



Impact of different recruitment strategies on accelerometry adherence and resulting physical activity data: A secondary analysis

Kevin Rudolf^{a,*}, Christopher Grieben^a, Katja Petrowski^b, Ingo Froböse^{a,c}, Andrea Schaller^{a,d}

^a Institute of Health Promotion and Clinical Movement Science, German Sport University Cologne, Am Sportpark Muengersdorf 6, 50933 Cologne, Germany

^b Department of Psychology and Psychotherapy, University Witten/Herdecke, Alfred-Herrhausen-Straße 50, 58448 Witten, Germany

^c Center for Health and Physical Activity, German Sport University Cologne, Am Sportpark Muengersdorf 6, 50933 Cologne, Germany

^d IST-University of Applied Sciences, Erkrather Straße 220 a-c, 40233 Düsseldorf, Germany

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ABSTRACT

Strategies for increasing adherence to physical activity assessments are often linked to extra financial or personal effort. This paper aims to investigate the influence of the recruitment strategy on participants' adherence to accelerometry and resulting PA data. Data were used from two previous studies conducted in 2013 and 2016 in Cologne, Germany, differing in recruitment strategy ($N = 103$, 40.8% male, mean age 20.9 ± 3.7 years, mean BMI 23.7 ± 4.1 kg/m²). In the passive recruitment (PR) group, vocational students took part in the accelerometry (ActiGraph GT3X+) in line with the main study unless they denied participation. In the active recruitment (AR) group, vocational students were invited to actively volunteer for the accelerometry. Impact of recruitment strategy on adherence and PA data was examined by regression analysis. Average adherence to the accelerometry was 66.7% (AR) and 74.0% (PR). No statistically significant influence of recruitment strategy on adherence and resulting PA was found (all $p > 0.05$). The difference in recruitment strategy did not affect adherence to accelerometry. The data imply that AR may be applicable. Future studies using larger sample sizes and diverse populations should further investigate these trends.

1. Background

The assessment of physical activity patterns is a keystone in many population surveys and in the evaluation of health promotion interventions and rehabilitation programs (Audrey et al., 2013; Weymar et al., 2015). For this reason, a variety of assessment methods have been developed over time; from easy-to-use questionnaires to cost-intensive chemical analyses like the doubly labeled water method, which is the current gold-standard in physical activity assessment (Müller et al., 2010). While questionnaires predominantly show only low to moderate validity (Müller et al., 2010; Helmerhorst et al., 2012), the more strongly valid assessment methods are often linked to a higher consumption of human and financial resources (Roth and Mindell, 2013; Rosenbaum, 2012). As a compromise between validity and practicability, accelerometers have become a method-of-choice in many studies over the last years (Rosenbaum, 2012; Guinhouya et al., 2013; Shiroma et al., 2015; Bornstein et al., 2011; Hansen et al., 2013).

In contrast to questionnaires, the objective measurement with accelerometers does not rely on the participants' memory and self-

reporting, thus recall bias and reporting bias are minimized (Reilly et al., 2008; Brown and Werner, 2008). Moreover, the application is simple and not restricted by language knowledge or education. However, the use of accelerometers requires closer participant cooperation in wearing the device for several days and only removing them while sleeping and during water activities (Weymar et al., 2015; Roth and Mindell, 2013). In most cases, data over at least four days, with a minimum of 10 h wear-time, are needed for the analyses of physical activity patterns (Skender et al., 2016; Trost et al., 2005). For this reason, the participants' adherence is essential for recording usable data (Audrey et al., 2013; van Sluijs and Kriemler, 2016).

As the sample size is limited by the number of available accelerometers, which is limited by the device's cost (Audrey et al., 2013; Rosenbaum, 2012), many studies only use small (Brown and Werner, 2008; Vanderloo and Tucker, 2015) or sub-samples (Opdenacker et al., 2008; Prins et al., 2012) for the objective measurement of physical activity. Especially for this scenario, the question arises of how to obtain the most usable accelerometer data. Different participant-based and investigator-based approaches were suggested in order to improve

Abbreviations: AR, active recruitment; CPM, counts per minute; GPAQ, Global Physical Activity Questionnaire; MVPA, moderate-to-vigorous physical activity; PR, passive recruitment
* Corresponding author.

E-mail addresses: k.rudolf@dshs-koeln.de (K. Rudolf), c.grieben@dshs-koeln.de (C. Grieben), katja.petrowski@uni-wh.de (K. Petrowski), froboese@dshs-koeln.de (I. Froböse), aschaller@ist-hochschule.de (A. Schaller).

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adherence in accelerometer studies (Trost et al., 2005), however, only a few of these approaches have hitherto been evaluated (Gorczyński et al., 2014; Sirard and Slater, 2009; Belton et al., 2013; Tudor-Locke et al., 2015). Moreover, most of the mentioned strategies involve additional financial burdens (e.g., incentives for wearing the device) or an increased workload for the research team (e.g., reminder calls) or participants (e.g., completing wear time logs). Hence, a resource-saving adherence-improving approach has yet to be found.

For this reason, the current paper aims to investigate the effects of different recruitment strategies on participants' adherence. Assuming that the people who actively volunteer for an objective assessment ("active recruitment") are more likely to provide sufficient accelerometer data than those people who passively accept the assessment in the context of a study ("passive recruitment"), this paper aims to examine whether (1) the manner of participant recruitment (passive vs. active) for objective physical activity assessments has an impact on participants' adherence, and (2) active and passive recruitment result in different physical activity data.

2. Material and methods

The present study was an exploratory, pooled secondary analysis of two main studies on physical activity promotion in 2013 and 2016. In brief, both studies, the Make Move study and the Web App study, aimed at web-based physical activity promotion in vocational school students in Cologne, Germany. Both studies were conducted in compliance with the Helsinki Declaration and were approved by the Ethics Committee of the German Sport University Cologne (Make Move reference: 2013; Web App reference: 118/2015). For further information on Make Move, see Frick et al. (2013), and for further information on Web App see Grieben et al. (2017).

2.1. Study design

For the present evaluation, data from the first week of the two different main studies (Make Move and Web App) was used to compare two groups with different recruitment strategy.

In the Make Move study, a total number of three classes was recruited according to prior agreement with school's principal and teachers. The objective measurement of physical activity was introduced as a component of the study, however, students, who did not want to participate in the measurement, were free to decline participation. In this way, the "passive recruitment" (PR) group was established, in which students were participating unless they freely declined participation.

In Web App the number of available accelerometers was smaller than the number of possible participants. Instead of randomly assigning participants, eligible participants from nine classes (same schools as in Make Move) were invited to participate in the objective physical activity measurement until all accelerometers were distributed. Those volunteers, who were participating of their own accord, form the "active recruitment" (AR) group of this secondary analysis.

All participants were informed that physical activity would be recorded by an accelerometer (ActiGraph GT3X+) that would have to be worn around the waist during waking hours. In addition to this, brief written instructions on accelerometer handling were provided.

The participants were informed that the study focuses on the physical activity behavior during their daily routine and, at the end of the investigation period, a written feedback about objectively measured physical activity would be provided for each individual participant. Exclusion criteria were limited mobility (e.g., orthopedic injuries) and insufficient knowledge of the German language.

No financial incentives for wearing the accelerometers were provided in either group. All participants provided informed consent.

2.2. Measures

All participants were instructed to wear an accelerometer (ActiGraph GT3X+) on the right-side of the waist during waking hours, removing them only while showering, bathing or swimming. The ActiGraph was previously validated for adults against heart rate telemetry ($r = 0.66\text{--}0.82$) (Melanson Jr and Freedson, 1995), indirect calorimetry ($r = 0.66\text{--}0.88$) (Melanson Jr and Freedson, 1995; Kelly et al., 2013) and the doubly labeled water method ($r = 0.26\text{--}0.58$) (Liu et al., 2005).

Accelerometer-data was collected with a sample rate of 30 Hz and saved in 30-s epochs. Prior to evaluation, the data were processed using the Freedson et al. (1998) and Troiano (2007) algorithms to obtain valid data on the duration and intensity of physical activity. Intensity cut-points were set at 0–99 counts per minute (CPM) for sedentary behavior, 100–1951 CPM for light intensity, 1952–5724 CPM for moderate intensity and > 5724 CPM for vigorous physical activity (Freedson et al., 1998). Moderate-to-vigorous physical activity (MVPA, > 1951 CPM) in bouts of at least 10 min with having a maximal interruption of 2 min (Masse et al., 2005), was calculated to interpret the data with regard to physical activity recommendations (World Health Organization, 2010). For this secondary analysis, the first seven days of baseline measurement were evaluated. Days having less than 1 h of recorded data were excluded from further evaluation (Skender et al., 2016; Trost et al., 2005). Adherence was defined as providing at least three days of minimum 10 h wear time.

To control for possible confounders on adherence and objective physical activity, self-reporting questionnaires were completed by each individual on demographics (sex, age, height, weight) and subjective physical activity (Global Physical Activity Questionnaire (GPAQ) (Armstrong and Bull, 2006)). The GPAQ collects information on the duration and intensity (moderate, vigorous) of physical activity and sedentary time in different dimensions (workplace, leisure time and transportation). The GPAQ has moderate validity ($r = 0.20\text{--}0.40$) (Bull et al., 2009; Trinh et al., 2009) and reliability ($r = 0.67\text{--}0.81$) (Bull et al., 2009).

2.3. Statistical analyses

Descriptive statistics (means, standard deviations, frequencies and percentages) were used to describe demographic characteristics and the data from questionnaires and accelerometers. Body mass index (BMI) was calculated using self-reported weight and height. Daily averages of MVPA and sedentary time (minutes in each activity category/number of recorded days) were calculated for GPAQ and accelerometer data.

Normality was checked using Kolmogorov-Smirnov tests with Lilliefors correction. Sex, BMI and age differences between groups (AR vs. PR) were tested by Pearson Chi-Square test and *t*-test, respectively.

For evaluating the impact of recruitment strategy on adherence (research question 1), a logistic regression model was used. Dichotomized adherence (≥ 3 days of minimum 10 h wear time vs. < 3 days of minimum 10 h wear time) was used as the dependent variable, recruitment strategy (AR vs. PR) as independent variable. To adjust for confounding, sex (female vs. male), BMI and age were included in the model. In a second model, self-reported physical activity (MVPA) was additionally included as an independent variable to explore whether (subjectively) physically active people were more adherent.

To explore the association between recruitment strategy and accelerometer-derived physical activity data (research question 2) a multiple linear regression model was calculated. For this purpose, the sample was restricted to adherent participants, i.e., providing at least three days of 10 h accelerometer wear time. Accelerometer-derived average MVPA per day was used as the dependent variable, since it is a commonly used indicator for health-related physical activity (World Health Organization, 2010). Recruitment strategy (AR vs. PR), sex (female vs. male), age and BMI were included in the model as

independent variables.

For metric variables, statistically significant beta scores indicate the magnitude of the variables' (positive or negative) impact on the dependent variable. For the two dichotomized variables "recruitment strategy" and "sex", statistically significant positive beta scores indicate a positive influence of "AR" and "female sex", respectively, while statistically significant negative beta scores indicate a positive influence of "PR" and "male sex", respectively.

The principal assumptions of linear regression were tested. In all regression models, participants with missing values in dependent or independent variables were excluded.

For all the statistical tests, the significance level was set at $p < 0.05$. All the analyses were run using IBM SPSS Statistics 24.

3. Results

3.1. Sample description

All of the 188 invited participants were eligible and 103 gave informed consent to participate in this sub study. Twenty-nine participants provided insufficient accelerometer data and were therefore marked as not adherent. Fig. 1 shows the flow chart illustrating the progress through the phases of the present study.

Overall, 42 (40.8%) participants were male and the mean age was 20.9 ± 3.7 years (age range: 16–40 years) (see Table 1). No statistically significant differences were found between the groups regarding sex ($p = 0.08$), age ($p = 0.18$) or BMI ($p = 0.79$). People declining or agreeing to participate in the study did not exhibit statistically significant differences regarding sex, age or BMI in either group (all $p > 0.05$, data not shown). Moreover, participants with insufficient accelerometer data did not show statistically significant differences from participants with sufficient accelerometer data regarding sex, age or BMI in either group (all $p > 0.05$, data not shown).

Descriptive statistics for accelerometer and GPAQ data are shown in Table 2. Including participants with insufficient data, AR group's ($n = 30$) and PR group's ($n = 73$) adherence was 66.7% and 74.0%, respectively. Those who were adherent wore the accelerometer for an average of 4.8 (AR) and 5.1 (PR) days. On average, both groups accumulated > 9.5 h of objectively measured sedentary time and < 12 min of objectively measured MVPA. The respective values in the GPAQ were higher for MVPA and lower for sedentary time.

3.2. Influencing factors on assessment adherence

Neither the recruitment strategy nor the individual-related variables (age, sex, BMI) made a statistically significant contribution to the prediction of adherence (all $p > 0.05$; Nagelkerkes $R^2 = 0.077$; see Table 3). Explained variation increased from 7.7% (model 1) to 9.7%

Table 1
Sample characteristics.

	Total sample ($n = 103$)	AR ($n = 30$)	PR ($n = 73$)	<i>p</i>
Sex [male] <i>n</i> (%)	42 (40.8)	8 (26.7)	34 (46.6)	0.08 ^a
Age [years] mean (SD)	20.9 (3.7)	21.8 (5.2)	20.5 (2.9)	0.18 ^b
BMI [kg/m ²] mean (SD)	23.7 (4.1)	23.5 (3.6)	23.8 (4.3)	0.79 ^b

^a Chi-square test.

^b *t*-Test.

Table 2
Descriptive statistics of adherence and physical activity data of both groups.

	AR	PR
Adherence ($n = 103$)		
Providing ≥ 3 days of minimum 10 h wear time [yes] <i>n</i> (%)	20 (66.7)	54 (74.0)
Accelerometer data ($n = 74$)		
Wear time [calendar days] mean (SD)	4.8 (1.3)	5.1 (1.3)
Wear time [min] mean (SD)	3991.8 (1141.6)	4226.7 (1439.5)
MVPA per day [min] mean (SD)	8.6 (9.4)	11.9 (17.6)
Sedentary time per day [min] mean (SD)	596.8 (57.7)	585.5 (108.8)
GPAQ data ($n = 86$)		
Self-reported MVPA per day [min] mean (SD)	63.1 (63.8)	96.0 (91.1)
Self-reported sedentary time per day [min] mean (SD)	553.0 (127.9)	514.3 (255.6)

when self-reported MVPA was included (model 2). However, sample sized decreased from $n = 103$ to $n = 86$ and no statistically significant contribution to the prediction of adherence was found in model 2 either (all $p > 0.05$; Nagelkerkes $R^2 = 0.097$).

3.3. Influencing factors on physical activity data

In line with the influencing factors on adherence, recruitment strategy and individual-related variables (age, sex, BMI) were not statistically significant associated with objectively measured MVPA (all $p > 0.05$; adjusted $R^2 = 0.045$; see Table 4).

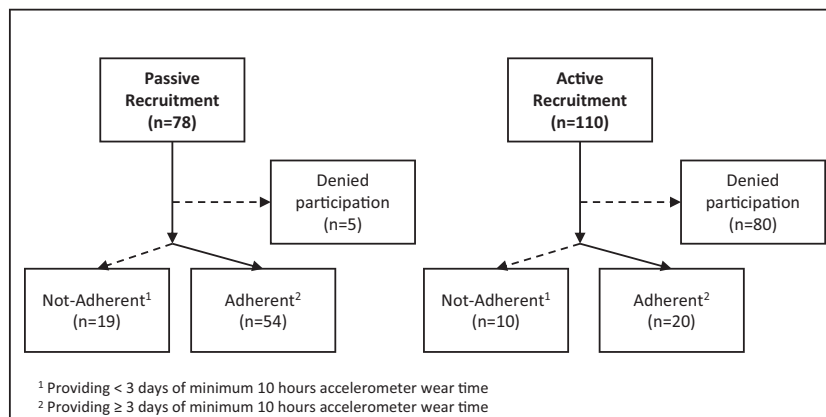


Fig. 1. Flow chart of participation progress.

Table 3
Regression analyses of influencing factors on adherence.

Model 1						
n = 103	Beta	SE (β)	Wald	Sig.	OR	95%-CI
Recruitment "AR vs. PR"	0.668	0.508	1.727	0.189	1.950	[0.720–5.278]
Age [years]	0.117	0.080	2.144	0.143	1.124	[0.961–1.315]
Sex "female vs. male"	−0.789	0.470	2.817	0.093	0.454	[0.181–1.141]
BMI [kg/m ²]	−0.010	0.059	0.027	0.869	0.990	[0.883–1.111]
Model 2						
n = 86	Beta	SE (β)	Wald	Sig.	OR	95%-CI
Recruitment "AR vs. PR"	−0.055	0.624	0.008	0.930	0.947	[0.279–3.216]
Age [years]	0.178	0.109	2.672	0.102	1.195	[0.965–1.480]
Sex "female vs. male"	−0.729	0.526	1.926	0.165	0.482	[0.172–1.351]
BMI [kg/m ²]	−0.036	0.064	0.316	0.574	0.965	[0.852–1.093]
Self-reported MVPA [min/day]	−0.001	0.003	0.073	0.787	0.999	[0.993–1.005]

Dependent variable: Dichotomized adherence (≥ 3 days of minimum 10 h wear time vs. < 3 days of minimum 10 h wear time); model 1: Nagelkerkes $R^2 = 0.077$, model 2: Nagelkerkes $R^2 = 0.097$.

Table 4
Regression analysis of Influencing factors on physical activity data.

n = 74	Beta	SE (β)	T	Sig.	95%-CI
Recruitment "AR vs. PR"	−1.862	4.189	−0.444	0.658	[−10.220–6.496]
Age [years]	−0.519	0.473	−1.097	0.276	[−1.462–0.424]
Sex "female vs. male"	−5.452	3.779	−1.442	0.154	[−12.991–2.088]
BMI [kg/m ²]	−0.660	0.448	−1.474	0.145	[−1.553–0.233]

Dependent variable: Accelerometer MVPA per day; adjusted $R^2 = 0.045$.

4. Discussion

Information on who adheres to objective physical activity assessment is scarce, with most studies casually examining differences between those who take part in assessment and provide sufficient data, and those who provide insufficient data (Husu et al., 2016; Lee et al., 2013; Loprinzi et al., 2014).

The current study aimed to gain information whether the recruitment strategy impacts participants' adherence in physical activity assessments and the resulting physical activity data by analyzing data of two study samples differing in participant recruitment strategy. Many studies use a form of "passive acceptance" for their assessments, because they recruit participants who are primarily interested in the topic of the study and not necessarily in the accompanying assessments. The assessment can be seen as a "burden" which participants accept to get the "benefit" of the study (e.g., a lifestyle intervention). We hypothesized that participants who specifically volunteer for the assessment would be more motivated to adhere to the assessment guidelines than participants "passively accepting" an assessment in the context of a study.

In contrast to our assumption, recruitment strategy had no impact on assessment adherence. Instead, both groups show moderate adherence with reference to possible accelerometer wear time (days) and a total of 29 participants (28.2%) not meeting the inclusion criterion of three days minimum wear time. In comparison to studies with older populations (Salvo et al., 2015; Schwaneberg et al., 2017), the average adherence of 66.7% to 74.0% is remarkably lower. As for the AR group, a possible explanation for these results may be that actively volunteering participants do not feel a strong obligation to wear the

device for the full time of the investigation. If the assessment is optional, it might give the impression that it is not as important as it would be if the assessment were to be obligatory. Therefore, the necessity of a long wear time for research must be made clear when distributing the devices to the participants.

The equally low adherence in the PR group reflects that the present study's population of young adults seems to be a special target group for physical activity assessments. The question whether participants forgot to wear the device or actively decided to not wear the device cannot be answered by using the available data. It stands to reason that - similar to adolescents, who state that the look of the assessment device influences wear time (Audrey et al., 2013) - young adults reject wearing a device on their waist when it makes them feel uncomfortable in the presence of other people at school or work who are not participating in the same study. Even though the ActiGraph can be worn under participants' clothes, it will show a bulge on the waist. Hence, a call for more unobtrusive devices seems legitimate (Audrey et al., 2013).

In regard to our exploratory assumption that people reporting to be more physically active are more adherent than subjectively inactive people, the absence of a statistically significant influence of self-reported MVPA on adherence complies important information for research practice. It indicates that accelerometry can be used to collect data from subjectively active and inactive people without the risk of a sampling bias (Fadem, 2009).

For the question of whether the recruitment of actively volunteering participants influences the resulting physical activity data, no statistically significant influence of recruitment strategy on objectively measured MVPA could be found. In this way, a potential bias that actively volunteering participants may be more physically active cannot be confirmed. Moreover, the present study shows no significant differences in sample characteristics for actively and passively recruited participants. These findings contrast with previous studies (Weymar et al., 2015; Harris et al., 2008) identifying women as more likely than men (OR = 1.7, 95% CI 1.1–2.7 and OR = 1.4, 95% CI 1.1–1.8) to decline participation in accelerometry. Similar to findings from Inoue et al. (2010), more women than men volunteered for accelerometry in the current study, although the difference to the PR group misses statistical significance ($p = 0.08$). Roth and Mindell (2013) could also not detect differences in accelerometry-participants and -decliners, however, they identified younger participants to provide less sufficient accelerometer data. Although the number of participants with insufficient data is quiet small in the present study, no such differences could be found, either.

Overall, the recruitment of actively volunteering participants may not increase the amount of usable data, but the present results indicate that this recruitment strategy for physical activity assessments may be applicable since it is not affected by sampling bias. However, a larger pool of people seems necessary, since only 30 out of 110 eligible people actively volunteered for the assessment.

4.1. Strengths and limitations

The study at hand provides a first attempt to investigate the impact of different recruitment methods on participants' physical activity and adherence. Due to the school-setting of the main studies, a comparison of actively and passively participating students was possible. Another strength of the present study is the use of objective as well as subjective assessment methods allowing a comprehensive consideration of activity behavior in the study sample.

The present study also has some limitations with the biggest limitation resulting from the design as a pooled secondary analysis. No influence could be made on the setting, sample size or the population under investigation. Consequently, the results' validity is restricted to the population of vocational school students. How a change of recruitment strategy would affect populations in other settings has yet to be investigated.

In an attempt to keep the sample size as large as possible, we

excluded participants with less than three days of at least ten hour wear time, although [Troost et al. \(2005\)](#) states that a minimum of four days best reflects physical activity behavior. However, the inclusion of at least four valid days decreases both the sample size to a total of 62 and the participants' adherence to 53.3% in the AR group and 63.0% in the PR group, however, no significant impact on predictors of adherence and physical activity data would have been found. Thus, the inclusion criterion of three days was kept to maintain the bigger sample size. However, the sample size – especially for the AR group – is still relatively small and the uneven number of participants in the two groups may still comprise some sort of unforeseen sources of variation. Accordingly, the present results should be interpreted with caution.

Even though participants of the present study did not demonstrate statistically significant differences from non-participants with regard to sociodemographic variables (age, sex, BMI), the existence of bias cannot be generally excluded since no objective data on physical activity levels of non-participants are available for comparison.

4.2. Implications for future research

Researchers conducting accelerometer studies will continue to face the challenge of how to raise adherence to the assessment protocol. As our results could neither confirm higher quality data nor indicate a sampling bias, further application-oriented research on physical activity might also consider active recruitment as a possible strategy. This might be a promising approach to face limited resources in studies. Nevertheless, we strongly suggest to conduct primary studies in order to confirm or reject the results of our secondary analysis, respectively. Thereby, studies with larger samples and also different populations (e.g., varying in education, socioeconomic status, health status or cultural background) should be considered. Moreover, qualitative studies focusing on the reasons for adhering and not-adhering could offer valuable insights.

5. Conclusion

The evaluation of health promotion and rehabilitation programs with help of objectively measured physical activity is a widely recognized challenge since it depends on participants' adherence. The present results showed no improvement of adherence by restricting the recruitment to actively volunteering participants. However, the recruitment of actively volunteering participants for evaluation of programs seems applicable since no bias was found. Although, a bigger number of eligible participants is needed for recruitment since only a relatively small number of eligible participants actively volunteers for the objective measurement.

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