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Criterion validity of two physical activity and one sedentary time questionnaire against accelerometry in a large cohort of adults and older adults

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ABSTRACT

Objectives We compared the ability of physical activity and sitting time questionnaires (PAQ) for ranking individuals versus continuous volume calculations (physical activity level (PAL), metabolic equivalents of task (MET), sitting hours) against accelerometry measured physical activity as our criterion.

Methods Participants in a cohort from the Tromsø Study completed three questionnaires; (1) The Saltin-Grimby Physical Activity Level Scale (SGPALS) (n=4040); (2) The Physical Activity Frequency, Intensity and Duration (PAFID) questionnaire (n=5902)) calculated as MET-hours·week^{-1} and (3) The International Physical Activity questionnaire (IPAQ) short-form sitting question (n=4896). We validated the questionnaires against the following accelerometry (Actigraph wGT3X-BT) estimates: vector magnitude counts per minute, steps·day^{-1}, time (minutes·day^{-1}) in sedentary behaviour, light physical activity, moderate and vigorous physical activity (MVPA) non-bouted and ≥10 min bouted MVPA.

Results Ranking of physical activity according to the SGPALS and quartiles (Q) of MET-hours·week^{-1} from the PAFID were both positively associated with accelerometry estimates of physical activity (p<0.001) but correlations with accelerometry estimates were weak (SGPALS (PAL): r=0.11 to 0.26, p<0.001) and weak-to-moderate (PAFID: r=0.39 to 0.44, p<0.01). There was 1 hour of accelerometry measured sedentary time from Q1 to Q4 in the IPAQ sitting question (p<0.001) and also weak correlations (r=0.22, p<0.01).

Conclusion Ranking of physical activity levels measured with PAQs appears to have higher validity than energy expenditure calculations. Self-reported sedentary time poorly reflects accelerometry measured sedentary time. These two PAQs can be used for ranking individuals into different physical activity categories supporting previous studies using these instruments when assessing associations with health outcomes.

Summary box

What are the new findings

- ► Ranking of the two included physical activity questionnaires reduces information content but may be the optimal way of processing self-reported physical activity.
- ► Volume calculations (physical activity level, metabolic equivalents of task hours) allow the biasses associated with self-reported physical activity to be more pronounced.
- ► Self-reported sitting time shows low validity and does not reflect accelerometry measured sedentary time.

INTRODUCTION

Physical activity surveillance at population level may support public health initiatives and allow researchers to track physical activity levels and patterns over time.[1] Physical activity is traditionally measured using self-reported methods such as questionnaires.[2] However, the validity of physical activity questionnaires (PAQ) is threatened by recall and social desirability bias, resulting in imprecise assessments.[3–6] Nevertheless, PAQs have over the years led to valuable knowledge on the effect of physical activity on health outcomes and mortality.[7–14]

Validation of PAQs is crucial to guide researchers when interpreting associations between self-reported physical activity and health outcomes. Moreover, PAQs may inherit different measurement properties. For example, one of the first developed PAQs, by Saltin and Grimby[15] named 'Saltin-Grimby Physical Activity Level Scale' (SGPALS),[16 17] ranks individuals by physical activity levels. A more recent PAQ, the Physical Activity Frequency, Intensity and Duration (PAFID) questionnaire,[18] allows the answers to be summed up as total physical activity volume (ie, energy expenditure, metabolic equivalents of task (MET)-hours per week). Finally, sedentary behaviour has been suggested as a risk factor for disease and mortality, which is also commonly assessed by PAQs,[19 20] such as the International Physical

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Activity Questionnaire (IPAQ) short-form sitting question.[21] Both PAQs (SGPALS,[16 22–26] PAFID[18 27]) and the IPAQ short-form sitting question[21] have previously been validated, however, the studies that compare these questionnaires against accelerometry are characterised by small sample sizes.[18 21 23] As population samples are heterogeneous and consequently result in heterogeneous findings, validation studies based on small samples may have limited representability. Furthermore, considering that already established longitudinal population cohorts have implemented PAQs from inception allowing for long follow-up time (SGPALS: >45 years,[28–30] PAFID: >35 years[31]), validation of PAQs and sitting questionnaires against accelerometry measured physical activity and sitting time from large heterogeneous samples will allow researchers to more accurately interpret results from longitudinal cohort studies where only questionnaires are the physical activity and sedentary time measure.

Moreover, although PAQs can inherit different measurement properties, the methods for processing the PAQs can result in similar expressions (eg, ranking of the SGPALS can be summarised as volume,[25] volume calculations can be grouped as quartiles), and thus the processing of questionnaires may also influence the validity differently.

We aimed to assess the validity of two PAQs inheriting different measurement properties; ranking of physical activity levels (SGPALS), volume calculations (PAFID) and one sedentary time questionnaire (IPAQ sitting short-form), by using accelerometry as our criterion, in a large heterogeneous sample of adults and older adults. Additionally, we aimed to assess how ranking and volume calculations of the PAQs reflects accelerometry measured physical activity and sedentary time.

METHODS

Design

We used participants from the seventh wave of the population-based cohort study named The Tromsø Study, which is conducted in Tromsø, Northern Norway. The study includes seven waves of data collection (Tromsø 1: 1974, Tromsø 2: 1979 to 1980, Tromsø 3: 1986 to 1987, Tromsø 4: 1994 to 1995, Tromsø 5: 2001, Tromsø 6: 2007 to 2008, Tromsø 7: 2015 to 2016) (details described elsewhere[32]).

Participants

All inhabitants in Tromsø municipality aged 40 years and older were invited to Tromsø 7. A total of 21 083 (65% of 32 591 invited participants) participants attended a first visit including questionnaires, biological sampling and clinical examinations. A random selection of 8346 participants attended a second visit at a later time point (>7 days), where 6778 participants were invited to wear an accelerometer, of which 6332 (93%) participants accepted. Of those who provided valid accelerometry data, 4040 participants completed both the leisure time and occupational time SGPALS; 5902 participants completed the PAFID questionnaire, and 5186 and 5088 participants completed the sitting question from the IPAQ short-form for week and weekend, respectively, where 4896 completed both.

All participants gave written informed consent.

Patient and public involvement

The Tromsø study advisory board includes patient (University hospital of Northern Norway) and public (eg, Norwegian Health Association, Tromsø municipality) representatives. Some participants are invited as ambassadors when data collection is ongoing, where they actively contribute to recruitment of participants. We have together with the Norwegian Health Association provided individual feedback on levels of physical activity to participants in Tromsø 7. There was no public involvement when designing this study.

Data collection

Height and weight were measured in light clothing without shoes. Body mass index (BMI) was calculated (kg/m^2) and defined as normal and underweight (<25 kg/m^2), overweight (25 to 29.9 kg/m^2) and obese (≥30 kg/m^2). Educational level was collected from questionnaires and categorised in; (1) primary school, (2) high school diploma, (3) university education <4 years and (4) university education ≥4 years.

The physical activity and sitting questionnaires

The Saltin-Grimby physical activity level scale

The SGPALS asks participants to rank their leisure time and occupational time physical activity level separately, choosing one of four options. Based on the idea of the original questionnaire by Saltin and Grimby[15], the SGPALS used in Tromsø 7 is a slight modification of Saltin and Grimby[15] according to Rödjer *et al*.[17] The SGPALS is presented in online supplementary table 1.

We computed the SGPALS as combined leisure time and occupational time where individuals were categorised as *(1) inactive*, *(2) moderately inactive*, *(3) moderately active* and *(4) active* according to Wareham *et al*[33] with some modifications. In order to calculate physical activity volume, we assigned a physical activity level (PAL) value from the combined leisure time and occupational time SGPALS, which we derived from a previous validation study that calculated PAL as energy expenditure obtained from doubly labelled water divided by the estimated basal metabolic rate.[25] The classifications and the assigned PAL value are presented in table 1.

The physical activity frequency, intensity and duration questionnaire

The PAFID questionnaire (table 2) includes three questions referring to frequency, intensity and duration of physical activity. We generated an index to reflect METs by multiplying intensity (METs) by duration (minutes) by frequency (times per week), and the outcome was expressed as MET-hours per week.[34 35] We also grouped

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Table 1 Physical activity classification by the combined leisure time and occupational time SGPALS (n=4040)

	Light LPA (n=532)	Moderate LPA (n=2429)	Hard LPA (n=969)	Very hard LPA (n=109)
Light OPA (n=2263)	Inactive (n=349, 8.6%) PAL: 1.4	Moderately inactive (n=1346, 33.3%) PAL: 1.5	Active (n=507, 12.6%) PAL: 1.7	Active (n=61, 1.5%) PAL: 1.9
Moderate OPA (n=1018)	Moderately inactive (n=105, 2.6%) PAL: 1.5	Moderately active (n=648, 16.0%) PAL: 1.6	Active (n=234, 5.8%) PAL: 1.8	Active (n=31, 0.8%) PAL: 2.0
Heavy OPA (n=651)	Moderately active (n=61, 1.5%) PAL: 1.6	Active (n=386, 9.6%) PAL: 1.7	Active (n=190, 4.7%) PAL: 1.9	Active (n=14, 0.3%) PAL: 2.2
Very Heavy OPA (n=108)	Active (n=17, 0.4%) PAL: 1.7	Active (n=50, 1.2%) PAL: 1.8	Active (n=38, 0.9%) PAL: 2.1	Active (n=3, 0.1%) PAL: 2.3

Data are shown as n and %. The number of participants and percentage distribution derives from our study sample. The assigned PAL value derives from Johansson and Westerterp,[25] who divided energy expenditure obtained from doubly labelled water by the estimated basal metabolic rate of their participants.
LPA, leisure time physical activity; OPA, occupational time physical activity; PAL, physical activity level; SGPALS, Saltin-Grimby Physical Activity Level Scale.

MET-hours per week in quartiles in order to assess the validity of ranking physical activity in this PAQ.

The International physical activity questionnaire, sitting question

In this study, the IPAQ short-form sitting question[21] was employed, asking participants to estimate their average amount of sitting hours on a typical week and weekend day during the last week. In addition to the reported volume, we also grouped sitting hours in quartiles to assess the validity of ranking sitting hours.

Accelerometry data processing

Accelerometry measured physical activity was measured with the triaxial (three planes; axial, coronal and sagittal) ActiGraph wGT3X-BT accelerometer (ActiGraph, LLC, Pensacola, USA), firmware 1.2.0 to 1.8.0. Trained technicians attached the accelerometer to the participants' right hip and instructed them to wear the accelerometer for 24 hours a day on eight consecutive days (the rest of the day following the visit in the clinic and seven more days) and only to remove the accelerometer during water-based activities (eg, showering or swimming) and contact sports. The accelerometer was returned by mail in a prepaid envelope. The ActiLife software (ActiGraph, LLC, Pensacola, USA) was used for initialisation and downloading the data. The accelerometer was initialised for raw data mode with a sampling frequency of 100 Hertz and recordings started at 00:00 the day following the visit in the clinic.

The raw acceleration files were filtered to 10 s epochs using the normal (default) proprietary filter in the ActiLife software. The acceleration units are expressed in triaxial vector magnitude (VM) (the square root of the sum of squared activity counts) counts per minute (CPM). We also extracted the number of steps in the accelerometer, which derives from the axial plane in a proprietary algorithm by the manufacturer. The .agd-files (epoch files) were further converted to .csv-files and further analysed in the Quality Control & Analysis Tool software (a custom-made software developed in Matlab: The MathWorks, Inc, Natick, Massachusetts, USA).

The 10 s epochs were further aggregated to 60 s and an epoch was classified as wear time if two of the following three criteria were fulfilled: (1) an epoch >5 VM CPM, (2) if at least two epochs >5 VM CPM in the proceeding 20 min or (3) at least two epochs >5 VM CPM in the following 20 min. Otherwise the acceleration was considered to be noise and classified as non-wear time.[36]

The triaxial VM CPM cut-points for different intensities are <150 VM CPM for sedentary behaviour[37] and ≥2690 VM CPM for moderate and vigorous physical activity

Table 2 Physical activity frequency, intensity and duration (PAFID) questionnaire. Number, MET-values and minutes in parentheses in answering alternatives represents the values for the calculation of MET-hours per week

Frequency (days)	Intensity (METs)	Duration (minutes)
How frequently do you exercise? With exercise, we mean walking, cross-country skiing, swimming or other exercise/sports.	*On average, how hard is the exercise?*	*On average, how long do you exercise?*
Never (0)	I take it easy without breaking into a sweat or losing my breath (3 METs)	<15 min (10 min)
Less than once a week (0.5)	I push myself so hard that I break into a sweat and lose my breath (6 METs)	15–29 min (22.5 min)
Once a week (1)	I push myself to near-exhaustion (9 METs)	30–60 min (45 min)
Two to three times per week (2.5)	N/A	>60 min (60 min)
Almost every day (5)	N/A	N/A

METs, metabolic equivalents of tasks.

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(MVPA),[38] where light physical activity is between 150 to 2689 VM CPM.

Extracted accelerometry measures were volume measures (steps per day and mean VM CPM per day) in addition to intensity measures (minutes per day in sedentary behaviour, light physical activity, MVPA and ≥10 min bouted MVPA).

Statistical analyses

We calculated Pearson correlation coefficients to assess the correlation between the PAQs volume outcomes (SGPALS: PAL score, PAFID: MET-hours·week^{-1}, IPAQ sitting: hours spent sitting) and accelerometry outcomes (VM CPM, steps per day, minutes in sedentary behaviour, light physical activity, non-bouted and bouted MVPA) where a coefficient of 0.00 to 0.10, 0.10 to 0.39, 0.40 to 0.69 and ≥0.70 was considered a negligible, weak, moderate and strong correlation, respectively.[39] Univariate analyses of variance (ANOVA) were performed to assess associations of accelerometry measures (VM CPM, steps, minutes in sedentary behaviour, light physical activity, non-bouted and bouted MVPA) with the SGPALS physical activity ranking, quartiles of MET-hours per week from the PAFID questionnaire and quartiles of reported sitting from the IPAQ. For the IPAQ sitting question, a Bland-Altman plot was created (online supplementary figure 1). The Alpha level was set to 0.05 and data are presented as mean±SEM unless otherwise is stated. All data were confirmed to follow normal distribution by visual inspection of residuals when performing the abovementioned analyses. The analyses were performed overall and in strata of sex, age (10 year groups), BMI (<25, 25 to 29, ≥30 kg·m^{-2}) and education (primary, high school, <4 years university, ≥4 years university). The Statistical Package for Social Sciences (V.25, International Business Machines Corporation, Armonk, New York, USA) was used to perform all statistical analyses.

Patient and public involvement

Patients and/or the public were involved in the design, or conduct, or reporting or dissemination plans of this research. Refer to the Methods section for further details.

RESULTS

The descriptive characteristics of the participants wearing the accelerometers and completing the PAQs are presented in table 3.

PAL scores calculated from the SGPALS correlated weakly with VM CPM (r=0.32), steps per day (r=0.27), sedentary behaviour (r=–0.20), light physical activity (r=0.22), non-bouted MVPA (r=0.25) and bouted MVPA (r=0.16) (all p<0.05), which was consistent across sex, age, BMI and educational level (all p<0.05) (online supplementary table 2). All accelerometry measures increased by increasing rank of self-reported physical activity (P_{trend} <0.001) (table 4).

Calculated MET-hours per week from the PAFID questionnaire showed negligible correlation with accelerometry measured light physical activity (r=0.06), weak correlation with VM CPM (r=0.34), moderate correlation with steps per day (r=0.43) and weak and moderate correlation with non-bouted MVPA (r=0.39) and bouted MVPA (r=0.44), respectively (p<0.001). This was consistent across sex, age, BMI and educational level (p<0.05) except for light physical activity, which did not correlate with MET-hours per week in some age groups (40 to 49 years; p=0.19, 50 to 59 years; p=0.13, 60 to 69 years; p=0.79), BMI classifications (<25 kg/m^2; p=0.54 and 25 to 29 kg/m^2; p=0.31) and educational levels (high school; p=0.07 and university ≥4 years; p=0.051) (online supplementary table 3).

Table 3 Participant characteristics

SGPALS	Women (n=1983)	Men (n=2057)	Total (n=4040)
Age (yrs)	58.9±9.5	61.0±9.9	60.0±9.7
Height (cm)	164.5±6.3	177.4±6.7	171.1±9.2
Weight (kg)	71.9±12.8	87.8±13.8	80.0±15.5
BMI (kg/m^2)	26.6±4.7	27.9±4.0	27.2±4.4
PAFID	**Women (n=3174)**	**Men (n=2728)**	**Total (n=5902)**
Age (yrs)	63.3±10.3	63.7±10.2	63.5±10.2
Height (cm)	163.6±6.3	176.9±6.7	169.8±9.3
Weight (kg)	71.7±12.8	87.0±13.8	78.8±15.3
BMI (kg/m^2)	26.8±4.7	27.8±3.9	27.3±4.4
IPAQ combined	**Women (n=2495)**	**Men (n=2401)**	**Total (n=4896)**
Age (yrs)	61.4±10.1	62.6±10.0	62.0±10.1
Height (cm)	164.2±6.2	177.2±6.6	170.6±9.2
Weight (kg)	71.5±12.8	87.1±13.7	79.1±15.4
BMI (kg/m^2)	26.5±4.7	27.7±3.9	27.1±4.3

Data are shown as mean±SD.
BMI, body mass index; IPAQ combined, International Physical Activity Questionnaire combined: mean of week and weekend; PAFID, Physical Activity Frequency, Intensity and Duration; SGPALS, Saltin-Grimby Physical Activity Level Scale.

Quartiles of MET-hours per week from the PAFID questionnaire showed positive association with all accelerometry measures (P_{trend} <0.001) (table 5).

Accelerometry measured sedentary hours per day correlated weakly with reported sitting hours from the IPAQ sitting question (week day; r=0.22, weekend day; r=0.15), combined (mean of week and weekend; r=0.22, all p<0.01), which was consistent across sex, age, BMI and educational level (p<0.01) (online supplementary table 4). There was a positive association between quartiles of reported sitting in the IPAQ and accelerometry measured sedentary time (P_{trend} <0.001) (table 6).

DISCUSSION

We assessed the criterion validity of two PAQs inheriting different physical activity measurement properties (physical activity ranking, volume calculation) and one sedentary

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Table 4 The combined leisure time and occupational time SGPALS, and the associations with the accelerometry estimates

n=4040	Inactive (n=349)	Moderately inactive (n=1451)	Moderately active (n=709)	Active (n=1531)
VM CPM*†	410.2±7.8	527.9±4.1	571.3±6.2	618.4±4.6
Steps per day*†	4900.5±107.8	7177.0±71.1	7487.2±103.7	8291.9±73.6
Light physical activity (min·day^{-1})*†	360.9±4.8	391.6±2.2	432.0±3.4	425.9±2.2
MVPA (min·day^{-1})*†	23.8±1.1	42.3±0.7	43.0±1.1	53.8±0.8
Bouted MVPA (min·day^{-1})*†	4.3±0.4	14.1±0.4	12.5±0.6	17.6±0.5

Data are shown as mean±SEM.
*Significant difference between ranks: p<0.001.
†Significant linear trend by increasing rank: p<0.001.
MVPA, moderate and vigorous physical activity; SGPALS, Saltin-Grimby Physical Activity Level Scale; VM CPM, vector magnitude counts per minute.

time questionnaire, processed as both ranking and volume calculations, against accelerometry as our criterion measure. We found positive associations between ranking of physical activity in both the SGPALS and the PAFID questionnaire, and accelerometry measured physical activity. When processed as calculated volume, we found at best moderate correlations between self-reported and accelerometry measured physical activity. The IPAQ sitting question showed weak correlations and a narrow range in mean accelerometry measured sedentary time between quartile 1 and 4 in the IPAQ (within 1 hour per day).

The validity of the questionnaires

We found positive associations between accelerometry measured physical activity and ranking in the SGPALS. For example, those who categorised themselves in the lowest rank in the combined SGPALS accumulated on average ~4900 steps and 23 min of MVPA per day, respectively, which is about half of the accumulated steps and MVPA per day in the highest rank (~8290 steps and 53 min MVPA). This illustrates the ability of the SGPALS to rank physical activity levels in a large cohort of adults and elderly. The findings of positive associations between SGPALS rankings and accelerometry measured physical activity are consistent with previous validation studies of the SGPALS.[23 26]

In contrast, when estimating PAL volume scores from the SGPALS, the correlations between PAL scores and accelerometry measured physical activity were weak, which accentuates the biasses associated with self-reported physical activity.[2–4 6] These findings may suggest that the biases associated with self-reported physical activity are more pronounced when physical activity is processed as total volume (eg, PAL, MET-hours per week) compared with ranking individuals according to their self-reported physical activity.

We found positive associations between quartiles of MET-hours per week from the PAFID questionnaire and accelerometry estimates. However, correlations between MET-hours per week from the PAFID questionnaire and accelerometry estimates were weak and only moderate for bouted MVPA. Such correlations are consistent with a previous validation study of the PAFID questionnaire.[18] As with the SGPALS, ranking by quartiles may be the preferred way of expressing self-reported physical activity.

Although we found a positive association between quartiles of reported sitting hours from the IPAQ and accelerometry measured sedentary time, the narrow 1 hour range between quartile 1 and 4 in the IPAQ suggests small differences in real sedentary time between quartiles in the IPAQ.

Table 5 Quartiles of MET-hours per week from the PAFID (n=5902)

Quartiles	1 (n=1355)	2 (n=1498)	3 (n=1473)	4 (n=1576)
Range MET-hours·week^{-1}	0.00–2.50	2.81–9.00	11.25–11.25	15.00–45.00
MET-hours·week^{-1}	1.03±0.02	5.13±0.03	11.25±0.00	21.44±0.16
VM CPM*†	448.3±4.4	508.9.5±4.3	557.4±4.3	610.5±4.6
Steps per day*†	5207.8±62.1	6342.9±63.4	7441.3±69.9	8559.4±78.2
Light physical activity (min·day^{-1})*†	386.4±2.6	406.2±2.3	407.9±2.3	404.9±2.0
MVPA (min·day^{-1})*†	25.9±0.7	35.2±0.7	44.6±0.7	55.8±0.8
Bouted MVPA (min·day^{-1})*†	3.9±0.2	9.4±0.3	15.2±0.4	23.7±0.5

Data are shown as mean±SEM.
*Significant difference between quartiles: p<0.001.
†Significant trend by increasing quartile: p<0.001.
Bouted MVPA, moderate and vigorous physical activity in ≥10 min bouts; MET, metabolic equivalent of tasks; MVPA, moderate and vigorous physical activity; PAFID, Physical Activity Frequency, Intensity and Duration; VM CPM, vector magnitude counts per minute.

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Table 6 Quartiles of reported hours sitting from the IPAQ sitting question, for a typical week and weekend day combined, and the association with accelerometry measured sedentary time

Quartiles	1 (n=783)	2 (n=1432)	3 (n=1277)	4 (n=1359)
Range IPAQ (hours·day^{-1})	0.0–4.0	4.0–5.0	6.0–7.0	8.0–24.0
IPAQ (hours·day^{-1})	2.8±0.03	4.7±0.03	6.6±0.5	9.7±1.9
Accelerometry sedentary time (hours·day^{-1})*†	9.3±0.06	9.6±0.04	9.9±0.04	10.3±0.04

Data are shown mean±SEM.
*Significant difference between quartiles: p<0.001.
†Significant trend by increasing quartile: p<0.001.
IPAQ, International Physical Activity Questionnaire.

Strengths

This study included one of the largest sample sizes in validation studies of PAQs, allowing us to assess the validity in a large heterogeneous sample with high participation rate, which may represent the heterogeneous population to a larger extent than smaller sample sizes. Consequently, the generalisability of the findings from this study is likely high, at least for adults >40 years in western high-income countries.

Limitations

Validation of PAQs is challenging. First of all, in contrast to doubly labelled water, which is the gold standard for measuring free-living energy expenditure,[40 41] there is no gold standard to measure all aspects (domain, context, intensity, duration, frequency and volume) of physical activity accurately.[16 42 43]

Second, we used specific cut-points to split intensity in the accelerometry data, which may not reflect the intended intensity by the participants when answering the PAQs. However, in general, accelerometry measured physical activity shows greater validity than self-reported methods when compared with energy expenditure estimated from doubly labelled water,[44–46] thus, a criterion validation from accelerometry can be considered applicable.

Third, the time periods for self-reported physical activity and sedentary time were not aligned with the accelerometry assessment. However, most physical activity instruments are intended to assess habitual physical activity.[47] Moreover, as all included questionnaires (SGPALS: Kappa: 0.69,[16] PAFID: Spearman's rho (ρ): 0.76 to 87),[18] IPAQ: ρ: 0.50 to 0.94[21]) and a 7 day accelerometry recording with four valid days (intraclass correlation: 0.8)[47] are found to provide acceptable reliability, we believe that the included instruments provide reasonable estimates of habitual physical activity and our comparison is justified.

Finally, the waist placement of accelerometers in our study does not assess sitting per se. Other placements, such as thigh-worn accelerometers, may be more suitable for validating self-reported sitting. Nevertheless, our results are consistent with a previous study that employed thigh-worn accelerometers,[48] suggesting that hip-worn accelerometers are able to measure sedentary time more accurately than self-reported methods.

CONCLUSION

Ranking of physical activity seems to be the preferred method to process PAQs, exhibiting higher validity against accelerometry measures than volume calculations of self-reported physical activity. Self-reported sedentary time poorly reflects accelerometry measured sedentary time. The two PAQs can be used for ranking individuals into different physical activity categories supporting previous studies using these instruments when assessing associations with health outcomes.

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Data availability statement Data may be obtained from a third party and are not publicly available. The data that support the findings of this study are available from the Tromsø Study but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. The data can be made available from the Tromsø Study upon application to the Data and Publication Committee for the Tromsø Study.

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