

Practicality of three self-report tools for assessing physical activity in third level students.

1 Validity and reliability of three self-report instruments for assessing attainment of physical activity
2 guidelines in university students.

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21 **Abstract**

22 **Purpose:** The purpose of this study was to compare the validity and reliability of three short physical
23 activity self-report instruments to determine their potential for use with university student populations.

24 **Methods:** Participants (N = 155; 44.5% male; 22.9 ± 5.13 years) wore an accelerometer for nine
25 consecutive days and completed a single item measure (SIM), the PACE+ and the IPAQ-SF
26 questionnaires on day 1 and 9.

27 **Results:** Correlations between self-reported and accelerometer derived moderate-to-vigorous physical
28 activity levels were moderate for the IPAQ-SF, while poor for the SIM and the PACE+. The
29 agreement level was high with the IPAQ-SF (77.4%) and moderate for both the SIM (45.2 %) and
30 PACE+ (44.5 %). The Intraclass Correlations between the two administrations were moderate to
31 strong across all measures (0.52 – 0.70) in 133 participants.

32 **Conclusions:** The IPAQ-SF is the most suitable of these three self-report instruments for use with this
33 population due to higher correlations and levels of agreement with accelerometry.

34 **Keywords:** Measurement, Validity, Reliability, Third level students.

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43 **Introduction**

44 University or tertiary level students comprise a large portion of the population and may wield a
45 sizable degree of future influence in society through their post-graduation roles (Hussain, Guppy,
46 Robertson, & Temple, 2013). Globally tertiary education enrolments reached 170 million in 2009, and
47 have been forecast to grow by an additional 21 million by 2020 (British Council, 2012). This makes
48 the tertiary level sector an important setting for specific population monitoring, surveillance and
49 intervention.

50 The transition from school to university brings greater independence in lifestyle choices, allowing
51 students to become involved in more healthy or unhealthy behaviours (Dinger, Brittain, &
52 Hutchinson, 2014). University students spend a considerable amount of time in educational
53 environments which promote sedentary behaviour and in addition are largely being educated for
54 sedentary occupations (Fotheringham, Wonnacott, & Owen, 2000), which may contribute to shaping
55 persistent and potentially long-term physical inactivity patterns (Lesliephillip, Owen, Salmon, Sallis,
56 & Lo, 1999; Owen, Lesliephillip, Salmon, & Fotheringham, 2000; Sallis, Bauman, & Pratt, 1998). In
57 Ireland, the physical activity guidelines (PAGL) state that adults should engage in at least 150
58 minutes of moderate-intensity aerobic physical activity or 75 minutes of vigorous-intensity aerobic
59 physical activity each week (Department of Health, 2009). Meeting these PAGL is associated with
60 positive physical and mental health benefits (Reiner, Niermann, Jekauc, & Woll, 2013), while a high
61 level of inactivity is a recognised risk factor for cardiovascular disease, diabetes, and some forms of
62 cancer (Hallal, Andersen, Bull, Guthold, & Haskell, 2012). The regular monitoring and surveillance
63 of population physical activity (PA) is of paramount importance (Hallal et al., 2012), but the
64 challenges are with establishing a universal measurement tool, one that is psychometrically valid and
65 specifically applies to this young adult population.

66 The measurement of PA can be challenging due to its varied nature (Janz, 2006), with a range of
67 measurement tools available. Subjective measures include questionnaires, surveys and diaries,
68 whereas objective methods include doubly-labelled water and motion sensors such as accelerometers

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69 (Strath et al., 2013). Selecting the most appropriate measurement tool depends on a range of factors
70 including the population of interest, the purpose of the study, the required outcome variables
71 (Chinapaw, Mokkink, van Poppel, van Mechelen, & Terwee, 2010; Ridgers, Timperio, Crawford, &
72 Salmon, 2012), and of prime importance the instrument's validity and reliability (Warren et al., 2010).
73 Self-report questionnaires, due to their feasibility and convenience, are the most commonly used
74 method of assessing populations PA levels (Helmerhorst, Brage, Warren, Besson, & Ekelund, 2012),
75 with a diversity of questionnaires available for this purpose (Dyrstad, Hansen, Holme, & Anderssen,
76 2014). However, the use of different measures for assessing PA often results in findings which are
77 inconsistent and incomparable across studies. For example, the reported prevalence of physical
78 inactivity in undergraduate students has ranged from 22-81 % in 23 countries (Pengpid et al., 2015) to
79 between 23-39% for an earlier study of 23 countries (Haase, Steptoe, Sallis, & Wardle, 2004).
80 Although these studies looked at different samples, they both assessed PA using two different self-
81 report methods. The use of one valid and reliable measurement tool, which is simple and effective for
82 assessing PA at a population level (Ridgers et al., 2012), would allow comparability of findings.

83 Three questionnaires frequently used to assess populations levels of PA are the single item measure
84 (SIM) (Milton, Bull, & Bauman, 2011), the PACE two item measure (Hardie Murphy, Rowe, Belton,
85 & Woods, 2015; Prochaska, Sallis & Long, 2001), and the International Physical Activity
86 Questionnaire- Short Form (IPAQ-SF) (Craig et al., 2003). Validity and reliability has only been
87 established for the IPAQ-SF in this population (Dinger, Behrens, & Han, 2006) but each questionnaire
88 has been validated against accelerometer derived moderate to vigorous physical activity (MVPA). The
89 SIM demonstrated moderate validity (Cohen, 1988) ($r = 0.46, p < 0.01$) in adults with the ActiGraph
90 GT3X accelerometer (Milton, Clemes, & Bull, 2013). Hardie-Murphy and colleagues (2015) found
91 the PACE had moderate validity ($r = 0.34 - 0.49, p < 0.01$) with ActiGraph GT1M and GT3X
92 accelerometers in children, however this measure has not yet been validated in adults. In university
93 students, the IPAQ-SF demonstrated acceptable validity for accelerometer (ActiGraph Monitor Model
94 7164) derived MVPA with moderate ($r = 0.45, p < 0.01$) and vigorous PA ($r = 0.20, p < 0.05$) (Dinger et
95 al., 2006). Research has reported the test-retest reliability of each measure in various populations

96 across different studies. The SIM demonstrated strong 2-5 day test-retest reliability ($r= 0.72 - 0.82$)
97 using a Spearman's rank correlation coefficient in adults (Milton et al., 2011). Using Intraclass
98 Correlation Coefficients (ICC), the PACE and IPAQ-SF reported strong test-retest reliability with the
99 PACE reporting scores of 0.74 – 0.82 in children (Liu et al., 2010) and with the IPAQ-SF reporting
100 scores of 0.71 – 0.89 in university students (Dinger et al., 2006).

101 There is a need to assess the validity and reliability of the SIM, the PACE and the IPAQ-SF for
102 measuring adherence to PAGL across populations, such as the university population (Bobakova et al.,
103 2015; Helmerhorst et al., 2012; Lee, Macfarlane, Lam, & Stewart, 2011). The purpose of this study
104 was to assess the SIM, PACE and IPAQ-SF among a population of university students.

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118 **Methods**

119 A convenience sample was recruited from 5 tertiary level institutions in Ireland (N = 463, 53% male,
120 mean age = 22.2 ± 4.5). All participants were aged 18 years and provided written informed consent to
121 take part in the study.

122 The three self-report measurement tools were presented to the participants in a questionnaire.

123 Participants were provided with definitions of walking, moderate and vigorous PA and instructed to
124 only include activities of this intensity when completing the questionnaire. The SIM asked

125 participants to report the number of days they were physically active at a moderate to vigorous level
126 for at least 30 minutes in the past 7 days (Milton et al., 2011). The PACE instrument was adapted

127 from a 60 to a 30 minute timeframe to reflect the adult PAGL and renamed the PACE+ (Hardie

128 Murphy et al., 2015). It used two items to assess PA. Item one of the PACE+ was a replica of the

129 single item measure, while item two of the PACE+ asked the same question with respect to a usual

130 week (Hardie Murphy et al., 2015). An average of the two items produced a score of days per week

131 that the participants accumulated at least 30 minutes of MVPA. The IPAQ-SF included 9 items and

132 required each participant to report the frequency and duration they were physically active at a

133 walking, moderate and vigorous intensity. Total minutes MVPA was generated for the IPAQ-SF by

134 accumulating each participants weekly moderate and vigorous PA. For the purpose of this study and

135 to make each measurement comparable, minutes of PA at a moderate and vigorous intensity were

136 combined and considered as minutes of MVPA. Compliance with the aerobic component of the

137 PAGL was defined in two ways depending on the measurement tool used; 1) 30 minutes MVPA on 5

138 or more days a week (30 mins MVPA/day; SIM and PACE+) and 2) 150 minutes of MVPA over 7

139 days (150 mins MVPA/week; IPAQ-SF).

140 PA was also objectively measured using the ActiGraph (GT1M and GT3X) accelerometer. This

141 monitor is an acceptable measure for evaluating questionnaire validity (Welk, 2005) and is widely

142 used for this purpose (Craig et al., 2003; Dinger et al., 2014; Hardie Murphy et al., 2015; Milton et al.,

143 2013). Participants were instructed to wear the device for nine consecutive days on their right hip

144 during all waking hours, except for when in water. The first and last days of wear time were excluded
145 from analysis to give seven full wear days. The epoch length was set at ten seconds with data being
146 downloaded and cleaned using the ActiLife software (Hardie Murphy et al., 2015). Consecutive zero
147 counts of sixty minutes or more (Choi, Liu, Mattws, & Buchowski, 2011) were eliminated from total
148 wear time and participants who did not meet the wear time criteria of at least 10 hours per day
149 (Troiano et al., 2008) on seven days were excluded from the analysis. Accelerometer data were then
150 analysed using the Troiano Adult cut-points (Troiano et al., 2008). A summary score of counts per
151 minute (CPM) represented total PA. Participant responses were dichotomised into meeting or not
152 meeting the PAGL for each measurement tool.

153 Researcher training across all institutional testing sites was conducted to ensure that standardized
154 procedures were adopted and used. Participants completed a supervised self-report questionnaire
155 which included demographic information (sex, age and year of study) and each of the three PA
156 measures. An all days method (AD) (Ridgers et al., 2012) was used to determine compliance over 7
157 individual days, compared to accelerometry, to the PAGL with the SIM and the PACE+. A total
158 minutes MVPA method (TM) was used to determine compliance over a total 7 days, compared to
159 accelerometry, to the PAGL with the IPAQ-SF. A second questionnaire, containing each of the PA
160 measure was given to the participants to complete nine days following the first. This allowed for the
161 test-retest reliability to be assessed with each of the self-report measurement tools.

162 Statistical Analysis

163 Descriptive statistics were calculated for demographic, self-report and accelerometer data. For
164 inclusion in the study, participants were required to have completed all the self-report measures and
165 meet the accelerometer wear time criteria. The sample that met the inclusion criteria was compared to
166 the full sample for sex and age. All statistical analyses were performed for the sample and stratified
167 by sex, allowing any differences to be reported. Spearman Rho correlation coefficients were
168 calculated between accelerometry (mins of MVPA/ day; CPM) and the SIM, PACE+ (mins of
169 MVPA/day), IPAQ-SF (minutes of MVPA/ day). The strength of the Spearman Rho correlations were

170 ranked as poor (>0.1), moderate (>0.3), and strong (>0.5) (Cohen, 1988). Percentage agreement
171 between each measure and accelerometer data was established by assessing the consistency of
172 classification of achieving the PAGL. Sensitivity (defined as proportion of participants meeting
173 PAGL that were correctly identified) and specificity (defined as the proportion of participants
174 correctly identified as not meeting the PAGL) were determined using the accelerometry derived
175 average MVPA/ day and the AD method for 7 valid days (Parikh, Mathai, Parikh, Sekhar, & Thomas,
176 2008) or by using the total MVPA/week and the TM method for 7 valid days. The percentage who
177 self-reported meeting the PAGL and who met the guideline via accelerometer data is represented by
178 the positive predictive value (PPV) and the percentage who self-reported not meeting the PAGL who
179 did not meet them, as measured by accelerometer data, by the negative predictive value (NPV)
180 (Parikh et al., 2008). Reliability analysis was available for all participants who completed the
181 questionnaire on both occasions, nine days apart. An ICC, using a two way mixed average method,
182 was recorded for each measure to determine its test-retest reliability, with scores being ranked as poor
183 ($0.0 - 0.2$), fair ($0.3 - 0.4$), moderate ($0.5 - 0.6$), strong ($0.7 - 0.8$), and almost perfect (>0.8) (Landis
184 & Koch, 1977).

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194 **Results**

195 155 (44.5% male; 22.93 ± 5.13) students met the inclusion criteria and could be used in the analysis.
196 Participants were excluded from the analysis if they were missing one of the self-report measurement
197 tools (N= 48) or if they did not meet accelerometer wear time criteria (N = 260). The final sample
198 were significantly older ($t(386) = 2.36, p < 0.05$) and more likely to be female ($X^2(1, N = 434) = 6.41,$
199 $p < 0.05$) than those excluded. Participants included were undergraduate (88.8%) and postgraduate
200 students spread across different years including 1st (30.5%), 2nd (38.1%), 3rd (11.4%), and 4th (20.0%).

201 **Table 1** shows PA levels and compliance with PAGL for all measures used. Across all participants
202 the proportion meeting the PAGL was 29.0% using the SIM and the 29.7 % using PACE+, but was
203 higher with accelerometry using the AD method (68.4%). A higher proportion met the PAGL with the
204 IPAQ-SF (76.8%) and accelerometry (94.8%) using the TM method. Males had significantly ($p < 0.05$)
205 higher values than females for self-reported PA using the SIM and IPAQ-SF, which are presented in
206 Table 1.

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Insert Table 1 about here

209 Correlation coefficients (**Table 2**) were poor to moderate ($r = 0.29 - 0.37, p < 0.01$) between each self-
210 report measurement of MVPA and accelerometer data in terms of minutes of MVPA per day and total
211 PA in the whole sample. Correlations were significant ($r = 0.29 - 0.47, p < 0.01$) for females and the
212 total sample for each of the self-report measures with accelerometer derived MVPA and total PA.
213 Significant scores were reported for males only between the IPAQ-SF and accelerometer derived
214 MVPA ($r = 0.31, p < 0.05$) and total PA ($r = 0.27, p < 0.05$).

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Insert Table 2 about here

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217 Details of agreement, sensitivity, specificity, PPV, and NPV between each of the self-report measures
218 and accelerometer data are displayed in **Table 3**. There was a moderate level of agreement with both

219 the SIM (45.2%) and the PACE+ (44.5%) measures with accelerometer data using the AD method.
220 IPAQ-SF demonstrated high levels of agreement with accelerometer data using the TM method
221 (77.4%). Overall, the accuracy of classifying those achieving the guidelines (sensitivity) was poor
222 with the SIM (31.1%) and the PACE+ (31.1%) but was high for the IPAQ-SF (78.2%). The
223 percentage of participants who self-reported meeting the PAGL, who actually met (PPV) was high
224 across all measures (71.7 - 96.6%). The accuracy of those not meeting the guidelines (specificity) was
225 high with the SIM (75.5%) and the PACE+ (73.5%), while moderate for the IPAQ-SF (50.0 %). The
226 percentage of participants who self-reported not meeting the guidelines who actually did not meet
227 (NPV) the guidelines was poor for the SIM (33.6%), PACE+ (33.0%), and the IPAQ-SF (11.1%).

228 **Table 4** shows the ICC scores for each of the self-report measures. These scores indicated moderate
229 reliability with the SIM (0.67) and the IPAQ-SF (0.52) but stronger with the PACE+ (0.70) in 133 of
230 the students (22 students were excluded from the analysis as they failed to complete the retest
231 measure).

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Insert Table 3 about here

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Insert Table 4 about here

235 **Discussion**

236 Few studies have been conducted to examine the validity of PA questionnaires in university students
237 using objective measures of PA such as accelerometers (Dinger et al., 2006). Additionally, few have
238 explored the associations between self-report PA measurements and accelerometer measured MVPA
239 using the recommended PAGL as the cut-points (Milton et al., 2013). The IPAQ-SF was the only
240 measure found to have a significant association with accelerometer derived MVPA and total PA for
241 males ($r = 0.27 - 0.31$, $p < 0.05$) and females ($r = 0.29 - 0.33$, $p < 0.01$). Similar results were reported in
242 a publication by Craig and colleagues (2003), which found the validity of the IPAQ-SF in adults to be
243 0.30 (CI = 0.23 – 0.36) across 12 countries. A significant association between accelerometry and both
244 the SIM and PACE+ was found in females only. Differences among sex have not been shown with
245 regards to the validity of measures in university students, but have been reported in adolescents
246 (Hardie Murphy et al., 2015; Rangul, Holmen, Kurtze, Cuypers, & Midthjell, 2008). Rangul and
247 colleagues (2008) suggested that self-report instruments may become better measures if sex
248 differences are taken into account.

249 The IPAQ-SF reported a strong level of agreement (77.4%) which was lower than previous findings
250 (66.0%), but similar results for sensitivity (78.2% vs. 77.0%) and specificity (78.2% vs. 77.0%)
251 (Ekelund et al., 2006). The SIM had a lower level of agreement (45.2%) and sensitivity (31.1%) with
252 accelerometry, with higher levels of both being reported in a previous study (Milton et al., 2013). The
253 PACE+ achieved similar results as the SIM, showing that it may be useful in adults but both of these
254 measures achieved poor overall validity with this population, when compared to the results produced
255 by the IPAQ-SF. This may be simply due to the fact that the IPAQ-SF contains more dimensions of
256 PA (i.e. walking, moderate and vigorous) and also asks about the duration of PA on each day. The
257 inability of the two shorter questionnaires to capture the same levels of information, as the IPAQ-SF,
258 may lead to their poorer validity.

259 Test-retest reliability showed the PACE+ score a strong ICC (0.70), followed by the SIM (0.67) and
260 finally the IPAQ-SF (0.52). Reliability scores reported in this study were lower than research suggests

261 for both the SIM (ICC = 0.86) (Milton et al., 2011) and the IPAQ-SF (ICC = 0.71 – 0.89) (Dinger et
262 al., 2006). The number of days between the first and second administration of each questionnaire was
263 longer in this study compared to previous research which may account for lower ICC scores for the
264 SIM and the IPAQ-SF in adults. Reliability scores were still moderate (SIM and IPAQ-SF) to strong
265 (PACE+) in this study suggesting that each of the measures has suitable reliability for use in this
266 population.

267 Overall, objectively measured PA showed that a high proportion of this sub-population of students
268 achieved the PAGL using the AD method (68.4%) and using the TM method (94.8%). A higher
269 number of participants achieving the PAGL using the TM method is due to participants' accumulated
270 minutes of MVPA reaching 150 minutes over a week but may not be spread over five or more days,
271 which is needed to achieve the PAGL using the AD method. The IPAQ-SF reported a high proportion
272 of students meeting the PAGL (76.8%), while the SIM and PACE+ reported much lower figures
273 (29.0-29.7%). Research has found that students reported being very physically active when using the
274 IPAQ-SF, engaging in 589 ± 405 minutes of total PA in the previous week (Dinger et al., 2006).
275 Although the IPAQ-SF typically overestimates when compared with objective measures (Lee et al.,
276 2011), it has underestimated in this study along with the other self-report measures. Other studies
277 have reported underestimating in self-report measures when compared to accelerometry (Ekelund et
278 al., 2006; Lim, Wyker, Bartley, & Eisenhower, 2015). Lim and colleagues (2015) reported that
279 participants with higher accelerometer values were more likely to underestimate PA levels using the
280 Global Physical Activity Questionnaire (GPAQ) in a sample of adults from New York City. This
281 study suggested that underestimation may have been due to the built environment and widespread
282 public transport in the participant setting, which led to more active body movement, thus potentially
283 leading to people being more physically active than perceived (Lim et al., 2015). All of the students in
284 the current study were in a university setting which could be considered as being built up, with
285 widespread active and public transport opportunities when compared to rural areas of Ireland. Like
286 Lim and colleagues' conclusion, this may have led to the current participants not considering their

287 active transport and occupational movements as being physically active, in turn causing the self-report
288 measures to underestimate when compared to accelerometry.

289 This study had a number of limitations which should be noted. A convenience sample was used to
290 recruit students across all faculties within each institution, however, a higher proportion of highly
291 active students took part. Research has suggested that the difference between self-report and
292 accelerometer measured MVPA may increase with higher activity and intensity levels (Dyrstad et al.,
293 2014). Rowe and Mahar (2006) have also stated that the validity of such tools is an ongoing process
294 and that when using a measure to validate against, it should be the most accurate measure of the
295 construct, bringing into question activity monitors as a measure to validate against. As this study was
296 being used as a precursor for future student surveys it is still important to use these findings to aid
297 with the selection of self-report measures for use in future studies and interventions. Future studies
298 should use representative samples, varying in PA levels in order to establish if these measures can be
299 used across all university students. Another limitation is that the self-report measures were given to
300 the participants before they wore the accelerometer meaning the same seven days were not being
301 reported, which is also important as PA is not a stable behaviour itself. The measures selected give an
302 indication of 'general or usual' physical activity levels, categorising population groups into meeting
303 versus not meeting the physical activity guidelines. As such their sensitivity should allow for an
304 objective measure to be administered over the same general time period.

305 The approach used for test-retest reliability may be questionable due to a behaviour such as PA not
306 being stable from day to day, meaning that the measure may seem like it is not repeatable when in fact
307 is measuring the correct PA levels. Using this approach can lead to measures having a low to
308 moderate reliability, rather than acknowledging that the behaviour itself might have low reliability or
309 stability (Kelly, Fitzsimons, & Baker, 2016).

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313 **Conclusion**

314 This paper would recommend that when assessing levels of high active university students achieving
315 the PAGL, the IPAQ-SF is the most suitable of these three self-report measures. This concurs with
316 Dinger et al. (2014) who also found the IPAQ-SF to be a suitable PA measurement tool for university
317 students. Another recommendation would be that other tools are available for PA measurement,
318 especially for measuring the number of days university students are achieving the PAGL. Although
319 validity for the SIM and the PACE+ were low, the overall results suggest that both tools may be
320 useful for this population in the future. Finally, it is important to ensure that suitable measures are
321 selected in future studies, depending on the population, aims and outcome measure of the studies.

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