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Concurrent validity of ActiGraph-determined sedentary time against the activPAL under free-living conditions in a sample of bus drivers

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1 **Concurrent validity of ActiGraph-determined sedentary time against the activPAL under**
2 **free-living conditions in a sample of bus drivers**

3 **Running head: SEDENTARY BEHAVIOUR MEASUREMENT**

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19 **Abstract**

20 This study explored the validity of ActiGraph-determined sedentary time (<50cpm,
21 <100cpm, <150cpm, <200cpm, <250cpm) compared with the activPAL in a free-living sample
22 of bus drivers. 28 participants were recruited between November 2013 and February 2014.
23 Participants wore an activPAL3 and ActiGraph GT3X+ concurrently for 7 days and completed
24 a daily diary. Time spent sedentary during waking hours on workdays, non-workdays, during
25 working-hours and non-working hours were compared between instruments. During
26 working hours, all ActiGraph cut-points significantly underestimated sedentary time
27 ($p < 0.05$), whereas during non-working hours the <50 cpm cut-point demonstrated the
28 closest agreement (ActiGraph sedentary time: 250 ± 75 minutes vs activPAL sedentary time:
29 236 ± 65 minutes). ROC analyses revealed that on workdays and non-workdays the ActiGraph
30 cut-points exhibited relatively low sensitivity (all < 0.62) and specificity (all < 0.49) values. The
31 use of the ActiGraph to measure sedentary time in this understudied, highly sedentary and
32 at risk occupational group is not recommended.

33

34 **Key words:** Bus drivers, sedentary behaviour, validation, ActiGraph, activPAL.

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42 Introduction

43 Sedentary behaviour, described as any sitting or reclining posture with an energy
44 expenditure ≤ 1.5 MET's during waking hours (SBRN, 2012), has been linked to numerous
45 adverse health outcomes, including obesity, type 2 diabetes, metabolic syndrome, some
46 cancers and mortality from all causes and cardiovascular disease (Wilmot et al., 2012;
47 Biswas et al., 2015). High levels (between 50- 60% of waking hours) of sedentary time have
48 been identified in office workers (Thorp et al., 2012; Brown et al., 2013; Clemes et al., 2015)
49 and bus drivers (Wong et al., 2014; Varela-Mato et al., 2015), which put them at greater risk
50 of co-morbidities and mortality in comparison to other occupational groups (John et al.,
51 2006; Katzmarzyk et al., 2009; Dunstan et al., 2013).

52 Accelerometers have been used to overcome the limitations of self-report
53 instruments and are commonly used in surveillance studies and interventions to quantify
54 both physical activity and sedentary time. In addition, studies have shown a robust
55 relationship between accelerometer-determined sedentary time and health outcomes
56 (Healy et al., 2008; Kozey-Keadle et al., 2011). The use of accelerometry to provide an
57 objective estimate of sedentary time, in addition to physical activity, has been widespread,
58 with the ActiGraph being one of the most popular measurement tools within the literature
59 (Kozey-Keadle et al., 2011; Hart et al., 2011; Berendensen et al., 2014). The ActiGraph is a
60 small lightweight device that traditionally has been worn on an elastic belt on the hip. This
61 device measures raw acceleration data by capturing the frequency and amplitude of the
62 acceleration of the body segment to which it is attached (Atkin et al. 2012). Once the
63 monitoring period is finished, these data can be clustered into sedentary, light, moderate
64 and vigorous activities during the post-processing analysis (Atkin et al. 2012). However,

65 ActiGraphs do not measure posture and instead sedentary time is estimated using a lack of
66 movement counts. Several different thresholds (cut-points) have been applied to
67 predominantly the vertical axis of the ActiGraph accelerometer, to estimate sedentary time
68 (Kozey-keadle et al., 2011; Hart et al., 2011; Ridgers et al., 2012). A cut-point of less than
69 100 counts per minute (cpm) has been the most widely adopted to define sedentary time
70 (Atkin et al., 2012) in studies ranging from clinical interventions to large scale
71 epidemiological studies (Matthews et al., 2008; Healy et al., 2011). However, this cut-point
72 was not empirically derived.

73 The activPAL is a lightweight device that is attached to the anterior aspect of the
74 thigh. This contains a uni-axial accelerometer which responds to signals related to
75 gravitational forces and provides information on thigh inclination (Kozey-Keadle et al.,
76 2011). The activPAL has been shown to be a highly sensitive and valid measure of posture
77 (Kozey-Keadle et al., 2011; Grant et al., 2006; Hart et al., 2011), overcoming the limitations
78 of other accelerometers used to estimate sedentary time (e.g. the ActiGraph). However,
79 literature studying the agreement between the ActiGraph and activPAL when measuring
80 sitting time in a free-living environment is limited (Ridgers et al., 2012; Decker et al., 2013).

81 As sedentary behaviours are ubiquitous in most adults' day to day lives, accurately
82 measuring sedentary time is important to establish dose-response relationships with health,
83 to determine sedentary behaviour levels and patterns, and to identify behaviour domains to
84 target in interventions. It is therefore important to assess the outputs from available
85 instruments to measure sedentary time (ActiGraph and activPAL) taking into account
86 different characteristics of each occupational group; as different job-related behaviours and
87 working-environments might have an impact on the monitors' ability to correctly identify

88 sedentary time. Most validation studies (comparing the ActiGraph against the activPAL) in
89 adults have been conducted under controlled laboratory conditions, which have typically
90 simulated computer-based working environments (Kozey-Keadle et al., 2011; Hart et al.,
91 2011; Berendsen et al., 2014). No validation studies have been conducted in occupational
92 drivers such as bus drivers, whereby the continuous vehicle accelerations and decelerations
93 may have an impact on the accelerometers sensitivity to identify true sedentary time.

94 Indeed, of the limited research available examining bus drivers' sedentary time using
95 accelerometry, vast differences in sedentary time have been reported across studies using
96 different measurement tools. For example, using the ActiGraph accelerometer, Wong et al
97 (2014) reported that bus drivers accumulated 8 hours/day of sedentary time on workdays
98 (using a cut-point of <150 counts/minute (cpm)), whereas Varela-Mato et al (2016) reported
99 that bus drivers accumulated 12 hours/day of sitting on workdays, using the activPAL. The
100 largest differences in sedentary time observed between studies appeared to occur during
101 working hours, with bus drivers reportedly spending up to 4 hours whilst at work sedentary
102 in the study by Wong et al. (2014), whereas in the study by Varela-Mato et al. (2016), bus
103 drivers spent approximately 7 hours sitting whilst at work. Whilst information on the drivers
104 work pattern, in terms of hours spent driving, the number of breaks, and distance between
105 stops is not available for a detailed comparison between studies, the large differences in
106 sedentary times observed between these studies warrants further investigation into any
107 potential differences between the measurement tools.

108 Despite the ActiGraph being used to assess sedentary time in bus drivers (Wong et
109 al., 2014), no evidence currently exists on the validity of this measurement tool in this
110 specific population. Due to the nature of their occupation which typically promotes

111 prolonged periods of sitting, and their higher levels of disease risk (John et al., 2006; Joshi et
112 al., 2013; Wong et al., 2014) bus drivers are an important group to study in sedentary
113 behaviour research. This study therefore aims to explore the validity of ActiGraph-
114 determined sedentary time (<50cpm, <100 cpm, <150cpm, <200cpm, <250cpm) in
115 comparison to the activPAL in a free-living sample of bus drivers. This study will further our
116 understanding of the validity of the ActiGraph as a sedentary behaviour measurement tool
117 in a different occupational group, considering their working environment.

118

119 **Methods**

120 ***Participants***

121 A convenience sample of bus drivers was recruited from a bus company within the
122 East Midlands, UK, via leaflets and personal approaches by the researcher. Participants were
123 recruited at their place of work during their breaks, with the manager's consent, between
124 November 2013 and February 2014. Participants drove single-decker buses travelling local
125 routes with an average of 20 stops per route. Participants breaks varied in number between
126 1 and 4 depending on the route and their shift (average shift duration: 9 hours/day).
127 Written consent was obtained from 35 eligible full-time bus drivers (42% of the driving
128 workforce). Ethical approval was granted from the Loughborough University Ethical Advisory
129 Committee.

130

131 ***Demographic measures***

132 Participants self-reported their age. Height was measured without shoes using a
133 portable stadiometer (Seca 206, Oxford, UK). Body composition and weight were assessed
134 using a Tanita BC-418 MA Segmental Body Composition Analyzer (Tanita, UK Ltd). BMI was
135 calculated as kg/m^2 .

136 ***Measurement of Sedentary Behaviour***

137 The activPAL was initialised and downloaded using activPAL Professional v.7.2.29
138 software (device firmware version 3.107). It was attached directly to the skin on the midline
139 of the anterior aspect of the right thigh using a hypoallergenic medical dressing (BSN
140 Hypafix). The activPAL3 determines posture using information derived from accelerations of
141 the thigh, including the gravitational component, using a triaxial accelerometer (Atkin et al.,
142 2012). Due to its precision to differentiate between postures during free-living activities
143 (Godfrey et al., 2007), the activPAL3 has been shown to be a valid measure of time spent
144 sitting/lying, standing and walking in adults (Kozey-Keadle et al., 2011; Grant et al., 2006;
145 Hart et al., 2011). This monitor has been used as the criterion measure in studies
146 investigating the validity of waist-worn accelerometers for estimating sedentary time (Oliver
147 et al., 2010; Ridgers et al., 2012). The activPAL3 was therefore used as the criterion measure
148 in this study.

149 The ActiGraph GT3X+ was worn on an elasticated belt on the waist above the mid-
150 line of the right thigh. The device was initialised at a frequency of 100HZ and downloaded
151 using ActiLife software v6.11.8 and firmware version 2.0.0. Several sedentary behaviour cut-
152 points ranging from 0 to 500 cpm, applied to the vertical axis, have been proposed in the
153 literature (Atkin et al., 2012; Kozey-Keadle et al., 2011), with the <100 cpm cut-point being
154 the most commonly used (Atkin et al., 2012; Healy et al., 2008; Brocklebank et al., 2015). In

155 this study ActiGraph data were downloaded in 60-seconds epochs and sedentary time was
156 defined as the sum of minutes where the monitor output (from the vertical axis) was
157 <50cpm, <100 cpm, <150cpm, <200cpm, <250cpm and <300cpm.

158 Participants were advised to wear both devices concurrently and continuously over a
159 seven-day period, except during water-based activities. In addition, participants were asked
160 to complete a daily log book where they recorded their waking hours. On workdays,
161 participants recorded the times they started and finished work, along with the times of their
162 breaks during the day. Information about any non-wear time was also recorded in the daily
163 log. At the end of the seven days the devices and diary were collected from the participants.

164

165 ***Data processing***

166 Downloaded data from the activPAL were processed manually using a customized
167 Microsoft Excel macro. The activPAL data which are downloaded into 15-sec epochs were
168 re-integrated and summarized (using the Microsoft Excel macro) over 60-sec epochs (to
169 match the ActiGraph data) and time spent sitting, standing and stepping, including number
170 of steps and average cadence and sit-to-stand transitions were extracted. Sleeping time was
171 identified as the last transition from standing to sitting/lying and the first transition from
172 sitting/lying to standing during the time that best matched the participants' daily log. For
173 each identified sleeping bout, data were explored 60 minutes before and after and included
174 as sleeping time if sitting/lying time was ≥ 30 minutes and < 20 steps were recorded. If any
175 standing time with < 20 steps was found during sleeping hours, this was considered as
176 sleeping time. Non-wear time was considered as time spent in either a sitting/lying or
177 standing position for ≥ 3 hours, with no transitions.

178 Using the ActiGraph data, the time spent sedentary for each participant was
179 determined by summing the minutes spent below the 6-different cut-points defined above.
180 Sleep time was interpreted as the consecutive strings of sedentary minutes during the night
181 time that best matched the activPAL data. Sleep time was excluded from the analysis. Non-
182 wear time data (continuous strings of zero counts) that best matched the activPAL data was
183 removed from the analysis.

184 To be included in the analyses participants were required to have worn both devices
185 concurrently for at least 600 minutes on at least 4 days, including three work days and one
186 non-work day. For each participant, time matched total minutes spent sedentary during
187 working hours and outside of working hours on workdays, and total sedentary and non-
188 sedentary time on non-workdays were extracted based on times derived from participant's
189 logs. Timed-matched data for waking hours during work and non-workdays and during
190 working and non-working hours were retrieved from the activPAL and ActiGraph. These
191 were analysed for each participant using a Microsoft Excel macro which summarised total
192 activPAL and ActiGraph-determined sedentary time for each domain.

193

194 ***Data analysis***

195 Sedentary times determined by the activPAL and ActiGraph during waking hours on
196 workdays and non-workdays, and during working-hours and non-working-hours on
197 workdays were analysed using SPSS version 22. These variables were tested for normality
198 using the Shapiro-Wilk Test, which confirmed that all data were normally distributed.
199 Paired-samples t-tests were used to compare the time (in minutes) spent sedentary
200 between instruments on workdays and non-workdays and during working hours and non-

201 working hours on workdays. The Cohen's d statistic has been reported to provide a further
202 insight into the magnitude of the differences between the activPAL and ActiGraph, by
203 providing information on the standardised difference between the means. An effect size
204 calculator (UCCS Lee Becker) was used to determine the effect sizes. A small effect is
205 classified as 0.2, a medium effect as 0.5 and a large effect is classified as 0.8 (Cohen, 1988).
206 The coefficient of variation was used to assess the variability of the standard deviation with
207 respect to the mean.

208 The mean difference in time spent sedentary within the different domains, along
209 with the 95% limits of agreement, were calculated using Bland-Altman plots (Bland and
210 Altman, 1986). In addition, to assess the agreement of total sedentary time between the
211 outputs of the two devices, two-way mixed Intraclass Correlation Coefficients (ICC) were
212 calculated. ICC results were interpreted as follows: 0-0.39 indicates poor agreement; 0.4-
213 0.59 indicates fair agreement; 0.6-0.74 indicates moderate agreement; and >0.75 indicates
214 excellent agreement (Cicchetti, 1994). Receiver operating characteristic (ROC) curve
215 analyses (95%CI) (Jago et al., 2007) were conducted to explore the sensitivity and specificity
216 of each of the cut-points applied to the ActiGraph data to determine sedentary time. The
217 area under the curve value (AUC; representing the percentage of time that the ActiGraph
218 correctly identified sedentary time) was used to determine the accuracy of the diagnostic
219 ability of the ActiGraph compared with the activPAL. These tests were used to examine if
220 the ActiGraph cut-points correctly identify sedentary and non-sedentary time compared to
221 the activPAL during workdays and non-workdays (Jago et al., 2007). Statistical significance
222 was set at $p < 0.05$. Results are presented as mean (SD) unless stated otherwise. The
223 ActiGraph and activPAL outputs were plotted against each other as a Figure for one person

224 during a workday and a non-workday to illustrate the level of agreement between both
225 devices.

226

227 **Results**

228 Of the 35 drivers enrolled in the study, 28 (100% male; mean age 43.9 (27) years;
229 mean BMI 28.5 (3.9) kg/m²) provided at least 4 days of valid data for both monitors. The
230 average wear times during waking hours for the activPAL and ActiGraph for workdays were
231 1014(57) minutes/day (working-hours: 604(85) minutes/day) and 869(295) minutes/day for
232 non-workdays.

233

234 ***Levels of agreement between sedentary times determined by the ActiGraph and activPAL***

235 Sedentary times recorded (mean minutes/day) by the activPAL and different
236 ActiGraph cut-points during each of the different domains over the monitoring period are
237 shown in Table 1. Bland-Altman plots depicting the mean differences and 95% limits of
238 agreement between sedentary times measured using the different ActiGraph cut-points and
239 the activPAL on workdays and non-workdays, and during working hours and non-working
240 hours on workdays are shown in Figures 1 and 2.

241 Relative to the activPAL, the ActiGraph significantly underestimated total daily
242 sedentary time during workdays when using the <50 cpm, <100 cpm and the <150 cpm cut-
243 points. All ActiGraph cut-points significantly underestimated sedentary time during working
244 hours (Table 1). Outside of working hours on workdays, and during non-workdays, no

245 significant differences were observed between sedentary times estimated using the <50
246 cpm cut-point in comparison to the activPAL. All other ActiGraph cut-points significantly
247 overestimated sedentary time, relative to the activPAL on non-workdays, and during non-
248 working hours on workdays. Effects sizes (Cohen's d) for the differences in sedentary times
249 between the devices ranged from small (0.1) to large (0.8), depending on the cut-point
250 (Table 1). The strength of the associations, as determined by the ICC, between ActiGraph-
251 determined sedentary time and sitting time measured using the activPAL were stronger on
252 non-workdays, and during non-working hours on workdays, across all cut-points in
253 comparison to workdays and working hours on workdays (Table 1).

254

255 ***Sensitivity and specificity of ActiGraph-determined sedentary time***

256 Figure 3 shows the area under the ROC curve for the ActiGraph during workdays,
257 which showed poor discrimination of sedentary time compared with the activPAL (ROC=
258 .617). Despite the different cut-points generally showing better sensitivity than specificity,
259 the sensitivity and specificity values across all cut-points were low (Table 2). Figure 4 shows
260 the area under the ROC curve for the ActiGraph during non-workdays, which showed better
261 discrimination of sedentary time compared to workdays (ROC= .706 versus ROC=.617). As
262 with the workday data, the sensitivity and specificity values across all cut-points were low
263 (Table 3).

264

265 ***Illustration of activity patterns on a typical workday and non-workday for a bus driver***

266 Figure 5 shows the ActiGraph output illustrating activity patterns on a typical
267 workday and non-workday for a bus driver compared with the activPAL. Sedentary time

268 identified by the activPAL is represented by a straight line. ActiGraph and activPAL outputs
269 are superposed and time-matched for waking hours during a typical workday and non-
270 workday.

271

272 **Discussion**

273 The aim of this study was to explore the validity of accelerometer-determined free-
274 living sedentary time (assessed using <50cpm, <100cpm, <150cpm, <200cpm, <250cpm
275 and<300cpm cut-points) during and outside working hours in comparison to the activPAL in
276 a sample of bus drivers. All ActiGraph cut-points assessed in this study significantly
277 underestimated sedentary time during working hours, which led to weak associations
278 between accelerometer-determined sedentary time and activPAL determined sitting time
279 on workdays. Whilst closer agreements were observed between accelerometer-determined
280 sedentary time and the activPAL on non-workdays, ROC analyses revealed that the
281 ActiGraph generally showed poor discrimination of sedentary time compared with the
282 activPAL on both workdays and non-workdays. These findings suggest that the ActiGraph is
283 not a valid tool to assess sedentary time in bus drivers, particularly during workdays.

284 Kozey-Keadle and colleagues identified in 2011 significant differences in ActiGraph-
285 determined sedentary time depending on which cut-point was applied to the data (ranging
286 from <50 cpm to <250 cpm) over a 6-hour direct observation period. In their study, which
287 involved simulated office work, the authors reported that the cut-point with the lowest bias
288 was the <150 cpm cut-point, which overestimated sedentary time by 1.8%. In contrast, the
289 most commonly used <100 cpm cut-point underestimated sedentary time by 4.9%. In a
290 different study which compared sedentary time estimated by different ActiGraph cut-points

291 to activPAL-determined sitting time in free-living adults, Hart et al. (2011). observed an
292 ActiGraph cut-point of <50 cpm had the closest agreement with the activPAL.

293 In contrast to the above studies, the present paper examined the validity of different
294 ActiGraph cut-points in a different occupational group comprising bus drivers. In the present
295 study, discrepancies in the most accurate ActiGraph cut-point for detecting sedentary time,
296 relative to the activPAL, existed between workdays and non-workdays. On workdays, the
297 <250 cpm cut-point provided the closest estimate of total daily sedentary time compared to
298 the activPAL (mean difference +17 minutes/day). However, on non-workdays total daily
299 sedentary time was best estimated using the <50 cpm cut-point, which underestimated
300 sedentary time by 34 minutes/day. During working hours, all cut-points underestimated
301 sedentary time relative to the activPAL, with the <300 cpm cut-point providing the closest
302 estimate (underestimating by 33 mins/day).

303 Wong et al. (2014) used the ActiGraph-accelerometer (<150 cpm) to measure
304 sedentary time in a sample of bus drivers in Australia. In this study, they showed that,
305 despite the sedentary nature of a driving occupation, bus drivers accumulated less
306 sedentary time during workdays in comparison to non-workdays (7.8 hours/day versus
307 8.9hours/day, respectively) and during working hours compared to non-working hours (3.7
308 hours/day versus 4.1 hours/day, respectively). These results are contrary to those presented
309 in this study, which revealed that drivers spent 715 minutes (~12 hours/day) sitting on
310 workdays and 536 minutes (8.8 hours/day) sitting on non-workdays, and 478 minutes (7.9
311 hours/day) sitting during working hours. Taking into account any potential cultural or
312 weather-related (UK and Australia) differences between these studies; these results suggest
313 that using accelerometer-applied cut-points to determine sedentary time (as done by Wong

314 and colleagues, 2014) may result in the underestimation of sedentary time, possibly due to
315 the misclassification of sedentary time as light physical activity in this occupational group,
316 due to the movement of the bus.

317 The ActiGraph accelerometer records the intensity of the body's movements and
318 sedentary time is estimated through a lack of movement counts (Chen et al., 2005). Any
319 motion over any of the cut-points applied within this sample of drivers will therefore be
320 considered as non-sedentary activity and clustered as light-activity, as indicated by the
321 findings of the current paper. Discrepancies between the activPAL and the ActiGraph could
322 therefore be due to the vibrations experienced during vehicle motion. Figure 5 illustrates
323 the ActiGraph output activity patterns on a typical workday and non-workday for a bus
324 driver, compared to the activPAL. This figure indicates that continuous accelerations during
325 working-hours are detected by the ActiGraph and classified as non-sedentary time, whilst
326 the time-matched activPAL output clustered this time as sitting based on the body's
327 posture. Therefore, it is plausible that the discrepancies detected between the activPAL and
328 the ActiGraph are aggravated by the vibrations experienced during vehicle motion by the
329 bus driver, leading to an underestimation of sedentary time by the ActiGraph, as the vertical
330 vibrations travel through the body. Resulting in tipping the classification over the sedentary
331 threshold, despite the driver being seated (Patterson et al., 1993).

332 This study provides novel information on sedentary behaviour measurement and
333 how sedentary time is accumulated during and outside working hours using two different
334 tools in a sample of bus drivers. This study is not without limitations however. One
335 limitation is that the bus vibrations were not objectively quantified and it is difficult
336 therefore to assess their impact on the monitor's sensitivity to accurately detecting

337 sedentary time. Moreover, the sample size of this study was relatively small and included
338 participants who were overweight or obese, which may have exacerbated the impact of the
339 vehicle vibrations on the monitor's performance. This issue should be investigated further in
340 larger samples and in other driving occupations.

341

342 **Conclusions**

343 The present paper highlights that the ActiGraph accelerometer, relative to the
344 activPAL, misclassifies sedentary time in bus drivers, particularly during working hours.
345 When the use of the activPAL is not possible in such occupational groups, further research
346 should explore a correction formula to apply to ActiGraph data for defining sedentary time
347 in occupational drivers. Overall, sedentary behaviour measurement techniques should be
348 improved in this understudied, highly sedentary and at risk occupational group.

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Table 1. Mean (SD) time spent sedentary in each domain recorded by the activPAL and ActiGraph. ICCs, t-test (95% CI) and Cohen's d results are based on the comparisons between the times spent sedentary (mins/day) measured using the different ActiGraph cut-points and sedentary time measured using the activPAL (the criterion)

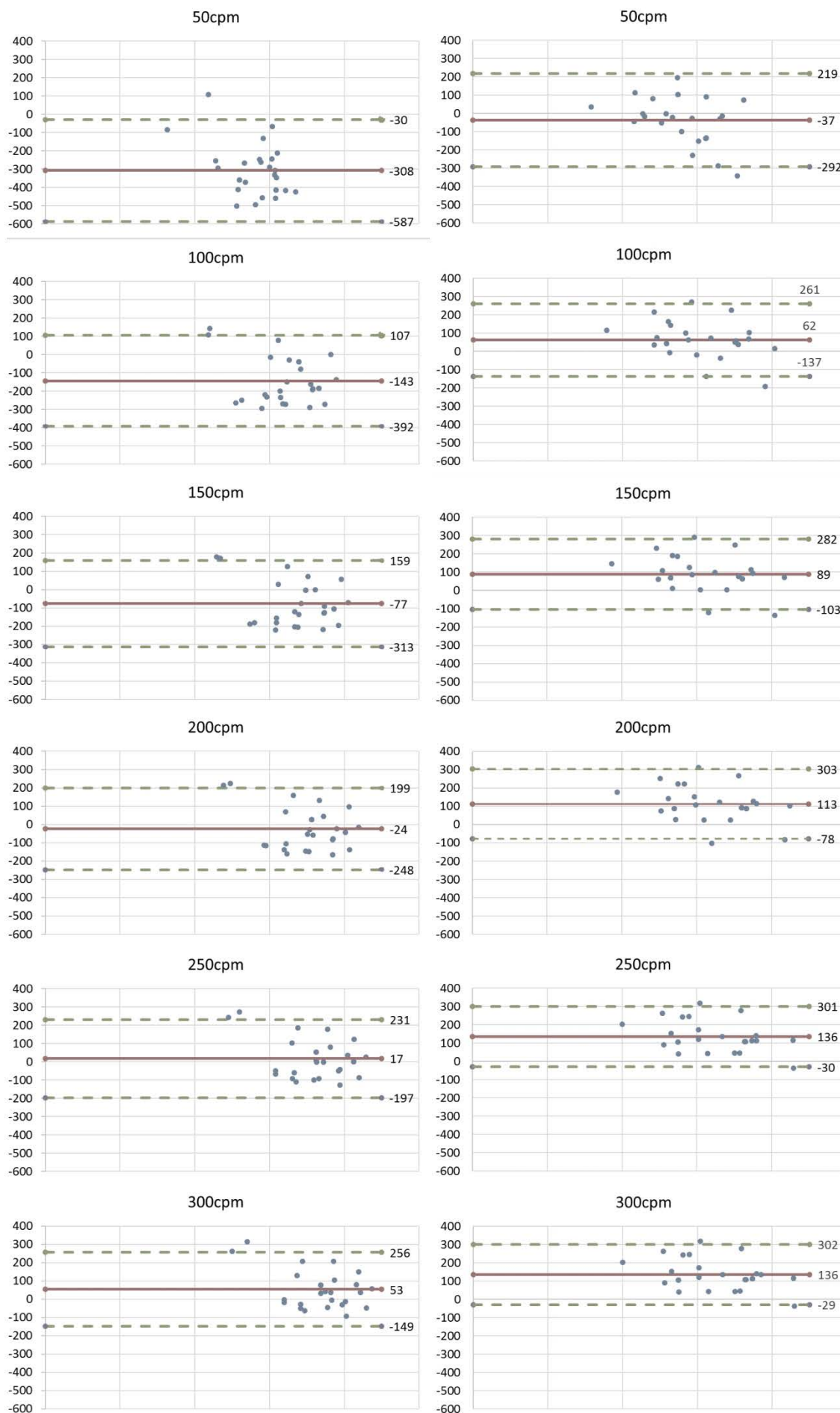
Domains	ActiGraph cut-points (cpm)	ActiGraph-determined sedentary time (min/day)	activPAL-determined sedentary time (min/day)	ICC between devices	CV (%)	p value (t-test)	95% CI (t-test)	Cohen's d (effect size)
Total waking hours on workdays	<50	480(92)		.261	14.2	<.001	-287.0, -182.5	0.7
	<100	572(96)		.334	14.8	<.001	-193.1, -92.4	0.5
	<150	638(95)	715(123)	.400	14.7	<.010	-124.6, -29.4	0.3
	<200	690(91)		.450	14.1	.274	-69.5, 20.6	0.1
	<250	732(84)		.481	13.0	.424	-26.1, 60.2	-0.1
	<300	768(84)		.523	13.0	.012	12.5, 94.1	-0.2
Total waking hours on non-workdays	<50	502(169)		.775	26.1	.170	-83.7, 15.6	0.1
	<100	594(199)		.879	32.4	<.010	18.2, 96.5	-0.1
	<150	619(206)	536(203)	.887	33.6	<.001	44.1, 121.2	-0.2
	<200	641(212)		.888	34.6	<.001	65.5, 143.1	-0.2
	<250	662(216)		.910	35.2	<.001	90.3, 160.6	-0.3
	<300	663(217)		.911	35.4	<.001	91.1, 161.4	-0.3
Working hours on workdays	<50	229(52)		.118	8.49	<.001	-293.1, -205.3	0.8
	<100	298(65)		.300	18.3	<.001	-221.6, -139.6	0.7
	<150	348(68)	478(106)	.418	19.2	<.001	-168.6, -92.8	0.6
	<200	388(69)		.496	19.5	<.001	-125.9, -54.9	0.5
	<250	420(70)		.552	19.7	<.010	-92.4, -25.3	0.3
	<300	445(71)		.593	20.0	.042	-65.5, -1.3	0.2
Non-working hours on workdays	<50	251(75)		.727	21.1	.158	-6.1, 34.9	-0.1
	<100	274(81)		.739	27.7	<.010	16.8, 58.9	-0.2
	<150	290(84)	236(65)	.747	28.8	<.001	32.7, 74.8	-0.3
	<200	302(85)		.752	29.1	<.001	44.9, 86.9	-0.4
	<250	312(86)		.752	29.5	<.001	54.7, 97.1	-0.4
	<300	323(84)		.764	28.8	<.001	66.3, 107.1	-0.5

Abbreviations: ICC, intraclass correlation coefficient. CI, confidence interval; CV, coefficient of variation

Difference in sitting time between the activPAL and the ActiGraph using different cut points (50,100,150,200,250,300 cpm)

Workdays

Non-Workdays



Mean activPAL and ActiGraph determined sitting time

460 Figure 1. Bland-Altman plots showing the mean difference and the 95% limits of
461 agreement in time spent sedentary on workdays and non-workdays, between the
ActiGraph GT3X+ (using different cut points) and the activPAL. The straight lines
462 represent the mean difference in minutes between the activPAL and the ActiGraph and
the dotted lines represent the 95% confidence intervals of the agreement between the
463 measures. The x axis represents the mean sedentary time calculated between devices
and the y axis is the difference in sedentary time (in minutes) between the ActiGraph
464 and the activPAL.

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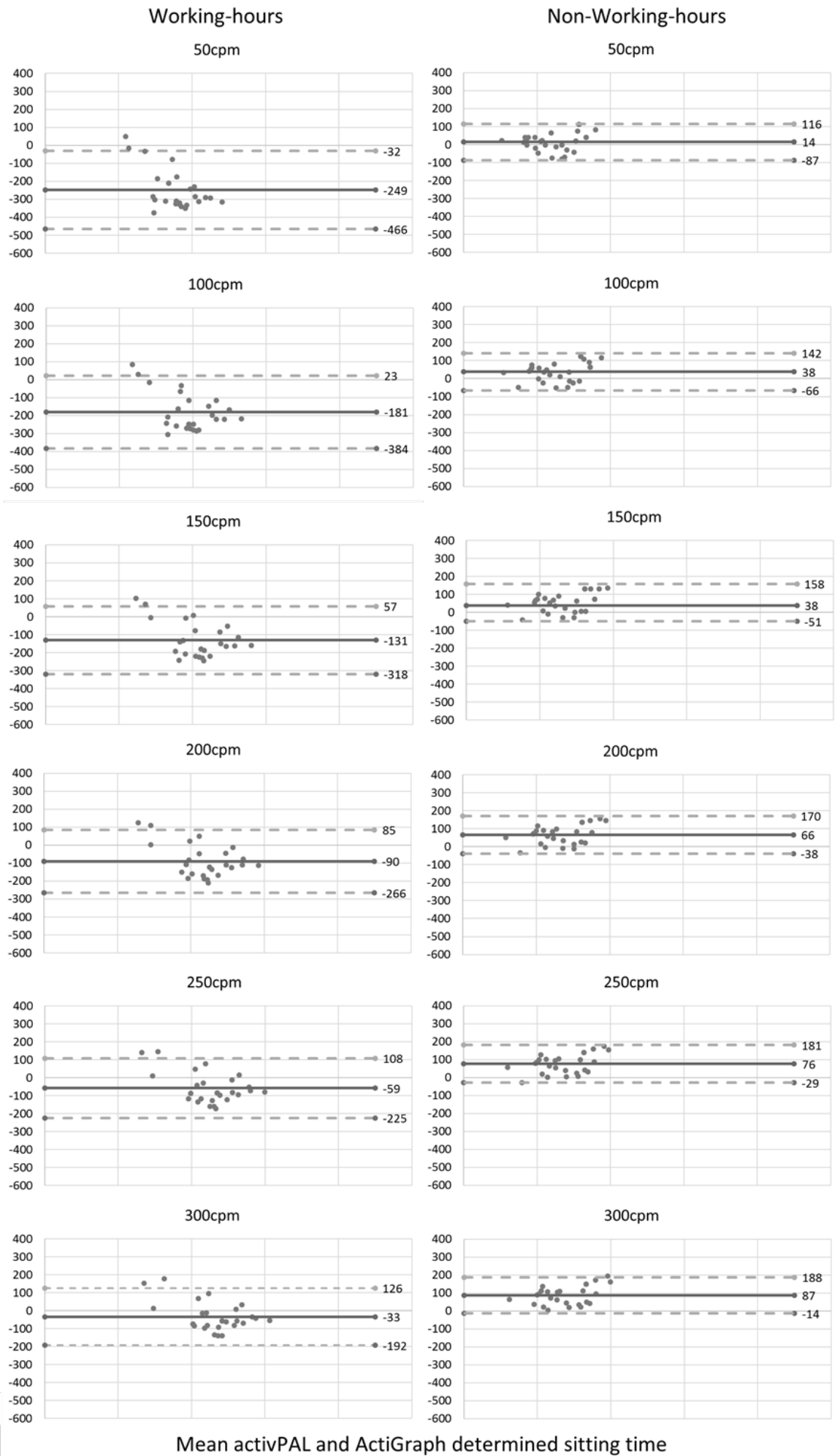
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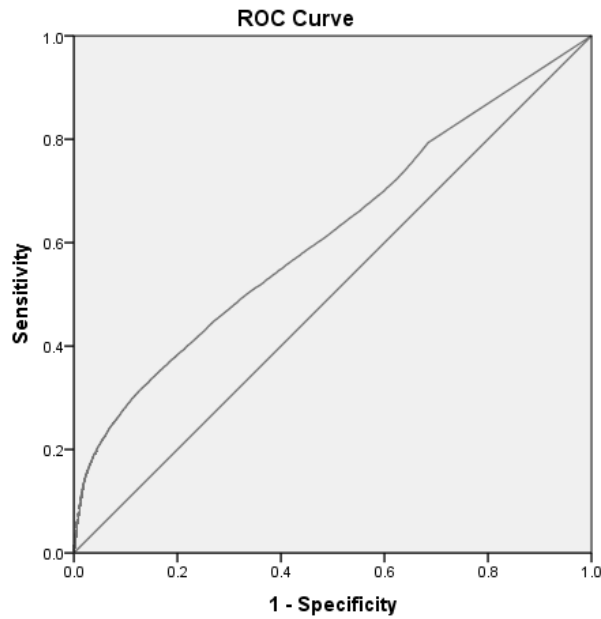
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Difference in sitting time between the activPAL and the ActiGraph using different cut points (50,100,150,200,250,300 cpm)



Mean activPAL and ActiGraph determined sitting time

479 Figure 2. Bland-Altman plots showing the mean difference and the 95% limits of
480 agreement in time spent sedentary during working-hours and non-working-hours on
workdays, between the ActiGraph GT3X+ (using different cut-points) and the activPAL.
481 The straight lines represent the mean difference in minutes between the activPAL
and the ActiGraph and the dotted lines represent the 95% confidence intervals of the
482 agreement between the measures. The x axis represents the mean sedentary time
between devices and the y axis is the difference in sedentary time (in minutes)
483 between the ActiGraph and the activPAL.



500 Figure 3. ROC curve for ActiGraph-determined sedentary time during workdays

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Table 2. Sensitivity and specificity values calculated across participants for each ActiGraph cut-point. The performance of each cut-point was compared to activPAL-determined total daily sitting time on workdays. The area under the ROC curve value to assess the accuracy of the ActiGraph to detect sitting time compared with the activPAL.

Area under the ROC curve (95% CI)		.617 (.613-.621)	
ActiGraph-determined sedentary cut points	Sensitivity	Specificity	
<50cpm	.620	.498	
<100cpm	.549	.400	
<150cpm	.498	.331	
<200cpm	.453	.277	
<250cpm	.413	.234	
<300cpm	.380	.197	

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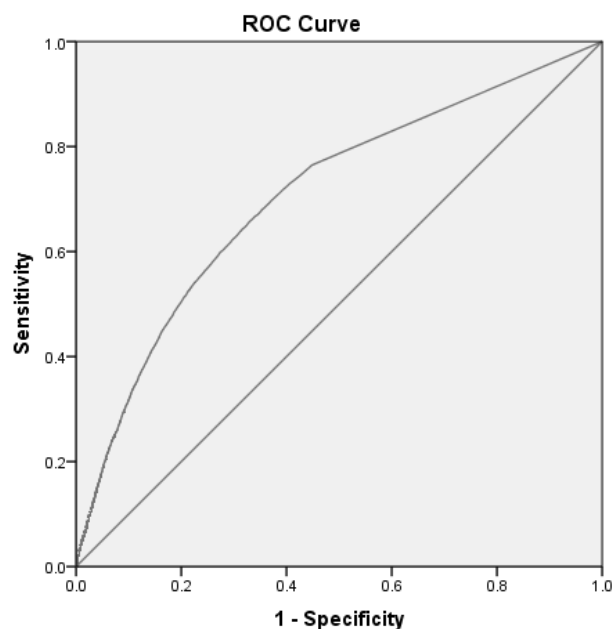
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519 Figure 4. ROC curve for ActiGraph-determined sedentary time during non-workdays

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Table 3. Sensitivity and specificity values calculated across participants for each ActiGraph cut-point. The performance of each cut-point was compared to activPAL-determined total daily sitting time on non-workdays. The area under the ROC curve value to assess the accuracy of the ActiGraph to detect sitting time compared with the activPAL.

Area under the ROC curve (95% CI)		.706 (.701-.712)	
ActiGraph-determined sedentary cut points	Sensitivity	Specificity	
<50cpm	.602	.278	
<100cpm	.532	.219	
<150cpm	.478	.182	
<200cpm	.437	.158	
<250cpm	.401	.139	
<300cpm	.372	.124	

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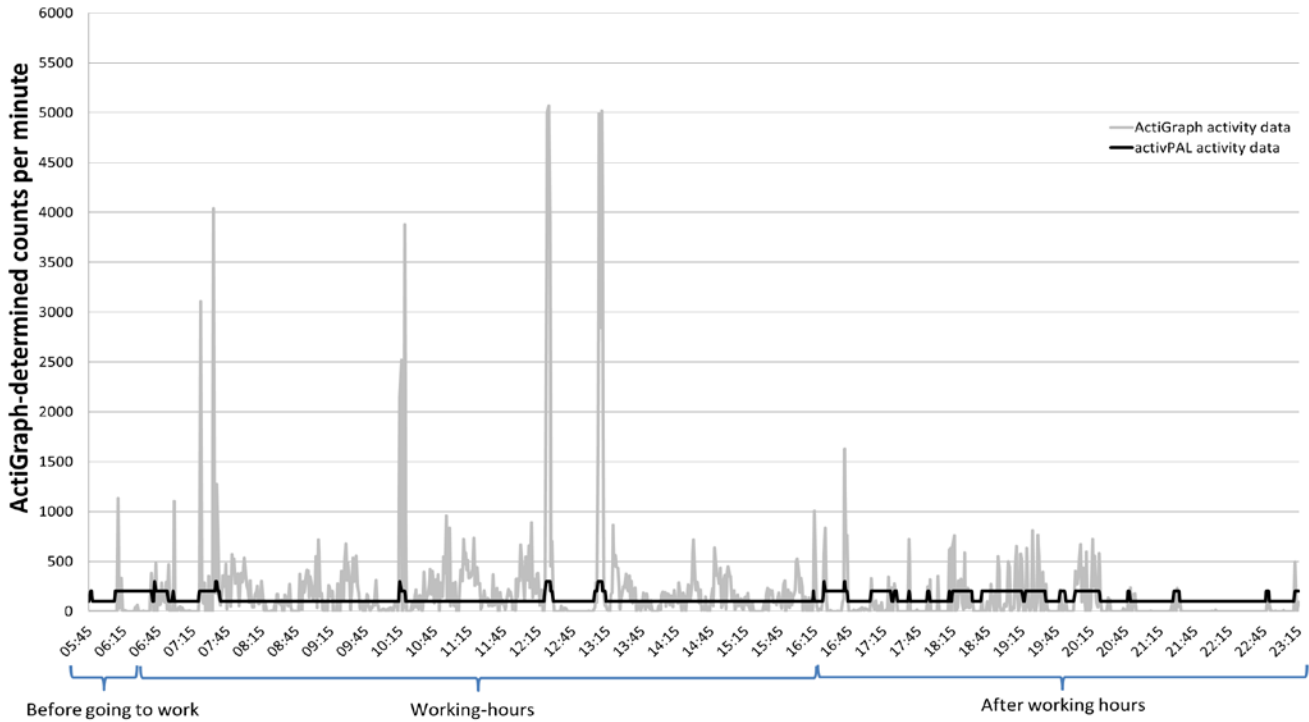
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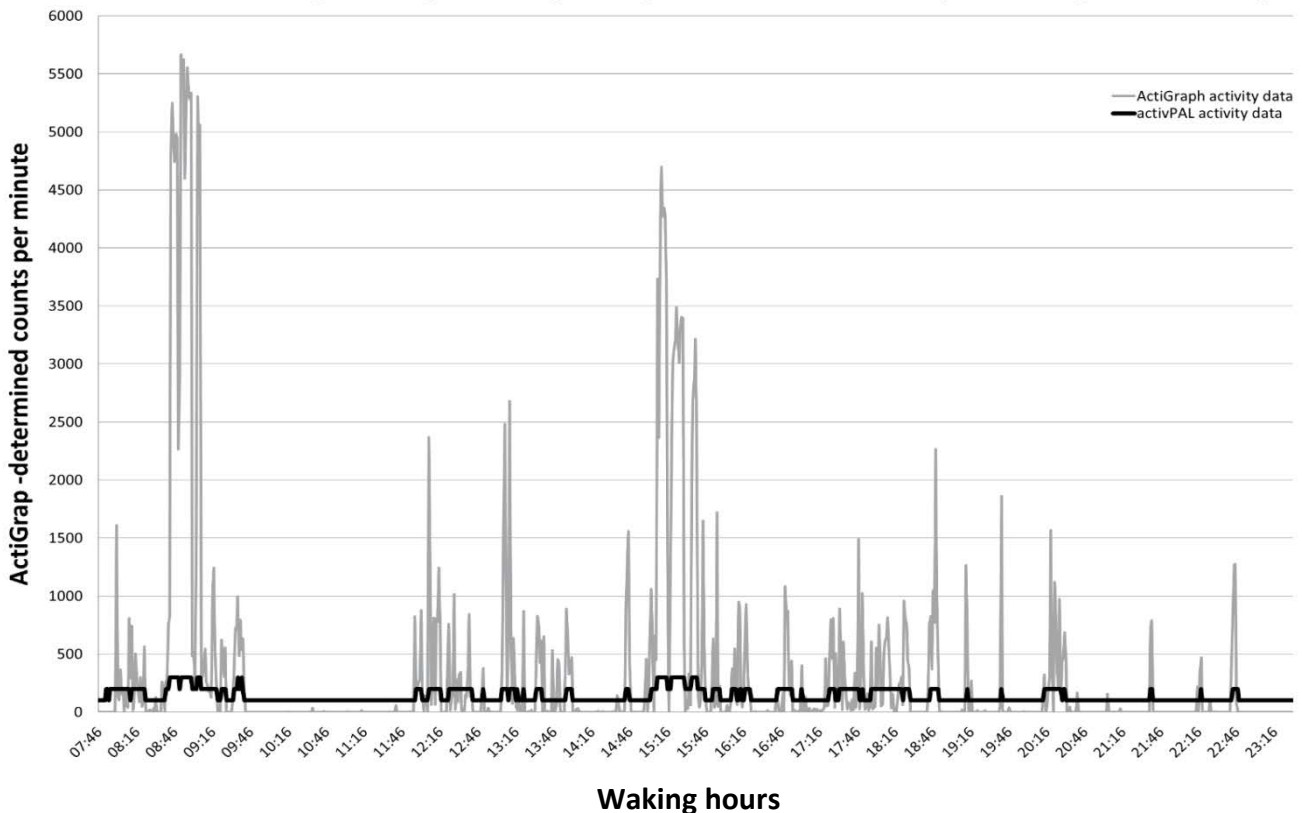
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ActiGraph activity data compared against the activPAL during a workday



ActiGraph activity data compared against the activPAL activity data during a non-workday



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550 Figure 5. ActiGraph output illustrating activity patterns on a typical workday and
551 workday for a bus driver, compared to the activPAL.