Validation of the W@WApp + MetaWearC sensor to monitor occupational sitting, standing and stepping in office employees: Validation Study

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Submitted to: JMIR mHealth and uHealth
on: July 02, 2019

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Abstract

Background: Replacing occupational sitting time with active tasks has several proposed health benefits for office employees. Smartphones and motion sensors, can provide objective information in real time on occupational sedentary behaviour (SB) – a key determinant of health. However, the validity and feasibility of using mHealth devices to quantify and modify occupational sedentary time is unclear.

Objective: To validate the new Walk@Work-Application (W@WApp) – including an external motion sensor (MetaWearC) attached to the thigh – for measuring occupational sitting, standing and movement in free-living conditions against the activPAL3M as a criterion measure. evices to quantify and modify occupational sedentary time is unclear.

Methods: Twenty office-workers (80% female, 39.5±8.1 yrs.) downloaded the W@WApp to their smartphones, wore a MetaWearC attached to their thigh in a tailored band and wore the activPAL3M for three to eight consecutive working hours. Differences between the two measures were examined using the Wilcoxon signed-rank tests. Associations between both measures were determined using the Spearman rank-order correlation coefficients, while agreement between measures were presented using Bland-Altman plots.

Results: The median recording time for the W@WApp+MetaWearC and the activPAL3M were 237.50±132.75 mins. and 240.00±127.50 mins. respectively (P<.001). No significant differences between sitting, standing and movement time were identified. Correlation coefficients identified very strong associations between the two measures for sitting and standing (rho=0.96 and 0.91, P<.001), with strong associations identified for movement (rho=0.74, P<.001). Bland-Altman plots indicated that sitting and standing time were under-reported with a mean bias of -1.66 mins. and -4.85 mins. respectively. For movement time, a positive mean bias of 1.15 mins. was identified.

Conclusions: The W@WApp+MetaWearC is a low-cost, accurate tool that can objectively measure occupational sitting, standing and movement in real-time. Using this tool could positively influence occupational activity behaviours in future interventions.

(JMIR Preprints 02/07/2019:15338)
DOI: https://doi.org/10.2196/preprints.15338

Original Manuscript

Original paper

Validation of the W@WApp + MetaWearC sensor to monitor occupational sitting, standing and stepping in office employees.

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Abstract

Background: Replacing occupational sitting time with active tasks has several proposed health benefits for office employees. Smartphones and motion sensors can provide objective information in real time on occupational sitting behaviour. However, the validity and feasibility of using mHealth devices to quantify and modify occupational sedentary time is unclear. **Objectives:** To validate the new Walk@Work-Application (W@WApp) – including an external motion sensor (MetaWearC) attached to the thigh – for measuring occupational sitting, standing and stepping in free-living conditions against the activPAL^{3M}. **Methods:** Twenty office-workers, 16 females (80%, 39.5±8.1 years old) downloaded the W@WApp to their smartphones, wore a MetaWearC attached to their thigh in a tailored band and wore the activPAL^{3M} for three to eight consecutive working hours. Differences between both measures were examined using paired samples t-tests and Wilcoxon signed-rank tests. Agreement between measures were examined using concordance correlation coefficients (CCC), 95% confidence intervals, Bland-Altman plots (mean bias, 95% Limits of Agreement - LoA) and equivalence testing techniques. **Results:** The median recording time for the W@WApp+MetaWearC and the activPAL^{3M} were 237.5±132.8 and 240.0±127.5 minutes respectively (*P*<.001). No significant differences between sitting (*P*=.53), standing (*P*=.12) and stepping time (*P*=.61) were identified. CCC identified substantial agreement between both measures for sitting (CCC=0.98, 95% CI: 0.96, 0.99), moderate agreement for standing (CCC=0.93, 95% CI: 0.81, 0.97) and poor agreement for stepping (CCC=0.74, 95% CI: 0.47, 0.88). Bland-Altman plots indicated that sitting time (mean bias = -1.66 minutes, 95% LoA: -30.37, 20.05) and standing time (mean bias = -4.85 minutes, 95% LoA: -31.31, 21.62) were under-reported. For stepping time, a positive mean bias of 1.15 minutes (95% LoA: -15.11, 17.41) was identified. Equivalence testing identified that the estimates obtained from the W@WApp+MetaWearC and the activPAL were considered equivalent for all variables excluding stepping time. **Conclusions:** The W@WApp+MetaWearC is a low-cost tool with acceptable levels of accuracy that can objectively quantify occupational sitting, standing, stationary time and upright time in real-time. Due to the feedback available to users, this tool could positively influence occupational sitting behaviours in future interventions.

Registration Clinical Trials: NCT04092738

Keywords: Validity, self-monitoring, sedentary behaviour, physical activity, smartphone, device-based measure

Introduction

Replacing sedentary time (i.e. sitting, lying or reclining postures that involve an energy expenditure of ≤1.5 metabolic equivalent units during waking hours) [1] with physical activity (PA) or movement of any kind has proposed health benefits for adults [2]. Positive associations have been reported with cardio-metabolic biomarkers, mortality risk reduction and body composition [3]. Many adults accumulate large amounts of daily sitting time at work, with white-collar workers being the most likely to engage in extensive occupational daily sitting [4]. Given that leveraging the time-inverse relationship between sedentary behaviours (SB) and PA could achieve important public health benefits [5], interventional efforts should target this high-risk subgroup [6] in the setting where daily sitting mostly occurs [5].

Self-monitoring is a key element to increase individuals' awareness and empowerment towards behaviour change [7]. For PA and SB, self-reported questionnaires have traditionally been the most commonly employed in large-scale population studies due to their low cost, simplicity and feasibility [8–11]. However, technological advances over the last two years have enabled the use of device-based measures, such as accelerometers, for self-monitoring PA and SB [8].

Evidence has identified smartphones as a potential alternative to accurately self-monitor PA and SB via inbuilt inertial sensors [12–15]. However, battery life and smartphone location have been major issues that have compromised usability and long-term monitoring. While external devices, such as wearables, may have overcome such weaknesses [16], the most popular devices are commercial motion sensors that use acceleration data to recognise activity behaviours (i.e. distance, time, and intensity). Unfortunately, such measures struggle to distinguish postures (i.e. sitting and standing), primarily due to wear position and the use of proprietary algorithms that do not accurately quantify such behaviours [7].

Commercially available devices that examine SB through postural positioning rather than−lack of movement (i.e. acceleration) are scarcer [17]. However, devices that quantify time spent sitting, standing and light intensity PA are critical when self-monitoring occupational behaviours, as moderate-to-vigorous physical activity is less prevalent during working hours or transport time to and from work (personal communication by Puig-Ribera A, in progress).

Smartphones alone struggle with postural identification due to the non-attachment of phones to the body and the ubiquitous nature of phone use [12]. However, the use of smartphones with external monitoring devices may have the potential to become an accurate, cost-effective self-monitor tool [12]. The range of novel and engaging smartphone-based intervention strategies, as well as the user´s perceptions on their usefulness and viability, highlights the potential of such technology on PA promotion [12].

In this context, the Walk@Work Application (W@WApp) was developed to self-monitor occupational PA and SB with a high level of validity. The W@WApp communicates with a MetaWearC external sensor [18], attached to a band on the thigh, to quantify occupational sitting, standing and stepping while offering real-time feedback on these behaviours; an essential component to change behaviours at the time and place where they occur. This study examined the validity of the W@WApp+ MetaWearC tool to quantify time spent in occupational sitting, standing and stepping against the current device-based gold standard measure for postural behaviours.

Methods

Measurement tools

The new W@WApp was developed from a previous version [19], adding a commercially available sensor (the MetaWearC-MbientLab Inc., San Francisco, CA.) to gather postural and movement information. The MetaWearC is a small sensor (24mm x 6 mm, 5.6g) covered with a waterproof round case. The sensor is a triaxial accelerometer with an amplitude range of ±16g and a sampling rate of 6.25 Hz. Key features of the MetaWearC sensor are shown at the Mbientlab web page [18].

Raw sensor data is synchronised with the W@WApp software via a low energy Bluetooth system with a long battery life (>30 days) and a range of up to 10-15 meters. The data are directly processed and displayed in real time by the app on the phone and securely stored to the back-end server. Figure 1 illustrates the W@WApp (login page) and the MetaWearC sensor.

The algorithm for the W@WApp+MetaWearC (Figure 2) was designed to analyse accelerometer output from the MetaWearC sensor. The MetaWearC sensor was worn within a small bag inside an elastic and adjustable band (Figure 1) attached to the participants' right thigh. The algorithm is based on two primary requirements (i) data can only be recorded during the defined recording period (i.e. working hours) and (ii) data can only be collected when both the device and the software are connected via Bluetooth. When these criteria have been met and the sensor detects an acceleration, the stepping counter gets started and the sitting and standing counters go to 0. The recognition of stepping time is applied when the sensor identifies a balance between false positives (i.e. counting a step when the step has not happened) and false negatives (i.e. not counting a step when the step has happened). There are three sensitivity modes for the step detector: normal, sensitive, and robust. These modes balance sensitivity (false negatives) and robustness (false positives). Normal mode is used in most applications as it is well balanced between false positives and false negatives. An example of a false positive would be the detection of a step while an individual was in a sitting position, potentially as a result of stretching ones leg.

The recognition of postures (sitting and standing) is based on the angle of the z-axis where 0 is for a completely vertical posture (standing) and 1 is for a completely horizontal posture (sitting). When the sensor detects in the z-axis a value higher than 0.8, the sitting counter gets started while the standing counter remains to 0. When the sensor detects in the z-axis a value lower than 0.8, the standing counter gets started while the sitting counter goes to 0. If either the sitting or standing counters reach 75 readings (approximately every 2 seconds), it means that the sensor has not detected stepping during 75 readings and therefore, the stepping counter stops and assumes that the user is either sitting or standing depending on which of these counters reaches 75.

Finally, if there is a difference greater than 15 minutes between the time counters for the W@Wapp-MetaWearC (stepping, sitting and standing) and the elapsed time, a weighted adjustment is completed. Normally, this difference is due to temporal disconnections of the sensor if it´s kept for more than 20 metres away from the mobile. For example, if the W@Wapp-MetaWearC has counted for 100 minutes (75 minutes stepping, 10 minutes standing and 15 minutes sitting) but the real time elapse is 115 minutes, the weighted adjustment will correct the W@Wapp-MetaWearC to 86 minutes stepping, 12 minutes standing and 17 minutes sitting.

The activPAL^{3M} (PAL Technologies Ltd., Glasgow, UK) is referred to as the gold standard device-based measure for postural recognition in free-living conditions [20]. The activPAL^{3M} was employed as the criterion measure for sitting, standing and stepping time. The activPAL^{3M} (9g, 25x45x5mm) was placed in a waterproof nitrile sleeve and was attached on the midline of the anterior aspect of the participants' thigh using a transparent film (10 x 10cm of hypoallergenic Tegaderm™ Foam Adhesive Dressing)

Participants and procedures

Office workers from the University of Vic-Central University of Catalonia (UVic-UCC) that owned a smartphone with a hardware newer than Android version 6.0.0/iOS version10.0.0 were invited to participate in the study. A convenience sample was recruited (n=23). All volunteers provided written informed consent prior to participation. This study was conducted within a Spanish national project (W@WApp-Diab; PI17/01788) led by the UVic-UCC. Ethical approval was obtained by the research ethics committee of the Research Institute of Primary Care Jordi Gol (IDIAP).

Participants installed and configured the W@WApp following the guidance provided by the researchers: (i) registration on the Walk at Work web platform [21], (ii) user verification through email, (iii) W@WApp installation and initialization, (iv) recording day and time period configuration (i.e. between 3 and 8 working hours) and (v) recognition of the MetaWearC sensor via Bluetooth. According to the EU General Data Protection Regulation, participants could read the private policy of the W@WApp in a clear and straightforward language at the Walk at Work web platform [21]. In addition, participants provided affirmative consent prior to using the W@WApp when they voluntarily registered to the web platform.

Researchers initialised the activPAL^{3M} and the W@WApp+MetaWearC and placed both devices on the midpoint (i.e. one over the other) of the anterior aspect of the thigh of the same leg to avoid measurement bias due to asymmetric leg positions and movements. To ensure that the timestamp of the W@WApp+MetaWearC and the activPAL^{3M} aligned for data analysis, they were initialised from the same PC.

Participants wore the W@WApp+MetaWearC and the activPAL^{3M} sensor in occupational free-living conditions for between three and eight hours. They were required to keep their smartphone within a five meters radius throughout the measurement period (i.e. participants were asked to keep their smartphones with them at all times).

Variables and Statistical analysis

The variables recorded and quantified by the W@WApp+MetaWearC tool were time spent in sitting and standing postures and time spent stepping. These variables were extracted from the W@WApp software. For the activPAL, once data collection was complete, files were processed via the activPAL Professional Software (version 7.2.32). Data was then exported to a Microsoft Excel (Microsoft Corporation, Microsoft Excel 2016, WA, USA) file format, providing data on sitting, standing and stepping in 15 second epochs. This enabled the quantification of the number of minutes spent sitting, standing and stepping. In addition, the time spent sitting and standing were added together to quantify stationary time, while the amount of time spent standing and stepping were added together to compute upright time. Total recording time (i.e. minutes) from both devices was calculated by summing the amount of time spent sitting, standing and stepping.

Descriptive characteristics (mean and standard deviation (SD); median and interquartile range (IQR) were used to describe the data. Differences between W@WApp+MetaWearC and the activPAL^{3M} were examined using paired samples t-tests and Wilcoxon signed-rank tests. Pearson correlation coefficients were used to determine the strength and direction of association between variables quantified by the two measures when the data was normally distributed. Spearman rank-order correlation coefficients were employed when data was not normally distributed. The concordance correlation coefficient (CCC) using Lin's approach [22], was used to examine the level of agreement between the W@WApp+MetaWearC variables and the activPAL^{3M} determined variables. The CCC values were interpreted using the categorisation recommended by McBride [23]. Bland-Altman plots with mean bias and limits of agreement (LoA) were constructed to examine the agreement between the W@WApp+MetaWearC variables and the activPAL^{3M} determined variables using similar approaches reported previously [24]. Equivalence was determined using two one-sided paired t-tests (90% confidence interval) for the mean difference between the W@WApp+MetaWearC variables and the activPAL^{3M} determined variables [25]. Equivalence was supported if the confidence interval for the mean difference was within 15% of the activPAL determined time spent sitting, standing and stepping. The equivalence region was arbitrarily defined, as limited biologically and analytically relevant criteria can be defined for the equivalence regions for sitting, standing and stepping. less conservative equivalence regions were also tested in case that equivalence was not supported for the 10% level. Additional tests to determine the region of equivalence were completed using increments of 5%. This approach was selected to provide a clear estimation of the accuracy of the W@WApp+MetaWearC [26]. Measures were expected to differ by no more than 30 minutes for sitting, 11 minutes for standing time and 4 minutes for stepping. All statistical analysis was conducted using IBM SPSS Statistics 25 (SPSS, Inc., an IBM Company, Chicago, IL) and Microsoft Excel (Microsoft Corp., One Microsoft Way, Redmond, WA).

Results

Twenty-three office-workers participated in the study, whereby activity behaviour information was recorded by both measures during workplace free-living conditions between October and November in 2018. After excluding three participants because of technical problems with the smartphone, data from 20 participants were included in the analyses (age: mean 39.5 years, SD 8.1, range 27–60; women 80%). A total of 115 hours of data was recorded, with an average of 5 hours per participant. Thirteen participants used an Android smartphone (Samsung, n = 5; BQ Aquaris, n = 4; Xiaomi, n = 2; Xperia, n = 1; and Huawei n = 1) with an operational system version ranging from 6.0.1 to 8.0.0. The other seven participants employed an iPhone 6 or iPhone 7 with an operational system version higher than 10.3.3.

Descriptive characteristics for variables of interest from the W@WApp+MetaWearC and the activPAL^{3M} and the statistical differences between the two measures for each variable are described in Table 1. The median recording time for the W@WApp+MetaWearC was 237.50 ± 132.75 minutes, while the activPAL^{3M} median recording time was 240.00 ± 127.50 minutes. No significant differences between the W@WApp+MetaWearC and the activPAL^{3M} were observed for sitting time (*P*=.53), standing time (p=.12) and stepping time (*P*=.54).

Table 1. Descriptive characteristics and statistical significance (*P* value) of the difference between the W@WApp+MetaWearC and the activPAL for minutes spent in different activity behaviours.

N=20	**W@Wapp**	**activPAL**	***P* value**
Recording time (mins.)	237.5 (132.8)[a]	240.0 (127.5)[a]	<.001
Sitting time (mins.)	191.0 (132.0)[a]	180.5 (124.3)[a]	.53
Standing time (mins.)	70.3 (38.1)	75.4 (36.1)	.12
Stepping time (mins.)	22.0 (24.0)[a]	24.0 (10.5)	.61
Stationary time (mins.)	223.5 (147.3)[a]	227.0 (138.0)[a]	.002
Upright time (mins.)	47.7 (23.6)	49.7 (21.8)	.25

[a]signifies data presented as median (IQR) due to non-normality. All other values are presented as mean (SD).

The W@WApp+MetaWearC showed strong to very strong correlations with activPAL determined activity variables. Concordance correlation coefficients identified substantial agreement between the two measures for sitting (CCC=0.98, 95% CI: 0.96, 0.99), moderate agreement for standing (CCC=0.93, 95% CI: 0.81, 0.97) and poor agreement for stepping (CCC=0.74, 95% CI: 0.47, 0.88). The correlation coefficients, CCC values, and associated 95% CI are shown in Table 2.

Table 2. Correlation Coefficients, Concordance Correlation Coefficients and 95% confidence intervals between the W@WApp+MetaWearC and the activPAL for minutes spent in different activity behaviours.

N=20	***r* (95% CI)**	**CCC[a] (95%CI)**
Recording time (mins.)	0.89 (0.73, 0.95)	0.99 (0.99, 0.99)
Sitting time (mins.)	0.97 (0.92, 0.99)	0.98 (0.96, 0.99)
Standing time (mins.)	0.93 (0.83, 0.97)	0.92 (0.82, 0.97)
Stepping time (mins.)	0.74 (0.44, 0.89)	0.74 (0.47, 0.88)
Stationary time (mins.)	0.96 (0.90, 0.98)	0.99 (0.99, 1.00)
Upright time (mins.)	0.95 (0.88, 0.98)	0.95 (0.87, 0.98)

[a]CCC = Concordance Correlation Coefficient. All *P*<.001.

The mean bias and LoA from the Bland-Altman analysis are provided in Table 3. The Bland-Altman plots, which compare the mean sitting, standing, stepping, stationary and upright time measured by the W@WApp+MetaWearC and the activPAL^{3M} are presented in Figures 3 and 4. The Bland-Altman plots present a graphical description of the means for sitting, standing, stepping, stationary and upright time as measured by the W@WApp+MetaWearC and the activPAL^{3M} against the difference of the time spent in each of these behaviours between both measures. For sitting, a smaller mean bias was observed (-1.66 minutes) with relatively wide LoA (-30.37, 27.05). The equivalence procedure indicated that the 90% confidence interval for the mean difference was 0.2 and 20.8 and was within the 15% equivalence region (-30.0 to +30.0 minutes). The estimates obtained from the two measures were considered equivalent for sitting time. The largest observed mean bias for a specific behaviour was observed for standing time (-4.85 minutes; LoA: -31.31, 21.62). The 90% confidence interval for the mean difference was -10.5 and 0.3 and was within the 15% equivalence region (-11.0 to +11.0 minutes). The estimates obtained from the two measures were considered equivalent for standing time. For stepping time, a small mean bias was observed (1.15 minutes; LoA: -15.11, 17.41). However, the equivalence procedure indicated that the 90% confidence interval for the mean difference was -4.5 and 2.1, which was not significantly within the 15% equivalence region (-4.0 to +4.0 minutes). The estimates obtained from the two measures were not considered equivalent for stepping time.

Table 3. Mean bias and limits of agreement for sitting, standing and stepping time.[a]

	Mean Bias	Lower LoA	Upper LoA
Recording time	-5.37	-13.56	2.81
Sitting time	-1.66	-30.37	27.05
Standing time	-4.85	-31.31	21.62
Stepping time	1.15	-15.11	17.41
Stationary	-6.52	-20.81	7.78
Upright time	-1.85	-15.76	12.06

[a]All variables presented as minutes (mins)

When combining variables, stationary time significantly differed between the two measures (*P*=0.002), while no differences were observed for upright time (*P*=0.25). However, stationary and upright time were strongly correlated with the criterion (*P*<.001). Time spent on stationary activities was underestimated with a mean bias of -6.52 minutes, with relatively small LoA (-20.81, 7.78 minutes). The 90% confidence interval for the mean difference was 1.3 and 12.4 and was within the 15% equivalence region (-41 to +41 minutes). The estimates obtained from the two measures were considered equivalent for stationary time. A mean bias of -1.85 minutes was identified for time spent upright, with relatively small LoA (-15.76, 12.06 minutes.) compared to the non-combined postural/activity variables. The equivalence procedure indicated that the 90% confidence interval for the mean difference was -0.9 and 4.8 and was within the 15% equivalence region (-7.0 to +7.0 minutes). The estimates obtained from the two measures were considered equivalent for upright time.

Discussion

This study examined the validity of the W@WApp+MetaWearC to measure occupational sitting, standing and stepping time in a free-living workplace environment. Our findings indicated that W@WApp+MetaWearC is a valid tool for self-monitoring occupational sitting, standing, stationary time and upright time, demonstrating moderate to very strong validity when compared to the criterion measure (activPAL^{3M}). However, the analysis demonstrated that the findings for stepping from the W@WApp+MetaWearC are not equivalent to those from the activPAL.

Although a small mean bias of 1.15 minutes for stepping between the W@WApp+MetaWearC and the activPAL was observed, poor agreement, wide confidence intervals and non-equivalence would suggest that the W@WApp+MetaWearC should not be recommended to use in detecting stepping time. However, it is quite plausible that the poor agreement, wide confidence intervals and non-equivalence observed can be attributed not only to variance from the W@WApp+MetaWearC tool but also the activPAL device. The activPAL is primarily used as a tool for the examination of postural position, namely sitting and standing, and has demonstrated high levels of accuracy in the detection of these behaviours in lab-based and free-living conditions [27] justifying its use as a device based comparison for the measurement of sitting and standing time. However, lower levels of validity for the activPAL^{3M} have been highlighted for stepping time and step count, particularly during activities of daily living. Therefore, future research should aim to utilise more accurate methods of movement when validating the W@WApp+MetaWearC tool. It should be acknowledged that W@WApp+MetaWearC tool compares relatively well in the detection of steps when compared with findings from other commercially available activity monitors in free-living conditions [28,29].

For stationary time (i.e. sitting and standing), the W@WApp+MetaWearC demonstrated high levels of accuracy when compared with previous validation studies employing a range of activity monitors

[30]. This is likely due to the W@WApp+MetaWearC detecting sitting and standing postures based on thigh acceleration. Recent studies have developed and validated self-monitoring devices that also provide real-time feedback on an integrated display, including the SitFit [31] or through a smartphone app via Bluetooth synchronisation such as the VitaBit [32] and Chair&App [33]. Similar to the findings presented here, the SitFit and the Chair&App devices reported that sitting time were highly accurate when compared to the activPAL^{3M} in free living conditions. However, the W@WApp+MetaWearC reported lower mean bias (W@WApp+MetaWearC) in comparison to other studies (SitFit). In contrast, the VitaBit device did not accurately distinguish between sitting and standing in free-living conditions but was accurate in the detection of movement. These findings are unsurprising, as deviceused as the comparison measure (ActiGraph) struggles to accurately distinguish sitting and standing behaviours [34]. Both the SitFit and the VitaBit were designed to be worn in the pocket of user’s trousers, which may be a usability barrier when wearing clothes without pockets. The Chair&App as well as the W@WApp focused on office-based jobs, but the Chair&App used a regular office chair equipped with pressure sensors instead of a thigh-attached device. That may remove compliance issues related to recording time but sitting away from the personal desk and other activity patterns such as standing and stepping cannot be captured. The W@WApp has demonstrated high levels of validity for sitting time, standing time, stationary time and upright time, while the wear location and attachment may increase compliance with wearing a self-monitoring tool in the workplace.

The W@WApp+MetaWearC is a novel tool that simulates the activPAL activity monitor in accurately recognising postural position at the workplace. The output from the W@WApp+MetaWearC tool for sitting time, standing time, stationary time and upright time were identified as equivalent to the current gold standard device-based postural measure, the activPAL. This suggests that this self-monitoring tool, which enables real-time feedback to users, is a worthwhile tool for use in interventions which aim to reduce sitting behaviour in the workplace. Self-monitoring is a key element to increase individuals' awareness and empowerment towards behaviour change [7]. This may result in a more accurate, affordable and accessible device than those currently available, enabling the more cost-effective inclusion of SB self-monitoring as a function of SB interventions in the future.

The strengths of this study include (i) the examination of the complete range of occupational sedentary and activity behaviour types (sitting/lying, standing and stepping), (ii) the examination of the validity of these measures in occupational free-living conditions and (iii) the use of the gold standard objective measurement device to determine the validity of the W@WApp+MetaWearC. The present study is not without limitations. Although the activPAL has been described as the gold standard for device-based measurement of sitting time [20] and is an acceptable field-based measure for activity behaviours in youth and adult populations [35,36], it is not the gold standard for comparison with stepping time. This should then be considered when interpreting the Bland-Altman plots, as these are designed to support comparison of a new measure to a previous gold-standard. The relatively small sample size with a large percentage of females (16 out of 20) and the homogeneity of workplace setting (i.e. all sampled from a university context) might differ from the general office population. Furthermore, the data gathered included an average of 5 hours per subject providing a limited sample. Additionally, the wide range of operating systems and hardware available added complexity on the app development and subsequent validation.

Conclusions

The W@WApp+MetaWearC demonstrates high levels of accuracy in determining postural position. The tool is a low-cost alternative tool for the examination of occupational sitting and standing time. The W@WApp+MetaWearC self-monitoring system supplements high levels of validity in detecting postural position with the provision of real-time feedback to users. Future research should examine the interventional effect of utilising this system as a self-monitoring tool to modify activity behaviours in office-based workers.

Acknowledgements

This study was funded by the Carlos III Health Institute (W@WApp-Diab; PI17/01788). The authors gratefully acknowledge the support of the Chair on ICT & Health of University of Vic-Central University of Catalonia. We also thank the App developers, Angels Calvet, Marc Icart and David Soler, for their hard work.

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Supplementary Files

Figures

Other materials for editor/reviewers onlies