Mexican Teachers' Cohort (MTC).

## Materials and methods

The MTC is a prospective study of 115 345 female teachers aged 25 years and older in Mexico. This study began in 2006 in two states and expanded to 10 more states in 2008. Teachers are members of the Teachers Incentives Program (TIP) (or *carrera magistral* in Spanish). This is

a well-established voluntary economic incentives program for public education teachers.<sup>10,11</sup>

*Participants.* In 2013, a random sample of 161 women aged  $\geq 35$  years from Mexico City were invited to participate in a validation study. In total, 99 teachers agreed to participate. Written informed consent was obtained from all participants. There were no statistically significant differences in mean weight, height, body mass index (BMI), and hip circumference between teachers that agreed to participate and those that disagreed. However, a statistically higher mean waist circumference was observed for those teachers that did not want to participate (data not shown).

*Procedure.* Teachers underwent telephone interviews and trained staff collected anthropometric data during 22 months. In the first month, teachers answered the IPAQ long-form (IPAQ1) by phone and underwent anthropometric measurements. At month three, a second IPAQ long-form (IPAQ2) was administered by phone. At month six, teachers visited the clinic and received an Actical accelerometer (AC1) (Mini Mitter Company, Bend, OR, USA). They were asked to wear this device, using an elastic belt all the time (except when in water) for the following nine days. In addition, teachers received a daily log that contained illustrated instructions on how to wear the accelerometer, removals, frequently asked questions and support contacts. After nine days, teachers returned the accelerometer, and a third IPAQ long-form (IPAQ3) was administered. At month nine, a fourth IPAQ long-form (IPAQ4) was self-reported by phone. During month 12, teachers answered a fifth IPAQ long-form (IPAQ5) by phone. And at month 22, a subsample of 69 teachers received and wore an Actical accelerometer (AC2) during seven consecutive days. The study was reviewed and approved by the *Instituto Nacional de Salud Pública* institutional review board (No. 1130). Written informed consent was obtained from all participants.

*IPAQ long-form.* The IPAQ was developed by a group of experts to understand and compare physical activity patterns around the world.<sup>6</sup> This is a 31-item questionnaire that estimates physical activity levels related to household and yard work activities, work-related activity, self-powered transport, walking, leisure time and sedentary activities during the last seven days in bouts of at least 10 minutes.<sup>6</sup> It can be applied by either face-to-face or telephone interview in 15 minutes.<sup>6</sup> The Spanish version of the questionnaire is available within the IPAQ webpage.<sup>12</sup>

Data cleaning of the IPAQ long-form was performed based on the IPAQ protocol according to the following criteria:<sup>13</sup> 1) data collected in hours were converted into minutes, 2) results reported as a weekly frequency were converted into an average daily time, and 3) "do not know", "refused" or "missing data" for duration or frequency were removed from the analysis. Truncation was performed for all daily duration values exceeding 180 minutes.<sup>13</sup>

Days and minutes per day of vigorous, moderate and walking were multiply to obtain minutes per week of vigorous (VPA), moderate (MPA) and walking (WPA) physical activity for each domain. Then, moderate and walking minutes per week were summed to create (MWPA) during household and yard activities, work-related, transportation, walking and leisure time. In addition, minutes per week of MWPA and VPA were added to create total moderate to vigorous physical activity (MVPA) minutes per week.

*Actical accelerometer.* The Actical is a waistband-mounted omnidirectional accelerometer (dimensions: 2.8 x 2.7 x 1.0 centimeters, weight: 17 grams), which has been previously used in adults to validate and measure physical activity.<sup>14</sup> The Actical accelerometer output is expressed as total counts per registered time (counts-min-1).

Data management and cleaning were performed using IBM SPSS software; version 24 (SPSS Inc., an IBM company Chicago Illinois, United States) and the Personal Activity and Location Measurement System (University of California, San Diego, California, United States). Compliance criteria for wearing accelerometers were defined as a minimum of four weekdays of wearing the accelerometer for at least 10 hours per day. All periods of 60 or more consecutive minutes with zero epochs were removed prior to calculating wear time for a given day.<sup>15,16</sup> To determine physical activity levels for participants, we used the following cut-points for each set of epochs (minutes of physical activity data):<sup>14</sup> sedentary ( $\leq 1.5$  Mets,  $<100$  accelerometer counts) or

engaged in light (1.5 to 2.9 Mets, 100 to  $<1\ 500$  accelerometer counts), moderate (3.0 to 5.9 Mets, 1 500 to  $<6\ 500$  accelerometer counts), or vigorous ( $\geq 6$  Mets,  $\geq 6\ 500$  accelerometer counts) intensity activity. Finally, MVPA that occurred in bouts of at least 10 consecutive minutes (with allowance of two minutes per each 10 minutes below the 1 530 epoch cut-point) was summed for each valid day and averaged to determine weekly moderate, vigorous, and MVPA.

*Physical activity classification (average IPAQs and average AC).* Teachers with complete IPAQs and AC data ( $n=58$ ) were classified as inactive if they accumulated  $<150$  minutes of MVPA, moderately active if they achieved 150-299 minutes of MVPA, and active if they accumulated 300 or more minutes of MVPA based on WHO physical activity recommendations.<sup>17</sup>

*Anthropometry.* Trained personal measured weight and height to the nearest 0.1 kg and 0.1 cm, and the BMI was calculated as  $\text{kg}/\text{m}^2$ .<sup>18</sup> Waist and hip circumferences were measured to the nearest 0.1 cm.

*Statistical analysis.* Descriptive analyses (means and standard deviation) were used to characterize the study population. Kolmogorov-Smirnov test was used to test normality in all physical activity variables. Variables that did not meet the normality criteria were logarithmically transformed. Log-transformed mean minutes per week per instrument were compared using student t-test.

Test-retest reliability for the log-transformed work-related, transportation, household, leisure-time, MWPA, VPA and MVPA per week of two accelerometers and five IPAQs long-form were tested using Pearson correlation coefficients. Linear Regression was used to estimate 95% confidence intervals (CI) for the correlation between instruments.

Pearson correlation coefficients and Intra-class correlation (two-way mixed, average measurements and absolute agreement) were used to determine the relationship between log-transformed minutes per week of MWPA, VPA, MVPA for the log-transformed minutes per week of five IPAQ long-form and accelerometers.

A linear regression was used to assess the association between MVPA minutes per week of IPAQ3 and AC1. The intercept and slopes of the regression line and their associated 95%CI was examined to observe if values were different from 0 and 1, respectively. Level of significance was set at  $p<0.05$ .

## Results

### Descriptive characteristics

Characteristics of participants at baseline are described in table I. In total, 86 women answered the IPAQs and on average 61 had two valid accelerometer values. The mean age was  $48.2 \pm 6.8$  years. The mean BMI was  $28.2 \pm 4.8$  kg/m<sup>2</sup>.

### Physical activity means and differences

With respect to intensities of physical activity, higher MVPA and MWPA were observed on IPAQ2 ( $504 \pm 421$  and  $463 \pm 393$  min/week, respectively) than IPAQ3 ( $387 \pm 289$  and  $341 \pm 251$  min/week, respectively), IPAQ4 ( $328 \pm 254$  and  $289 \pm 223$  min/week, respectively), and IPAQ5 ( $333 \pm 306$  and  $300 \pm 295$  min/week, respectively). There were no differences between IPAQ1 and IPAQ2 for all intensities. MWPA minutes per week were significantly higher based on IPAQ1 and IPAQ3 compared to IPAQ4 and IPAQ5 ( $451 \pm 350$  and  $341 \pm 251$  vs.  $289 \pm 223$  and  $300 \pm 295$ , respectively). Based on domains of physical activity, teachers reported higher minutes per week of household physical activities for all IPAQs compared to other domains ( $p < 0.01$ ) (figure 1).

Related to household physical activity, statistically significant differences were observed between IPAQ1 and IPAQ3, IPAQ4 and IPAQ5 ( $200 \pm 198$  and  $162 \pm 106$ ,  $138 \pm 133$ ,  $126 \pm 174$  minutes per week, respectively) ( $p < 0.05$ ). The same pattern was observed for active transportation (IPAQ1:  $100 \pm 114$  vs. IPAQ3:  $72 \pm 92$ , IPAQ4:  $63 \pm 100$ , IPAQ5:  $66 \pm 93$  minutes per week,  $p < 0.05$ ). Leisure time physical activity was significantly different between IPAQ2 and IPAQ5, and IPAQ3 and IPAQ5 ( $111 \pm 142$  and  $83 \pm 130$  minutes per week) and ( $106 \pm 162$  and  $83 \pm 130$  minutes per week) respectively

**Table I**  
**CHARACTERISTICS OF PARTICIPANTS IN A STUDY ON**  
**THE RELIABILITY AND VALIDITY OF**  
**IPAQ LONG-FORM (N= 86). MEXICO, 2013-2015**

|                                      | Mean  | SD*  |
|--------------------------------------|-------|------|
| Age (years)                          | 48.2  | 6.8  |
| Weight (kg)                          | 68.1  | 12.3 |
| Height (m)                           | 155.4 | 6.2  |
| Body mass index (kg/m <sup>2</sup> ) | 28.2  | 4.8  |
| Waist circumference (cm)             | 88.2  | 10.9 |
| Hip circumference (cm)               | 104.4 | 9.9  |

\* Standard deviation

( $p < 0.05$ ). Work-related physical activity was statistically significant different between IPAQ2 and IPAQ3 ( $66 \pm 187$  vs.  $46 \pm 115$  minutes per week) (figure 1).

Based on accelerometer measures, there were no statistically significant differences between minutes per week in AC1 and AC2 at any intensity. Statistically significant differences were found between average accelerometers and average IPAQs long-form for all intensities ( $p < 0.001$ ) (figure 1).

### Reliability

The test-retest correlation between five IPAQs long-form is presented in table II. IPAQ1 minutes per week of MWPA, VPA, MVPA, work-related, transportation, household and leisure-time physical activity were significantly correlated to those minutes of IPAQ2, IPAQ3, IPAQ4 and IPAQ5 with  $r$  values ranging from 0.29 to 0.59. The same result was observed for the correlation between minutes per week of MWPA, VPA and MVPA, work-related, transportation, household and leisure-time physical activity IPAQ2 vs. IPAQ3, IPAQ4, IPAQ5, IPAQ3 vs. IPAQ4 and IPAQ5, and IPAQ4 vs. IPAQ5 (range: 0.26 to 0.65), except for the correlation between minutes per week of VPA IPAQ2 and IPAQ4 and minutes per week of transportation IPAQ2 and IPAQ5.

Based on accelerometer estimates, a high correlation ( $r \geq 0.60$ ) was observed between AC1 and AC2 minutes per week of MWPA, VPA and MVPA (table II).

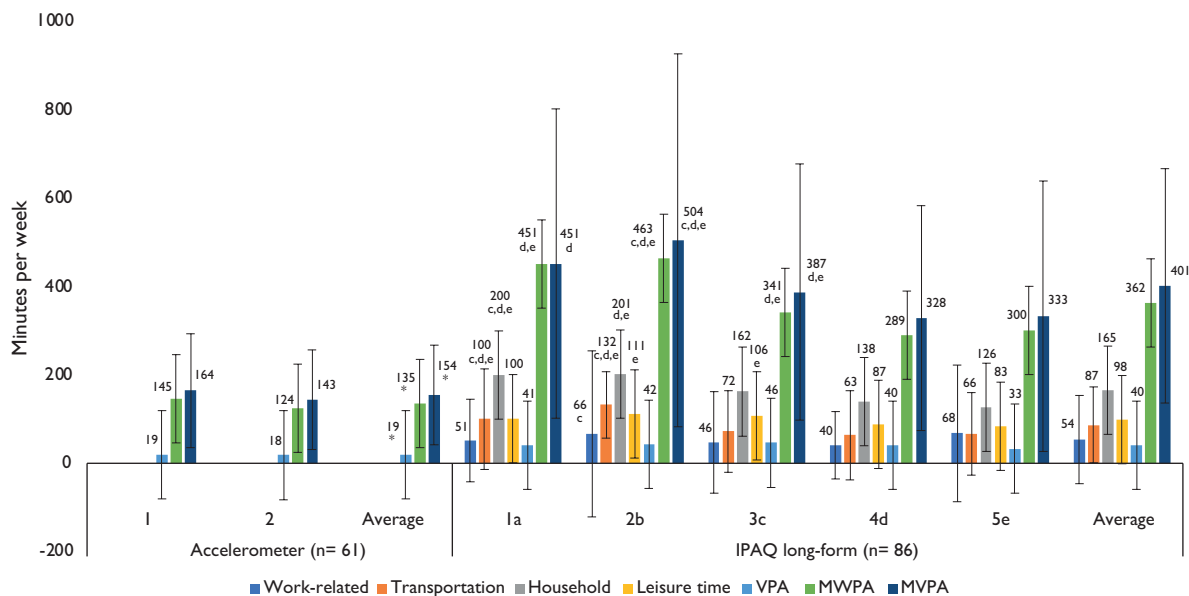
### Validity

Compared to the log-transformed minutes per week AC1 values, VPA and MVPA were significantly correlated to average log-transformed minutes per week IPAQ long-form values (Pearson correlation: 0.31, 95%CI: 0.11, 0.47 and 0.25, 95%CI: 0.04, 0.55, respectively). Long-transformed minutes per week AC1 VPA and MVPA measures were significantly correlated ( $p < 0.05$ ) to IPAQ3 values  $r = 0.44$  and  $r = 0.24$ , respectively. Higher correlations were observed using Intra-class correlation for all intensities (table III).

As shown in figure 2, when IPAQ3 MVPA measures were used to predict accelerometer 1, the intercept was 1.57 ( $p < 0.001$ ) and the slope was 0.22 ( $p < 0.05$ ). This interception suggests that those teachers with lower MVPA measured by accelerometers over-reported MVPA levels, however, this over-report decreased as objectively measured MVPA increased. The interception between the line of identity and the Pearson correlation line was at 126 minutes per week of MVPA.

The distribution of teachers across physical activity categories was significantly different between average





MWPA: moderate and walking activities  
 VPA: vigorous physical activity  
 MVPA: moderate-to-vigorous physical activity  
 Line: standard deviation  
 Number: mean

\* Statistically significant differences between different methods ( $p < 0.05$ )

a,b,c,d,e: Statistically significant differences between IPAQs (a- IPAQ1, b- IPAQ2, c- IPAQ3, d- IPAQ4, e- IPAQ5) ( $p < 0.05$ )

**FIGURE 1. ACCELEROMETERS AND IPAQs-LONG FORM MEASURED PHYSICAL ACTIVITY (MEAN AND STANDARD DEVIATION). MEXICO 2013-2015**

IPAQs and average AC. Based on average AC, 56.9% were classified as inactive, 34.5% as moderately active and 8.6% as active. Whereas, 12.1% were classified as inactive, 27.6% as moderately active and 60.3% as active based on average IPAQs (data not shown).

## Discussion

The main purposes of this study were to determine the test-retest reliability and validity of the IPAQ long-form in a sub sample of Mexican teachers. Our findings indicated that minutes per week of three different intensities of physical activity (VPA, MWPA and MVPA) between IPAQs long-form were correlated (range:  $r = 0.26$  to  $0.65$ ). Minutes per week of four domains of physical activity (work-related, transportation, housework and leisure-time) had a correlation between  $0.24$  and  $0.64$ . Furthermore, minutes per week of MVPA and VPA AC1 were correlated to average MVPA and VPA IPAQs ( $r = 0.25$  and  $r = 0.31$ ), and MVPA and VPA estimates of AC1 were correlated with IPAQ3-long form measures answered one-week apart ( $r = 0.24$  and  $r = 0.44$ ).

Teachers reported higher average mean values for all intensities based on IPAQs long-form compared to the Actical accelerometer estimates. This over-report has been observed in other self-reports<sup>19</sup> and in the IPAQ short-form for Mexican population.<sup>7</sup> The overestimation of physical activity levels by the questionnaire could be due to social desirability and/or social approval bias. However, the underestimation of the Actical accelerometer could be related to the lack of record of water activities and strength exercises such as weight lifting.<sup>4,5,7</sup>

Data from this study showed that in three out of five self-reported IPAQs teachers accumulated more than 150 minutes per week on household physical activities. In other words, teachers achieved physical activity recommendations only by performing activities at home. In addition, compared to other domains, higher number of minutes per week of household physical activity were reported. The same pattern has been observed in previous Latin American studies.<sup>20</sup> There are many possible reasons of this observation; first, there could be a misclassification of physical activity intensities during

**Table II**  
**TEST-RETEST RELIABILITY OF THE ACCELEROMETER AND THE IPAQ LONG-FORM. MEXICO 2013-15**

| (Min/week)<br>r (CI95%) | Accelerometer<br>(n= 61)   |                            |                            |                            |                            | IPAQ long-form<br>(n= 86)  |                            |                            |                            |                            |                            |
|-------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
|                         | 1,2                        | 1,2                        | 1,3                        | 1,4                        | 1,5                        | 2,3                        | 2,4                        | 2,5                        | 3,4                        | 3,5                        | 4,5                        |
| Domains of PA           |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |
| Work-related            | NA                         | <b>0.40</b><br>(0.20,0.60) | <b>0.39</b><br>(0.19,0.61) | <b>0.46</b><br>(0.28,0.68) | <b>0.36</b><br>(0.14,0.52) | <b>0.45</b><br>(0.26,0.66) | <b>0.37</b><br>(0.17,0.59) | <b>0.51</b><br>(0.31,0.66) | <b>0.38</b><br>(0.18,0.58) | <b>0.34</b><br>(0.13,0.50) | <b>0.38</b><br>(0.16,0.52) |
| Transportation          | NA                         | <b>0.35</b><br>(0.15,0.58) | <b>0.36</b><br>(0.14,0.51) | <b>0.34</b><br>(0.13,0.56) | <b>0.36</b><br>(0.16,0.56) | <b>0.48</b><br>(0.25,0.58) | <b>0.40</b><br>(0.19,0.59) | 0.20<br>(-0.01,0.39)       | <b>0.51</b><br>(0.40,0.79) | <b>0.42</b><br>(0.24,0.67) | <b>0.24</b><br>(0.02,0.43) |
| Household               | NA                         | <b>0.53</b><br>(0.29,0.60) | <b>0.44</b><br>(0.19,0.50) | <b>0.51</b><br>(0.25,0.53) | <b>0.57</b><br>(0.30,0.57) | <b>0.38</b><br>(0.16,0.54) | <b>0.32</b><br>(0.10,0.47) | <b>0.42</b><br>(0.25,0.60) | <b>0.36</b><br>(0.15,0.54) | <b>0.31</b><br>(0.09,0.50) | <b>0.42</b><br>(0.22,0.62) |
| Leisure-time            | NA                         | <b>0.49</b><br>(0.31,0.60) | <b>0.59</b><br>(0.42,0.78) | <b>0.56</b><br>(0.39,0.76) | <b>0.45</b><br>(0.25,0.64) | <b>0.50</b><br>(0.30,0.67) | <b>0.49</b><br>(0.29,0.67) | <b>0.53</b><br>(0.33,0.69) | <b>0.59</b><br>(0.42,0.77) | <b>0.56</b><br>(0.37,0.73) | <b>0.64</b><br>(0.47,0.80) |
| Intensity of PA         |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |
| MWPA                    | <b>0.60</b><br>(0.39,0.80) | <b>0.35</b><br>(0.19,0.70) | <b>0.47</b><br>(0.38,0.91) | <b>0.51</b><br>(0.32,0.68) | <b>0.48</b><br>(0.29,0.67) | <b>0.45</b><br>(0.28,0.70) | <b>0.61</b><br>(0.33,0.60) | <b>0.34</b><br>(0.10,0.42) | <b>0.60</b><br>(0.30,0.55) | <b>0.43</b><br>(0.17,0.45) | <b>0.62</b><br>(0.45,0.80) |
| VPA                     | <b>0.61</b><br>(0.43,0.81) | <b>0.33</b><br>(0.13,0.54) | <b>0.43</b><br>(0.24,0.64) | <b>0.29</b><br>(0.09,0.52) | <b>0.32</b><br>(0.12,0.57) | <b>0.26</b><br>(0.05,0.48) | 0.18<br>(-0.03,0.41)       | <b>0.28</b><br>(0.08,0.52) | <b>0.38</b><br>(0.19,0.60) | <b>0.45</b><br>(0.27,0.68) | <b>0.48</b><br>(0.29,0.69) |
| MVPA                    | <b>0.65</b><br>(0.44,0.83) | <b>0.35</b><br>(0.18,0.69) | <b>0.49</b><br>(0.40,0.89) | <b>0.52</b><br>(0.31,0.66) | <b>0.52</b><br>(0.35,0.74) | <b>0.54</b><br>(0.38,0.77) | <b>0.64</b><br>(0.35,0.60) | <b>0.38</b><br>(0.15,0.49) | <b>0.64</b><br>(0.34,0.57) | <b>0.49</b><br>(0.24,0.54) | <b>0.65</b><br>(0.54,0.91) |

NA: Not applicable

PA: physical activity

MWPA: moderate and walking activities

VPA: vigorous physical activity

MVPA: moderate-to-vigorous physical activity

Bold type: statistically significant correlations

CI: confidence interval

household activities,<sup>21</sup> second, questionnaire structure problems (ex.: since IPAQ is conformed by four different domains, it could be difficult for respondents to understand, differentiate and report minutes per week of each domain),<sup>20</sup> and third, there is good evidence that women truly perform more household activities than in any other domain.<sup>22</sup>

Mean differences were observed in almost all minutes per week for transportation, household, MWPA and MVPA between IPAQs. Similar results have been observed in previous repeatability studies worldwide<sup>23,24</sup> and in Mexico.<sup>7</sup> These differences could be related to the fact that teachers accumulated different minutes of physical activity throughout the year, over or underestimation of minutes per week of physical activity and the recognition of activities performed throughout the year.<sup>7,23,24</sup>

The correlation between accelerometers 17 months apart was good for MVPA ( $r=0.65$ ) and was slightly lower for VPA than for MWPA ( $r= 0.61$  vs.  $r= 0.60$ , respectively). Some studies have found different correlation values between accelerometers ( $r$  ranged from 0.47 to 0.96).<sup>25-28</sup> The main differences in the correla-

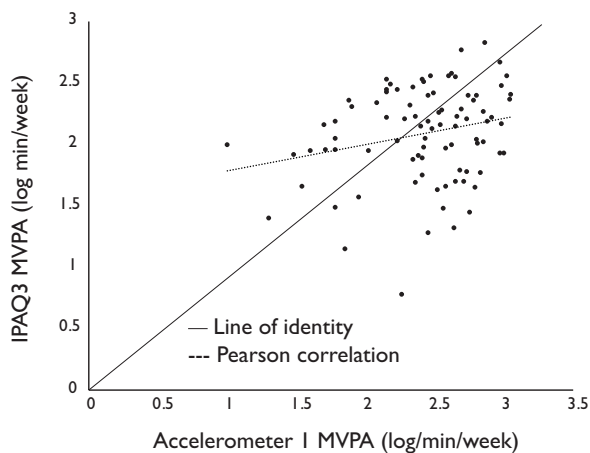
tion values could be a shorter interval range between measurements,<sup>25</sup> the use of laboratory settings and controlled activities,<sup>25</sup> seasonal physical activity variability,<sup>27</sup> differences between weekdays and weekends,<sup>28</sup> intra-individual variance,<sup>28</sup> types of accelerometer,<sup>25-29</sup> changes in physical activity participation,<sup>30</sup> and accelerometer hip position (left or right).<sup>29</sup>

The test-retest reliability for IPAQ long-form MVPA was lower compared to previous studies.<sup>6,31-34</sup> Some explanations of the lower MVPA correlations could be related to the fact that most of the studies that reported higher correlation values had a shorter time interval between surveys.<sup>6,31-35</sup> Lower correlation values have been observed for VPA than for MWPA.<sup>31,32</sup> This could be attributed to the low frequency of VPA. In addition, in almost all IPAQ test-retests, lower repeatability correlation values were observed for transportation physical activity (ranging from 0.20 to 0.51) compared to other domains. In contrast, higher correlation values were observed for the leisure-time domain (ranging from 0.45 to 0.64). These results could be explained by the fact that transportation activities could vary from day to day and leisure-time activities are the most regular physical activities.<sup>31,32</sup>

**Table III**  
**PEARSON AND INTRACLASS CORRELATIONS**  
**BETWEEN LOG-TRANSFORMED MINUTES PER WEEK**  
**ACCELEROMETERS AND LOG-TRANSFORMED MINUTES**  
**PER WEEK IPAQ LONG-FORM. MEXICO 2013-15**

|                             | Variables (r (95%CI))              |                                     |
|-----------------------------|------------------------------------|-------------------------------------|
|                             | Pearson                            | ICC                                 |
| Average IPAQ vs.AC1 (n= 82) |                                    |                                     |
| MWPA                        | 0.17<br>(-0.06, 0.44)              | 0.17<br>(-0.06, 0.26)               |
| VPA                         | <b>0.31</b><br><b>(0.11, 0.47)</b> | <b>0.42</b><br><b>(0.06, 0.63)</b>  |
| MVPA                        | <b>0.25</b><br><b>(0.04, 0.55)</b> | <b>0.25</b><br><b>(-0.13, 0.51)</b> |
| IPAQ3 vs.AC1 (n= 87)        |                                    |                                     |
| MWPA                        | 0.16<br>(-0.07, 0.42)              | 0.21<br>(-0.12, 0.45)               |
| VPA                         | <b>0.44</b><br><b>(0.33, 0.83)</b> | <b>0.60</b><br><b>(0.39, 0.74)</b>  |
| MVPA                        | <b>0.24</b><br><b>(0.04, 0.50)</b> | <b>0.31</b><br><b>(-0.04, 0.54)</b> |

ICC: intra-class correlation  
 IPAQ: International Physical Activity Questionnaire – long form  
 AC: accelerometer; MWPA: moderate and walking activities  
 VPA: vigorous physical activity; MVPA: moderate-to-vigorous physical activity  
 Bold type: statistically significant correlations (p<0.05)  
 CI: confidence interval  
 MVPA: moderate-to-vigorous physical activity  
 MWPA: moderate and walking activities



MVPA: moderate-to-vigorous physical activity  
**FIGURE 2. LOG-TRANSFORMED MINUTES PER WEEK**  
**OF MVPA BETWEEN IPAQ3 AND ACCELEROMETER**  
**I. MEXICO 2013-2015**

Minutes per week of MVPA and VPA for average IPAQ vs. AC1 and IPAQ3 vs. AC1 were significantly correlated. However, minutes per week of MWPA were not correlated. Similar results have been observed in

previous studies.<sup>36</sup> This could be explained by the fact that vigorous physical activities are easier to remember and report than moderate physical activities.<sup>36</sup> In addition, underreport of minutes of moderate physical activity.<sup>34,36</sup>

The correlation of the average minutes MVPA between the IPAQ long-form vs. AC1 was  $r=0.25$ . Compared to other self-report instruments, slightly higher correlation values have been observed in different settings and countries for IPAQ long-form ranged from 0.30 to 0.38.<sup>6,19,32,35</sup> One explanation for the low correlation observed in this type of analysis for all intensities could be the fact that subjects wore an Actical accelerometer one week, and this week does not represent the physical activity performed during almost 12 months (IPAQ assessment). The difficulty for participants to estimate the physical activity intensity in which they are engaged in,<sup>35</sup> and social desirability bias might also produce an overestimation of physical activity levels.<sup>35</sup> However, a slightly low correlation was observed between AC1 and IPAQ3 answered one week apart. This result is similar to what has been observed in previous studies using IPAQ-long form ( $r=0.31$  Mexico vs.  $r=0.33$  global)<sup>6</sup> and similar compared to IPAQ-short form ( $r=0.31$  long form vs.  $r=0.31$  short form).<sup>7</sup>

The prevalence of physical inactivity was higher based on average AC (56.9%) than for average IPAQs (12.1%). This result is similar to previous studies in Mexican population.<sup>7</sup> Caution should be taken when using self-report physical activity questionnaires, because misleading prevalence could conduct to underreported associations (physical activity vs. determinants, and vs. health outcomes).<sup>7</sup>

**Strengths and limitations**

This is one of the few studies that validated the IPAQ long-form in a Mexican sample. Although participants used the Actical accelerometer day and night during seven days, we asked them to remove their device every time they had contact with water (ex.: swimming, showers). This could result in an underestimation of the physical activity levels. It is well known that accelerometers and questionnaires measure different constructs of physical activity, accelerometers capture body movements, whereas questionnaires measures behaviors, making it difficult to compare.<sup>4,5</sup> The 10-minute cut off point of the IPAQ could lead to overestimation, in other words, respondents could have rounded the minutes of physical activity less than 10 minutes. In addition, self-report questionnaires based on seven previous days are limited to last week, this might not represent necessarily the usual physical activity. We could not test the validity

of domain-specific physical activity because accelerometers could not differentiate between these domains. In addition, it is important to remind that this study was limited to female Mexican teachers from Mexico City, which increases its internal validity, but results may not represent women with other professions, residents from other cities, nor men.

## Conclusion

Test-retest reliability of the IPAQ long-form was modest for MVPA and the validity against accelerometer was fair for MVPA and VPA in a sub sample of Mexican female teachers. Although these correlation values were similar to those reported previously, future studies should consider the use of objective measures to estimate physical activity levels.

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