Comparison of psychometric properties between usual-week and past-week self-reported physical activity questionnaires: a systematic review

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Abstract

The aim was to critically appraise the methodological quality of studies and determine the psychometric qualities of Past-week and Usual-week Physical Activity Questionnaires (PAQs). Data sources were obtained from Pubmed and Embase. The eligibility criteria for selecting studies included: 1) at least one psychometric property of PAQs was examined in adults; 2) the PAQs either had a recall period of usual 7-days (Usual-week PAQs) within the past 12 months or during the past 7-days (Past-week PAQs); and 3) PAQs were self-administered. Study quality was evaluated using the COSMIN taxonomy and the overall psychometric qualities evaluated using pre-established psychometric criteria. Overall, 45 studies were reviewed to assess the psychometric properties of 21 PAQs with the methodological quality of most studies showing good to excellent ratings. When the relationship between PAQs and other instruments (i.e., convergent validity) were compared between recall methods, Past-week PAQs appeared to have stronger correlations than Usual-week PAQs. For the overall psychometric quality, the Incidental and Planned Exercise Questionnaire for the Usual-week (IPEQ-WA) and for the Past-week (IPEQ-W) had the greatest number of positive ratings. For all included PAQs, very few psychometric properties were assessed with poor ratings for the majority of the overall qualities of psychometric properties indicating the limitation of current PAQs. More research that covers a greater spectrum of psychometric properties is required to gain a better understanding of the qualities of current PAQs.

Keywords: Physical activity questionnaires, Recall methods, Psychometrics, Validity, Reliability

Background

Increasing the level of physical activity (PA) is paramount for improving physical and psycho-social health across a wide range of populations [1]. In fact, physical inactivity is now considered to be one of the four leading risk factors for developing chronic disease and global mortality [2]. Subsequently, measuring the level of PA is important to ascertain at-risk populations and monitor interventions aimed at reducing chronic disease development. However, PA determination is only viable when implementing valid and reliable measures that: a) determine frequency, intensity and type of PA; b) identify individuals that meet health recommendations; and c) evaluate the effectiveness of various PA modalities on specific outcome measures [3].

Several objective measures of PA have been developed including accelerometers, pedometers and heart rate monitors [4]. Whilst these methods are considered valid and reliable for determining PA level [4], they are often too costly and/or cumbersome to use. Furthermore, the validity of accelerometer-based estimates of PA has also been called into question [5]. Prior to these objective measuring devices, subjective measures such as PA questionnaires (PAQs) were used to determine PA level and still remain the preferred method as they can be self-administered and convenient and cost-effective, particularly in large-scale clinical trials [6]. However, misreporting of PA is common with PAQs, particularly due to
difficulties recalling the intensity and type of PA performed previously [7]. Subsequently, greater attention is needed to determine the quality of psychometric properties of a range of PAQs.

Currently, there are two main recall methods that determine previous PA level. The first method identifies recent PA level over the past 7 days (i.e., Past-week PAQs) [8]. The second method assesses average week PA level within the past 1–12 months (i.e., Usual-week PAQs) [9]. Both types of PAQs have several advantages and disadvantages. For example, Usual-week PAQs can provide habitual PA patterns minimising the inherent weekly variation in PA [10]. However, respondents may experience difficulty in recalling their PA patterns over a longer period of time, particularly at light-moderate intensities [11]. Conversely, Past-week PAQs result in more accurate recall of recent PA patterns and therefore may better represent objective measures [12]. However, Past-week PAQs do not account for week-to-week variability in PA level and thus may misclassify individuals as physically active/inactive. Therefore, Past-week and Usual-week PAQs provide distinct characteristics of PA which researchers need to consider when selecting PAQs for their intervention. Delbaere et al. [13] compared different recall versions (i.e., Past-Week [W] vs. Average Weekly PA over the past three months [WA]) of the Incidental and Planned Exercise Questionnaire (IPEQ) in older people noting that IPEQ-WA had better psychometric properties overall, with better internal consistency and higher test-retest reliability than the IPEQ-W. However, examination of convergent validity against objective measures (e.g., accelerometers, pedometers) was not conducted for each recall method of IPEQ, despite using objective measures considered as the best approach for establishing PAQ validity [14]. Furthermore, whilst [13] measured test-retest reliability, convergent validity, structural validity and internal consistency, they did not compare measurement error between IPEQ-W and IPEQ-WA and content validity was not addressed. In order to identify the delimitations of PAQs due to different recall methods, and to assist practitioners and researchers with the best selection of robust PAQs, all psychometric properties of PAQs should be evaluated.

The Consensus-based Standards for the selection of health Measurement Instrument (COSMIN) group developed a critical appraisal tool to evaluate the methodological quality of studies that examined the psychometric properties of health measurement instruments [15]. This appraisal tool, known as the COSMIN checklist, allows for determination of the quality of study design and statistical analyses on validity, reliability and responsiveness of questionnaires [15]. Silsbury et al. [16] recently examined the methodological quality of studies examining the psychometric properties of ten selected self-reported PAQs using the COSMIN checklist. The authors reported fair-to-good test-retest reliability of PAQs and variable convergent validity against other objective measures. Whilst these findings provide insight on the usability of the 10 selected PAQs, the authors did not provide a clear description of the inclusion/exclusion criteria used for selecting PAQs nor give consideration for PAQs recall methods which introduces bias. Furthermore, appropriate search strategies for literature database using ‘subject headings’ and ‘free texts’ were not reported, limiting the replicability of the searches. Moreover, [16] did not interpret the psychometric quality of PAQs based on an established quality criterion. Terwee et al. [17] developed a quality criterion to interpret results from studies assessing the psychometric properties of questionnaires based on previously existing guidelines and consensus amongst experts. Furthermore, [18] suggested synthesising and combining results from COSMIN rating of study quality and [17] rating of psychometric quality to report the overall quality of psychometric properties of each questionnaire.

Indeed, previous studies have used similar quality criteria to review the psychometric quality of self-reported PAQs [19–21]. However, these review papers appeared to have been derived by the same literature search and were separated according to PAQs for youth [20], adults [19] and the elderly [21]. Combining results of studies that have examined the psychometric qualities of PAQs amongst different population groups may provide a more holistic understanding of the usability of existing PAQs. Furthermore, the computerised search for these systematic reviews [19–21] was conducted in May 2009 and thus warrants an update considering the constant growing body of literature in psychometrics. Importantly, none of the systematic reviews published to date have systematically compared the quality of psychometric properties between PAQs with different recall methods (e.g., usual-week versus past-week PAQs) using previously established quality criteria.

Therefore, the aims of this systematic review were to critically appraise the methodological quality of studies that have examined the psychometric properties of past-week and usual-week PAQs in adult and elderly populations using the COSMIN checklist to determine the overall psychometric quality for each PAQ, and to compare the quality of measurement properties between past-week and usual-week PAQs. Identification of recall differences would substantially assist practitioners and researchers with their selection and implementation of robust and high quality PAQs.

**Methods**

The methodology and reporting of this systematic review was based on the PRISMA guidelines which enables transparent and complete reporting of systematic reviews [22].
Inclusion/exclusion criteria
The following inclusion criteria for studies were adhered to: 1) studies that examined at least one measurement property of PAQs used in adults (i.e., ≥ 18 years of age); 2) studies that were written in English; 3) studies that examined PAQs with a recall period of 7-days PA within the past 12 months (i.e., Usual-week PAQs) or studies that examined PAQ during the past 7-days (i.e., Past-week PAQs); 4) studies that examined self-administered PAQs; and 5) studies where the PAQ identified the following PA characteristics: duration, intensity and/or type of PA performed. Studies were excluded if: 1) questionnaires were based on physical function measures; 2) PAQs were administered as an interview; and 3) results published as a conference abstract, review or case report. Studies were excluded if questionnaires were translated into a language other than English.

Selection process
Two independent reviewers conducted the stepwise selection process. Initially, all titles and abstracts that potentially met the eligibility criteria were screened as either meeting the eligibility criteria (“yes”), potentially meeting the eligibility criteria (“maybe”) or not meeting the eligibility criteria (“no”). Following abstract screening, a random sample (40%) of the abstracts was reviewed to determine the inter-rater reliability between both reviewers. A Weighted Kappa calculation of 0.76 (95% CI: 0.71–0.82) was obtained and considered as acceptable for inter-rater reliability [23]. Following this confirmation, all corresponding original journal articles (both “yes” and “maybe”) were retrieved and further screening was undertaken based on the inclusion/exclusion criteria.

Methodological quality using COSMIN taxonomy
The methodological quality of included studies was assessed using the COSMIN taxonomy of measurement properties with definitions for health-related patient-reported outcomes shown in Table 2. The COSMIN checklist consists of nine domains: internal consistency, reliability (test-retest reliability, inter-rater reliability and intra-rate reliability), measurement error (absolute measures), content validity, structural validity, hypothesis testing, cross-cultural validity, criterion validity and responsiveness [15]. Of these domains, responsiveness, cross-cultural validity and criterion validity were not assessed for the following reasons: responsiveness – determination of the instrument’s sensitivity to changes over time was beyond the scope of the current review; cross-cultural validity – questionnaires assessed in

Table 1 Search terms and databases

| Initial search: Assessment retrieval | Database and Search Terms | Limitations |
|-------------------------------------|---------------------------|-------------|
| **Subject Headings**               | **Embase**: (Questionnaire/OR Health status/OR "severity of illness index") AND (Physical capacity/OR "physical constitution and health")/OR "movement (physiology)"/OR "physical activity, capacity and performance"/OR Exercise/OR Performance/OR Motor performance/) AND (Validation study/OR validity/OR Psychometry/OR Reliability/OR Measurement accuracy/OR measurement error/OR measurement precision/OR measurement repeatability/) | Humans; English; Adult: 18 to 64 years OR Aged: 65+ years |
| **PubMed**: ("Physical Conditioning, Human")[Mesh] OR "Physical Fitness"[Mesh] OR "Physical Therapy Modalities"[Mesh] OR "Physical Endurance"[Mesh] OR "Physical Exertion"[Mesh] OR "Exercise"[Mesh] OR "Motor Activity"[Mesh] OR "Exercise"[Mesh] OR "Exercise Movement Techniques"[Mesh] OR "Exercise Therapy"[Mesh] OR "Psychomotor Performance"[Mesh] OR "Motor Skills"[Mesh] OR "Motor Activity"[Mesh]) AND ("Questionnaires"[Mesh]) AND ("Psychometrics"[Mesh] OR "Reproducibility of Results"[Mesh]) OR "Validation Studies as Topic"[Mesh] OR "Bias (Epidemiology)"[Mesh] OR "Observer Variation"[Mesh]) | Humans; English; Adult: 19+ years |
| **Free Text Words**                | **Embase**: (questionnaire) AND (physic* OR movement* OR capacit* OR exercise* OR train* OR performance* OR motor) AND (psychometric* OR reliability OR validit* OR reproducibility OR bias) | Publication date from 2013 – current; Adult: 18 to 64 years OR Aged: 65+ years |
|                                    | **PubMed**: As per Embase Free Text | Publication date from 2013/05/01 to 2016/07/04; Humans; English; Adult: 19+ years |
languages other than English were excluded during screening; and criterion validity – currently, there is no globally-accepted ‘golden standard’ based on consensus for assessing PA level [24, 25]. Interpretability was not examined as this component is not considered as a psychometric property. Each domain of the COSMIN checklist was assessed using scales consisting of 5 to 18 items that addressed issues on study design and statistical analyses. To determine the overall methodological quality per domain, [15] suggested to report the lowest item rating within the domain using their 4-point rating system (i.e., excellent, good, fair and poor, respectively). However, as this scoring system does not account for subtle differences in the psychometric qualities of each study, a revised version was implemented as previously described [26]. The raw item scores were transformed into a percentage of rating using the following formula:

\[
\text{Total score of each domain} = \frac{\text{(Total score obtained - minimum score possible)}}{\text{(Highest score possible - minimum score possible)}} \times 100
\]

The final rating percentage for each domain was then qualitatively defined using the following categories: Poor = 0–25.0%, Fair = 25.1–50.0%, Good = 50.1–75.0%, Excellent = 75.1–100.0% [26]. Furthermore, all studies were appraised by two raters, independently with differences in ratings resolved via consensus.

**Quality of the psychometric properties**

To compare the strength of reliability (i.e., test-retest reliability) between Usual-week and Past-week PAQs, we calculated the weighted mean of correlation coefficients (i.e., \(r\)-values) using the following formula:

\[
\bar{r} = \frac{\sum_{i=1}^{n} W_i r_i}{\sum_{i=1}^{n} W_i}
\]

Where \(w = r\)-value of each study and \(x = \) sample size of each study

The weighted means of the \(r\)-values were calculated to account for sample size varying between comparisons within studies or between studies. When the sample size of each comparison was identical, the normal non-weighted \(r\)-values were averaged. The mean \(r\)-values were also calculated to compare the strength of
convergent validity between Usual-week and Past-week PAQs and between PAQs compared with direct measures (e.g., accelerometers, pedometers, PA diaries) and PAQs with indirect measures (e.g., maximal oxygen consumption test [VO₂max]). The strength of the r-values was interpreted based on Cohen's classifications in the order of 0.10 as weak, those of 0.30 as moderate, and those of 0.50 as strong in terms of magnitude [27].

We also classified the psychometric quality of each measurement property for each study as either “positive” (+), “conflicting” (±), “indeterminate” (?), “negative” (−) “not reported” (NR) or “not evaluated” (NE) using quality criteria as previously described (Table 3) [17, 28]. For example, if the reported intra-class correlation coefficient (ICC) was 0.9 (≥0.7 classified as acceptable), then the psychometric quality for that particular psychometric property of the study will be classified as “positive”. Conversely, if the reported ICC was 0.6 (not acceptable given that it is less than 0.7), then the psychometric quality of the study will be classified as “negative”. If a number of reliability analyses had ICC values of above (i.e., ≥ 0.7) and below (i.e., < 0.7) acceptable standards within the same study, than the psychometric quality of the study will be classified as “conflicting”. Studies that received a poor COSMIN rating were excluded from further analysis and were classified as “not evaluated” (NE).

To determine the overall quality per psychometric property for each PAQ, the methodological quality based on the COSMIN checklist and the psychometric quality based on [17] of each study were combined to determine the Level of Evidence [18], thus generating an overall psychometric quality rating.

Data items and synthesis of results
Relevant items from the COSMIN checklist and from the quality criteria by [17] and [18] were analysed for each included study. Results were assessed and reported using the following sequence: 1) the description of the systematic literature search; 2) the characteristics of the instruments and description of all studies included in this review; 3) the methodological quality of each study reporting on psychometric properties of included PAQs based on the COSMIN checklist; 4) the psychometric quality based on the criterion by [17] for each psychometric property per study, including a comparison of the magnitude of weighted r-values of test-retest reliability and convergent validity; 5) the overall rating of psychometric properties using the Levels of Evidence by [18] for each PAQ and its comparison between Usual-week and Past-week PAQs.

| Table 3 | Modified criteria of psychometric quality rating based on Terwee, Bot [15] and Cordier, Chen [26] |
|-----------------|-------------------------------------------------|
| **Psychometric property** | **Score** | **Quality Criteria** |
| Content validity | + | A clear description is provided of the measurement aim, the target population, the concepts that are being measured, and the item selection AND target population and (investigators OR experts) were involved in item selection |
| | ? | A clear description of above-mentioned aspects is lacking OR only target population involved OR doubtful design or method |
| | − | No target population involvement |
| | ± | Conflicting results |
| Structural validity | + | Factor analysis performed with adequate sample size. Factors should explain at least 50% of the variance |
| | ? | No factor analysis performed and explained variance not mentioned |
| | − | Factors explain <50% of the variance |
| | ± | Conflicting results |
| Hypothesis testing | + | Specific hypotheses were formulated AND at least 75% of the results are in accordance with these hypotheses; Convergent validity: correlation between similar assessments is at a statistically significant level (p < 0.05) and strength of relationship is ≥0.5 which is consistent with the hypothesis; Discriminant validity: uses appropriate statistical analysis (e.g., t-test p < 0.05 or Cohen’s d effect size ≥0.5) |
| | ? | Doubtful design or method (e.g., no hypotheses) |
| | − | Less than 75% of hypotheses were confirmed, despite adequate design and methods; Convergent validity: correlation between similar assessments is not at a statistically significant level (p ≥0.05) and strength of relationship is <0.5 which is inconsistent with hypothesis |
| | ± | Conflicting results between studies within the instrument |
| Internal consistency | + | Factor analyses performed on adequate sample size (7 * # items and 100) AND...
Table 3 Modified criteria of psychometric quality rating based on Terwee, Bot [15] and Cordier, Chen [26] (Continued)

| Measurement error | Reliability                |
|-------------------|----------------------------|
|                    | + MIC < SDC OR MIC outside the LOA OR convincing arguments that agreement is acceptable |
|                    | ? Doubtful design or method OR (MIC not defined AND no convincing arguments that agreement is acceptable) |
|                    | - MIC SDC OR MIC equals or inside LOA, despite adequate design and method |
| ± Conflicting results | NR No information found on internal consistency |
| ± Conflicting results | NE Not evaluated due to “poor” methodological quality |
| ± Conflicting results | NR No information found on reliability |
| ± Conflicting results | NE Not evaluated due to “poor” methodological quality |

| Cronbach’s alpha(s) calculated per dimension AND Cronbach’s alpha(s) between 0.70 and 0.95 |
| ? No factor analysis OR doubtful design or method |
| - Cronbach’s alpha(s) <0.70 or >0.95, despite adequate design and method |
| ± Conflicting results |
| NR No information found on internal consistency |
| NE Not evaluated due to “poor” methodological quality |
| NR No information found on reliability |
| NE Not evaluated due to “poor” methodological quality |

*Scores: positive rating (+), indeterminate rating (?), negative rating (−), conflicting data (±), not reported (NR), not evaluated (NE)

*Double factor design or method is assigned when a clear description of the design or methods of the study is lacking, sample size smaller than 50 subjects (should be at least 50 in every subgroup analysis), or any important methodological weakness in the design or execution of the study

*Measurement error: MIC minimal important change, SDC smallest detectable change, LOA limits of agreement

### Results

#### Systematic literature search

A total of 3981 abstracts were screened based on the inclusion criteria after removal of duplicate abstracts from the two databases. Following screening, 255 original articles and their corresponding 76 PAQs were assessed for eligibility. Of these, 21 PAQs met the inclusion criteria, while 55 PAQs were excluded. Reasons for exclusion of PAQs included: recall period of only 24 h; single-item PAQs; no specific recall periods; recall periods of over 7 days; recall periods of less than 7 days; and a combination of various recall periods. Accordingly, the psychometric properties of 21 PAQs were evaluated using 44 of the corresponding original articles.

#### Included physical activity questionnaires

The characteristics of the 21 included PAQs and description of studies for the development and validation of PAQs are displayed in Tables 4 and 5, respectively. Seven PAQs assessed 7-days of Usual PA level with a 12-month recall period for three PAQs, a 3-month recall period for three PAQs, and a 1-month recall period for one PAQ. Conversely, 14 PAQs assessed PA level over the Past 7-days. The subscales for the majority of PAQs were separated by intensity of PA level (e.g., light, moderate and vigorous) although a number of other PAQs were categorised according to mode of activity (e.g., walking, stairs, transportation, occupational and yard activities).

#### Psychometric properties of PAQs

Based on the COSMIN rating method for all included 21 PAQs (Table 6), none of the studies showed “poor” ratings and thus the psychometric qualities of all studies were rated. The most frequently reported psychometric properties were hypothesis testing (all 21 PAQs) which ranged from good to excellent quality. This was followed by reliability testing (18 PAQs), which ranged from fair to excellent quality; content validity (7 PAQs), which ranged from fair to excellent quality; and internal consistency (6 PAQs), which ranged from fair to excellent quality. The least reported psychometric properties were structural validity (2 PAQs) with good qualities and measurement error (2 PAQs) ranging from good to excellent quality.

Table 7 provides a comparison of the magnitude of the weighted mean of the r-values for test-retest reliability and convergent validity. The magnitude of the weighted mean of the r-values of PAQs were compared with direct measures (e.g., other PAQs, diaries or objective measures) or indirect measures (e.g., VO2max test). A further comparison was done between the magnitude of the weighted mean of the r-values for test-retest reliability of Usual-week and Past-week PAQs. The magnitude of the r-values for both Usual-week and Past-week PAQs were comparable (\( r = 0.62 \)) with similar sample sizes \( n = 1071 \) and 901, respectively. Only one study (Stanford Usual Activity Questionnaire) compared test-retest reliability between both direct (accelerometer) and indirect (VO2max test) measures with both objective measures showing higher test-retest reliability \( r = 0.67 \) and 0.68, respectively) than the Stanford Usual Activity Questionnaire (Subjective measure; \( r = 0.46 \)). When comparing convergent validity between recall methods, the magnitude of the weighted mean of the r-values appeared
Table 4: Characteristics of instruments assessing level of physical activity

| Instrument                     | Purpose of instrument                                                                 | Reference                  | Publication year | Type of administration/Recall method       | Relevant number of subscales/forms | Total relevant number of items | Response options                                                                 |
|--------------------------------|---------------------------------------------------------------------------------------|----------------------------|------------------|-------------------------------------------|-----------------------------------|--------------------------------|----------------------------------------------------------------------------------|
| EPAQ2 Usual 7-days             | To assess average weekly physical activity over the past year in home, work and recreational settings | Wareham, Jakes [29]        | 2002             | Usual 7-days over last 12 months           | 3                                 | 72                             | Type of activity apart from work:                                                                                     |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Distance: Hours/day; Frequency/day                                                                                        |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Type of activity at work:                                                                                          |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Hours/week; Frequency/day; ≥1 h/day; Distance                                                                            |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Recreation: Frequency/week or month; Hours:Minutes/activities                                                          |
| EPIC PAQ Usual 7-days          | To estimate usual daily energy expenditure over the course of the past year            | Pols, Peeters [31]         | 1997             | Usual 7-days over 12 months                | 4                                 | 13                             | Occupation:                                                                                                          |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Sedentary; standing; manual; heavy manual                                                                             |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Type of activity:                                                                                                     |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Hours/week                                                                                                          |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Vigorousness of activity:                                                                                             |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Yes or No                                                                                                           |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Flights of stairs:                                                                                                    |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Floors/day                                                                                                          |
| IPECWA Usual 7-days            | To assess frequency and duration of several levels of incidental and planned physical activity in older people during the past 3 months | Delbaere, Hauer [11]       | 2010             | Usual 7-days over 3 months                 | 3                                 | 11                             | Type of activity:                                                                                                    |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Frequency/week; 0–4 h/session                                                                                       |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Walking activities:                                                                                                   |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Frequency/week; 0–4 h/day                                                                                           |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Household activities:                                                                                                 |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - 0–4 h/day                                                                                                           |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Daily flights of stairs:                                                                                              |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - ≤2; 3–4; 5–9; 10–14; ≥15                                                                                           |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Physical activity per week:                                                                                           |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - 0–11+ hours                                                                                                        |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Sedentary time per week:                                                                                              |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - 0–90+ hours                                                                                                        |
| NHS II Usual 7-days            | Prospective study of determinants of breast cancer and other major illnesses in young women | Belanger, Speizer [32]     | 1976             | Usual 7-days over 12 months                | 3                                 | 16                             | Moderate activity:                                                                                                    |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Standing; Sitting; Sleeping or reclining                                                                             |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - None; 1–14 min; 15–30 min; 30–60 min; 1–2 h; 2–4 h; >4 h                                                             |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Everyday activities:                                                                                                  |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Recreational activities:                                                                                              |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Yes or No                                                                                                           |
| Seven-day Adventists and non-Adventists (SDANA) Usual 7-days | To assess physical activity levels in Adventists | Singh, Tonstad [33]       | 1996             | Usual 7-days over 3 months                 | 4                                 | 28                             | Type of activity:                                                                                                    |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Hours/week                                                                                                          |
| Stanford Usual Activity Survey Usual 7-days | To assess frequency of everyday and recreational physical activity levels | Sallis, Haskell [34]      | 1985             | Usual 7-days over 3 months                 | 2                                 | 11                             | Everyday activities:                                                                                                  |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | Recreational activities:                                                                                              |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Yes or No                                                                                                           |
| YPAS Usual 7-days              | To assess physical activity among older adults                                         |                            |                  |                                           | 6                                 | 39                             | Type of activity:                                                                                                    |
|                                |                                                                                        |                            |                  |                                           |                                   |                                | - Hours/week                                                                                                          |
| Instrument       | Description                                                                 | Reference       | Start Year | Frequency/Week or Month | Duration in Minutes |
|------------------|------------------------------------------------------------------------------|-----------------|------------|-------------------------|--------------------|
| AAS Past 7-days  | Population surveillance of physical activity in Australian adults           | Commission [36] | 1997       | Past 7-days             | 4                  |
| CAQ-PAI Past 7-days | To measure overall kilocalories expended in leisure-time physical activity | Paffenbarger, Wing [37] | 1978       | Past 7-days             | 3                  |
| Checklist Questionnaire Past 7-days | Assess the frequency and duration of physical activities performed in the previous 7 days | Masse, Fulton [38] | 2012       | Past 7-days             | 10                 |
| GPPAQ Past 7-days | Assesses the duration of physical activities performed in the previous 7 days | Health [39] | 2013       | Past 7-days             | 2                  |

Vigorousness of activity:
- Frequency/week or month
- Leisured walk
- Frequency/week or month; Duration in minutes
- General movement:
  - Hours/day
  - Standing and sitting
  - Hours/day Seasonal changes:
  - Compare current season
- Walking activities:
  - Vigorous yard work
  - Vigorous activities other than yard work
  - Moderate activities:
    - Frequency/week
    - Hours: minutes/week
- Walking:
  - Blocks/day
  - Stairs
  - Flights/day
- Recreational activities:
  - Frequency/week
  - Hours: minutes/session
- Self-report:
  - Household activities:
    - Yard activities:
    - Family activities:
    - Community/volunteer/church:
    - Transportation:
    - Miscellaneous:
    - Other time:
      - Frequency/week
      - Hours: minutes/week
  - Interview
- Exercise, sports and dancing:
  - Employment:
    - Miscellaneous:
    - Other time:
      - Frequency/week
      - Hours: minutes/week
  - Cycling

- Occupational activities
Table 4 Characteristics of instruments assessing level of physical activity (Continued)

| Instrument                      | Frequency       | Duration     | Type of activity                                                                 |
|---------------------------------|-----------------|--------------|----------------------------------------------------------------------------------|
| IPAQ-LF Past 7-days             | Past 7-days     | As for IPAQ-LF (Telephone) | Walking, Housework/Childcare, Gardening/DIY, As for IPAQ-LF (Telephone)          |
| IPAQ-SF Past 7-days             | Past 7-days     | 4            | Vigorous activities, Moderate activities, Light activities, Sitting time          |
| IPAQ-SF w/recall confidence Past 7-days | Past 7-days     | 5            | Vigorous activities, Moderate activities, Light activities, Sedentary activities, Confidence ratings: Very unsure; quite unsure; about 50/50; quite sure; very sure |
| IPEC-WA Usual 7-days            | Past 7-days     | 3            | Type of activity: Frequency/week, 0–4 h/session, Walking activities              |
| OSPAQ Past 7-days               | Past 7-days     | 2            | Time at occupation: Hours/week, Days/week, Occupational activities               |
| OSWEQ Past 7-days               | Past 7-days     | -            | Recreational activities: Frequency/week, 1 h, 1–2 h, 2–4 h or >4 h, Yes or no, Type of activities, Household activities, Hours/week, Type of activities |
| Physical Activity Scale         | Past 7-days     | 3            | Recreational activities: Frequency/week, 1 h, 1–2 h, 2–4 h or >4 h, Yes or no, Type of activities, Household activities, Hours/week, Type of activities |
| for the Elderly (PASE) Past 7-days | Past 7-days     | 27           | -                                                                                |

Assesses physical activity level that can be used to obtain internationally comparable data.
As for IPAQ-LF (Telephone).
Past 7-days.

IPAQ-LF: International Physical Activity Questionnaire - Short Form.
IPAQ-SF: International Physical Activity Questionnaire - Short Form with self-administered recall.
IPAQ-SF w/recall confidence: International Physical Activity Questionnaire - Short Form with self-administered recall confidence.
IPEC-WA: International Physical Activity Questionnaire - Work Activity.
OSPAQ: Occupational Self-Reported Physical Activity Questionnaire.
OSWEQ: Oslo Web-based Exercise Questionnaire.
PASE: Physical Activity Scale for the Elderly.

References:
1. Tudor-Locke, Ainsworth [40].
2. Cust, Armstrong [41].
3. Delbaere, Hauer [11].
4. Chau, Van Der Ploeg [42].
5. Taylor, Lawton [43].
6. Washburn, Smith [44].
Table 4 Characteristics of instruments assessing level of physical activity (Continued)

| PA Recall Instrument | Past 7-days | Characteristics | Instruments | Study Year | Frequency | Duration | Activities |
|----------------------|-------------|----------------|-------------|------------|-----------|----------|------------|
| PA Recall Instrument Past 7-days | Assess multiple domains of physical activity against accelerometer data among overweight and non-overweight adults | Timperio, Salmon [45] | 2003 | Past 7-days | 3 | 3 | Light activities: Moderate activities: Vigorous activities: |
| SPAQ2 Past 7-days | To measure stage of exercise behaviour change and 7 day recall of physical activity | Lowther, Mutrie [46] | 1997 | Past 7-days | 2 | 8 | Recreational activities: Occupational activities: |
| Stanford 7-day Physical Activity Recall (PAR) Past 7-days | To assess sleep and physical activity patterns | Sallis, Haskell [34] | 1985 | Past 7-days | 6 | 15 | Occupational activities: |
| TPAQ Past 7-days | To measure physical activities for recreation and transport | Adams, Goad [47] | 2014 | Past 7-days | 3 | 21 | Transport to work; business; school; shops; friends: |

EPAQ2 EPIC Physical Activity Questionnaire 2, EPIC PAQ EPIC Physical Activity Questionnaire, IPEC-WA Incidental and Planned Exercise Questionnaire for the Usual-week, IPEC-W Incidental and Planned Exercise Questionnaire for the Past-week, NHS II Nurse’s Health Study, SDANA Seven-day Adventists and non-Adventists, YPAS Yale Physical Activity Survey, AAS Active Australia Survey, CAQ-PAI College Alumnus Questionnaire Physical Activity Index, GPPAQ General practice physical activity questionnaire, IPAQ-LF International Physical Activity Questionnaire – Long Form, IPAQ-SF International Physical Activity Questionnaire – Short Form, OSFAQ Occupational Sitting & Physical Activity Questionnaire, OSWEQ Online Self-reported Walking and Exercise Questionnaire, PASE Physical Activity Scale for the Elderly, SPAQ2 Scottish Physical Activity Questionnaire, PAR Stanford 7-day Physical Activity Recall, TPAQ Transport Physical Activity Questionnaire.
| Instrument | Reference | Purpose of study | Study population | Age range (R; mean ± standard deviation) or (R; median [IQR]) |
|------------|-----------|-----------------|-----------------|-------------------------------------------------------------|
| EPAQ2Usual 7-days | Españo-Romero, Golubic [48] | To compare physical activity sub-components of the EPIC PAQ with a combined heart rate and body movement sensor | Male (I) & Female (II); Validity (N = 813 & 876) | Total sample: R = NR (NR); (I) NR (62.8 ± 1.2)y; (II) NR (62.9 ± 1.1)y |
| | Golubic, Martin [49] | Validity of EPAQ2 with accelerometers amongst early old-aged adults | Combined unemployed/employed (I) & Unemployed (II); Validity (N = 1705 * 819) | Total sample: R = NR (NR); (I) NR; (II) NR |
| | Wareham, Jakes [29] | 1) To compare EPAQ2 with measures of energy expenditure assessed by heart rate monitoring; 2) to assess the repeatability of the questionnaire | Male: Repeatability (I) & Validity (II) (N = 187 & 84) Female: Repeatability (I) & Validity (IV) (N = 212 & 89) | Total sample: R = NR (64.6 ± 8.4); (I) NR (65.0 ± 8.2)y; (II) NR (58.8 ± 7.9)y; (III) NR (63.8 ± 8.4)y; (IV) NR (55.4 ± 6.7)y |
| EPIC PAQ Usual 7-days | Cust, Smith [27] | To examine the validity and long-term repeatability of total physical activity measurements estimated from the past-year recall EPIC questionnaire, using accelerometers as an objective reference measure | Validity & Repeatability (N = 182) | Total sample: R = 50–65 (NR)y |
| | Cust, Armstrong [41] | To assess whether self-reported confidence in recall of physical activity was a predictor of the validity and retest reliability of the EPIC PAQ and IPAQ | Validity & Repeatability (N = 177) | Total sample: R = 50–65 (NR)y |
| | Wareham, Jakes [50] | 1) Compared the EPIC PAQ with energy expenditure assessed by heart rate monitoring with individual calibration; and 2) Assessed the repeatability of the EPIC PAQ | Validity (N = 173) | Total sample: R = NR (57.1 ± 7.3)y |
| IPEQ-W Usual 7-days | Delbaere, Hauer [11] | As for IPEQ-WA | As for IPEQ-WA | As for IPEQ-WA |
| IPEQ-WA Usual 7-days | Delbaere, Hauer [11] | Assess the validity and reliability of the IPEQ-W and IPEQ-WA instruments | IPEQ-W: Repeatability (I) & Validity (II) (N = 50 & 115) IPEQ-WA: Repeatability (III) & Validity (IV) (N = 30 & 108) | Total sample: R = NR (77.4 ± 6.1)y; (I) NR; (II) NR; (III) NR; (IV) NR |
| NHS IIUsual 7-days | Wolf, Hunter [51] | Reproducibility and validity of the NHS II PAQ and 2 physical inactivity questions | Non-African-American (I) & African-American (II): Repeatability (I) & Validity (II) (N = 153 & 96) (III) NR; (IV) NR | Total sample: R = 25–42 (39.0 ± 4.6)y; (I) R = NR (39 ± 4.3)y; (II) R = NR (39 ± 4.5)y |
| Seven-day Adventists and non-Adventists (SDANA) Usual 7-days | Singh, Tonstad [33] | Construct validity and reliability of white Seventh-day Adventists and non-Adventists physical activity questionnaire | Adventist males (I), Non-Adventist males (II), Adventist females (III) & Non-Adventist females: Validity (N = 55, 59, 56 & 34); Repeatability (N = 28, 31, 41 & 12) | Total sample: NR; (I) NR (53.6 ± 15.2)y; (II) NR (50.0 ± 11.9)y; (III) NR (54.6 ± 17.0)y; (IV) NR (50.4 ± 11.8)y |
| | Singh, Fraser [52] | Convergent validity and reliability of white Seventh-day Adventists and non-Adventists physical activity questionnaire | Validity (I) (N = 104); Repeatability (II) (IV) (N = 138) | Total sample: NR (49 ± 14.5)y; (I) NR; (II) NR |
Table 5 Description of studies for the development and validation of usual-week and past-week physical activity questionnaires (Continued)

| Stanford Usual Activity Questionnaire Usual 7-days | Jacobs; Ainsworth [53] | As for CAQ-PAI | As for CAQ-PAI | As for CAQ-PAI |
|--------------------------------------------------|------------------------|----------------|----------------|----------------|
| YPAS Usual 7 days                                | Resnicow, McCarty [54] | Convergent validity of physical activity questionnaires with physical fitness | Total sample (I), Male (II), Female (III), Income (IV) & Education (V): Validity (N = 138, 29, 109, 122 & 138) | (I) Total sample: R = 21–68 (40.7 ± 8.9)y; (II) NR; (III) NR, (IV) NR, (V) NR |
| AAS Past 7-days                                   | Brown, Burton [55]     | Assessed the test-retest reliability (repeatability) and validity of the modified version of the Active Australia Survey as used in the Australian Longitudinal Study of Women's Health | Validity (I) (N = 44); Repeatability (II) (N = 159) | Total sample: R = NR (54.9 ± 1.4)y; (I) NR (54.7 ± 1.6)y; NR (54.9 ± 1.4)y |
| CAQ-PAI Past 7-days                              | Ainsworth, Berry [56]  | Construct validity of CAQ-PAI with physical fitness | Inactive (I), Low active (II) & Active (III): Validity (N = 37, 99 & 53) | Total sample: NR (18.3 ± 1.0)y, (I) NR, (II) NR, (III) NR |
|                                                 | Ainsworth, Leon [57]   | Measured test-retest reliability and convergent validity of CAQ-PAI | Male (I) & Female (II): Validity & Repeatability (N = 78) | Total sample: 21–59 (38.0 ± 9.0)y; (I) NR; (II) NR |
|                                                 | Albanes, Conway [58]   | Convergent validity between eight physical activity questionnaires | Validity (N = 21) | Total sample: 28–55 (37.8 ± 1.8)y |
|                                                 | Bassett, Cureton [59]  | Convergent validity of CAQ-PAI with pedometers | Combined gender (I), Male (II) & Female (III): Validity (N = 96, 48 & 48) | (I) Total sample: 25–70 (39.9 ± 11.3)y; (II) NR (40.9 ± 11.2)y; (III) NR (39.0 ± 11.5)y |
|                                                 | Jacobs, Ainsworth [53] | Compared physical activity questionnaires with objective and subjective measures of physical activity | Validity & Repeatability (N = 78) | Total sample: 20–59 (37.3 ± 9.9)y |
|                                                 | Resnicow, McCarty [54] | As for YPAS | As for YPAS | As for YPAS |
|                                                 | Strath, Bassett [60]   | Compared estimates of intensity-specific and total physical activity measured by CAQ-PAI to those measured by the heart rate and motion sensor, over 7 days | Male (I), Female (II): Validity (N = 12 & 13) | Total sample: 20–56 (30.0 ± 10.5)y; (I) NR (30.6 ± 9.9)y; (II) NR (29.5 ± 11.4)y |
|                                                 | Washburn, Goldfield [61]| Construct validity of self-reported activities enough to induce sweating | Combined gender (I), Male (II), Female (III), age 25–39 (IV) & age 40–65 (V): Validity (N = 657, 275, 382, 375 & 282) | (I) Total sample: 25–65 (39.5 ± 10.8)y; (II) NR (38.2 ± 10.6); (III) NR (40.5 ± 10.8)y; (IV) NR (31.7 ± 4.3)y; (V) NR (49.8 ± 7.6)y |
| Checklist Questionnaire Past 7-days              | Mase, Fulton [38]      | Compared the validity of two physical activity questionnaire formats | Validity (N = 260) | Total sample: R = 40–70 (49.2 ± 7.0)y |
|                                                 | Ahmad, Harris [62]     | Assess reliability and validity of GPPAQ in the elderly | Validity (N = 298) | Total sample: R = 60–74 (NR) |
|                                                 | McKeon, Slevin [63]    | Pilot study to validate the Sensewear Armband and the International Physical Activity Questionnaire in developing a methodology to measure and explore the physical activity of men with intellectual disability | Validity (N = 17) | Total sample: R = 19–59 (NR) |
|                                                 | Cust, Armstrong [41]   | As for EPIC PAQ | As for EPIC PAQ | As for EPIC PAQ |
|                                                 | Kaleth, Ang [64]       | As for EPIC PAQ | As for EPIC PAQ | As for EPIC PAQ |
|                                                 | Kaleth, Ang [64]       | Validity & Repeatability (N = 30) | Total sample: R = 28–72 (49.1 ± 9.6)y | |
Table 5 Description of studies for the development and validation of usual-week and past-week physical activity questionnaires (Continued)

| Study Description | References | IPAQ-SF (recall confidence) | OSPAQ | OSWEQ | PASE | Total sample |
|-------------------|------------|-----------------------------|-------|-------|------|--------------|
| To determine the construct validity and test-retest reliability of two self-report physical activity questionnaires IPAQ-SF and CHAMPS in a fibromyalgia population | Tierney, Fraser [65] | Validity (N = 22) | | | | Total sample: NR (60 ± 13) y |
| To examine whether agreement between self-reported and accelerometer measured physical activity varies by BMI category in a low-income black sample | Warner, Wolin [66] | Convergent validity of IPAQ-SF (telephone) with Sense Wear Armband amongst patients with rheumatoid arthritis | | | | Total sample: R = 24–64 (43.4 ± 11.6) y; (I) R = NR (42.9 ± 12.1) y; (II) R = NR (43.9 ± 11.0) y |
| To determine the validity and repeatability of the OSPAQ | Cust, Armstrong [41] | As for EPIC PAQ | | | | As for EPIC PAQ |
| | Chau, Van Der Ploeg [42] | Developed and validated OSPAQ | | | | Total sample: 19–60 (NR) y |
| | Chau, Van Der Ploeg [42] | Validity of the OSPAQ with accelerometers Combined waist/thigh (I), waist (II) & thigh (III) | | | | Total sample (I): 18–50+ (NR)y; (II): NR; (III) NR |
| To determine the validity and test-retest reliability of the OSPAQ in older adults | Chau, Van Der Ploeg [42] | | | | | Total sample (I): 42.9 ± 12.1 y; (II) NR; (III) NR |
| To develop an online PA questionnaire for estimating energy expenditure (EE) and time spent in moderate-to-vigorous physical activity (MVPA); 2) examine the test-retest reliability of the new online PA questionnaire and the IPAQ short form; and 3) compare the online questionnaire, IPAQ short form, and accelerometer measurement for EE and time spent in MVPA | Taylor, Lawton [43] | Validity (I) (N = 49); Repeatability (II) (N = 59) | | | | Total sample: NR (27 ± 11.9) y; (I) NR; (II) NR (27 ± 11.9) y |
| To determine the validity and test-retest reliability of PASE amongst elderly patients in a rural community | Allison, Keller [67] | Reliability and validity of PASE amongst elderly patients in a rural community | | | | Total sample: 67–83 (72 ± 4.24) y |
| To determine the validity of PASE with accelerometers amongst patients with chronic obstructive pulmonary disease | DePew, Garofoli [28] | Validity and Repeatability (N = 67) | | | | Total sample: NR (71.4 ± 7.91) |
| To determine the validity of the EPIC with accelerometers | Ewald, McEvoy [68] | Convergent validity of PASE with pedometers in older adults Male (I) & Female (II): Validity (N = 319 & 350) | | | | Total sample: 55–85 (66.3 ± 7.7) y; (I) NR; (II) NR |
| To determine the validity of three physical activity questionnaires with accelerometers | Garfield, Canavan [69] | Validity (N = 43) | | | | Total sample: NR (68.0 ± 90) y |
| To determine the validity of PASE with accelerometers amongst patients with lung cancer | Granger, Parry [70] | Convergent validity of EPIC with accelerometers | | | | Total sample: NR (68.0 ± 51.5–74.0) y |
| Assess the known-groups and construct validity of CHAMPS, PASE and YPAS | Harada, Chiu [71] | Assessment of validity of CHAMPS, PASE and YPAS (I): Validity (N = 36 & 51) | | | | Total sample: (I) R = 65–89 (75.0 ± 6.0) y; (II) R = 65–86 (73.0 ± 5.0) y |
| | | Validation (N = 471) | | | | Total sample: 65+ (71.7 ± 4.9) y |
Table 5 Description of studies for the development and validation of usual-week and past-week physical activity questionnaires (Continued)

| Study | Description of studies | Validation & Repeatability | Total sample: NR | Validation & Repeatability | Total sample: NR |
|-------|------------------------|-----------------------------|-------------------|-----------------------------|-----------------|
| Martin, Rejeski [72] | Convergent validity of PASE with physiological measures in physical disability | Validity & Repeatability (N = 119) | Total sample: NR (73.4 ± NR)y | | |
| Washburn, Smith [44] | Convergent validity and reliability of PASE with accelerometers | Total sample (I), age ≤70y (II) & age >70y (III): Validity (N = 20, 9, 11) | | | |
| Washburn and Ficker [73] | Convergent validity of PASE with accelerometers | Total sample (I), Male (II), Female (III), age 55–64y (IV), age ≥65y (V): Validity (N = 190, 56, 134, 87 & 102) | | | |
| Washburn, McAuley [74] | Construct validity of PASE with physiological measures | Total sample (I), Male (II), Female (III), age 55–64y (IV), age ≥65y (V): Validity (N = 190, 56, 134, 87 & 102) | | | |
| Zalewski, Smith [75] | Convergent validity of PASE with accelerometers in older adults | Validity (N = 590) | Total sample: NR (83.8 ± NR)y | | |
| PA Recall Instrument Past 7-days | | | | | |
| Timperio, Salmon [45] | Validity and reliability of physical activity recall instrument among overweight and non-overweight men and women | Male total sample (I), Male BMI ≤25 (II), Male BMI >25 (III), Female total sample (IV), Female BMI ≤25 (V), Female BMI >25 (VI): Validity (N = 55, 28, 27, 63, 40 & 23), Validity (N = 57, 28, 29, 59, 36 & 23) | Total sample: 18+ (38.7 ± 14.9)y, 18+ (37.8 ± 12.7)y, NR, NR, NR, NR | | |
| SPAQ2 Past 7-days | | | | | |
| Lowther, Mutrie [46] | To establish the test-retest reliability and convergent validity of the SPAQ2 | Validity (I) (N = 96); Repeatability (II) (N = 34) | Total sample: NR (33.0 ± 11.6)y, NR (33.0 ± 11.5)y | | |
| Stanford 7-day Physical Activity Recall (PAR) Past 7-days | | | | | |
| Ainsworth, Jacobs [76] | Validity and reliability of occupational physical activity from PAR | Validity & Repeatability (N = 75) | Total sample: NR (37.3 ± 9.5)y | | |
| Ainsworth, Richardson [77] | Convergent validity of occupational activity between physical activity questionnaires | Validity (N = 46) | Total sample: 20–60 (39.4 ± 11.8)y | | |
| Dishman and Steinhardt [78] | Reliability and convergent validity of PAR in college students | (I) Study 1: Validity & Reliability (N = 158), (II) Study 2: Validity (N = 91) (III), Study 3: Validity (N = 74), (IV) Study 4: Validity (N = 24) | Total sample: NR (21.9 ± 2.9)y, NR (23.0 ± 3.0)y | | |
| Jacobs, Ainsworth [53] | As for CAQ-PAI | As for CAQ-PAI | | | |
| TPAQ Past 7-days | | | | | |
| Adams, Goad [47] | Reliability and convergent validity of TPAQ with accelerometers | Moderate intensity (I), Moderate-vigorous intensity (II) & Vigorous intensity (III): Validity (N = 53, 52 & 46), Walking for transport (I), Cycling for transport (II), Walking for recreation (III), Cycling for recreation (IV), Moderate intensity (V), Vigorous intensity (VI) & Total physical activity (VII): Repeatability (N = 164, 164, 165, 165, 165, 163 & 161) | Total sample for validity: NR | | |
| | | | | | |

*EPQ2 EPIC Physical Activity Questionnaire 2, EPIC PAQ EPIC Physical Activity Questionnaire, IPEC-WA Incidental and Planned Exercise Questionnaire for the Usual-week, IPEC-W Incidental and Planned Exercise Questionnaire for the Past-week, NHS II Nurse’s Health Study, SDANA Seven-day Adventists and non-Adventists, YPA Yale Physical Activity Survey, AAS Active Australia Survey, CAQ-PAI College Alumnus Questionnaire Physical Activity Index, GPPAQ General practice physical activity questionnaire, IPAQ-LF International Physical Activity Questionnaire – Long Form, IPAQ-SF International Physical Activity Questionnaire – Short Form, OSPAQ Occupational Sitting & Physical Activity Questionnaire, OSWEQ Online Self-reported Walking and Exercise Questionnaire, PASE Physical Activity Scale for the Elderly, SPAQ2 Scottish Physical Activity Questionnaire, PAR Stanford 7-day Physical Activity Recall, TPAQ Transport Physical Activity Questionnaire*
| Instrument                  | Study Name                      | Study Reference | Reliability | Content Validity | Construct Validity | Hypothesis testing |
|-----------------------------|---------------------------------|-----------------|--------------|------------------|-------------------|--------------------|
| EPAQ: Usual 7-days          | Espana-Romero, Golubic [48]     | NR              | NR           | NR               | NR                | Direct: 80.6% (Excellent) |
|                             | Golubic, Martin [49]            | NR              | NR           | NR               | NR                | Direct: 81.3% (Excellent) |
|                             | Wareham, Jakes [29]             | NR              | 86.1% (Excellent) | NR               | NR                | Direct: 77.8% (Excellent) |
| EPIC PAQ: Usual 7-days      | Cust, Smith [27]                | NR              | 77.3% (Excellent) | 81.8% (Excellent) | NR                | Direct: 80.6% (Excellent) |
|                             | Cust, Armstrong [41]            | NR              | 77.3% (Excellent) | NR               | NR                | Direct: 77.8% (Excellent) |
|                             | Wareham, Jakes [50]             | NR              | 76.9% (Excellent) | NR               | NR                | Direct: 83.3% (Excellent) |
|                             |                                |                 |              |                  |                   | Direct: 81.3% (Excellent) |
| IPEQ-WA: Usual 7-days       | Delbaere, Hauer [11]            | 84.4 (Excellent) | 75.0% (Good) | NR               | NR                | Direct: 75.0% (Good) |
| NHS II: Usual 7-days        | Wolf, Hunter [51]               | NR              | 73.9% (Good) | NR               | NR                | Direct: 77.8% (Excellent) |
| SDANA: Usual 7-days         | Singh, Tonstad [33]             | 55.0 (Good)     | 73.1% (Good) | NR               | NR                | Indirect: 75.0% (Good) |
|                             | Singh, Fraser [52]              | NR              | 76.9% (Excellent) | NR               | NR                | Indirect: 83.3% (Excellent) |
| Stanford Usual Activity Questionnaire: Usual 7-days | Jacobs, Ainsworth [53]         | NR              | 72.7% (Good) | NR               | NR                | Direct: 72.2% (Good) |
| YPA: Usual 7-days           | Resnicow, McCarty [54]          | NR              | NR           | NR               | NR                | Indirect: 77.8% (Excellent) |
| AAS: Past 7-days            | Brown, Burton [55]              | NR              | 86.4% (Excellent) | NR               | NR                | Direct: 75.0% (Good) |
|                             |                                |                 |              |                  |                   | Direct: 65.6% (Good) |
| CAQ-PAI: Past 7-days        | Ainsworth, Berry [56]           | NR              | NR           | NR               | NR                | Indirect: 83.3% (Excellent) |
|                             | Ainsworth, Leon [57]            | NR              | 65.9% (Good) | NR               | NR                | Direct: 72.2% (Good) |
|                             | Albanes, Conway [58]            | 32.5 (Fair)     | NR           | NR               | NR                | Direct: 58.3% (Good) |
|                             | Bassett, Cureton [59]           | NR              | NR           | NR               | NR                | Direct: 72.7% (Good) |
|                             | Jacobs, Ainsworth [53]          | NR              | 72.7% (Good) | NR               | NR                | Direct: 72.2% (Good) |
|                             | Resnicow, McCarty [54]          | NR              | NR           | NR               | NR                | Indirect: 77.8% (Excellent) |
|                             | Strath, Bassett [60]            | NR              | NR           | NR               | NR                | Direct: 63.9% (Good) |
|                             |                                |                 |              |                  |                   | Discriminant: 59.4% (Good) |
| Checklist Questionnaire | Past 7-days | IPAQ-LF Past 7-days | IPAQ-SF Past 7-days | IPAQ-SF (recall confidence) Past 7-days | IPAQ-W Past 7-days | OSPAQ Past 7-days | OSWEQ Past 7-days | PASE Past 7-days | PA Recall Instrument | SPAQ2 Past 7-days |
|-------------------------|-------------|---------------------|---------------------|------------------------------------------|-------------------|------------------|------------------|-----------------|---------------------|-------------------|
| Washburn, Goldfield [61]| NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Masse, Fulton [38]      | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Ahmad, Harris [62]      | NR          | NR                  | 85.4% (Excellent)   | NR                                       | NR                | NR               | Discriminant: 62.5% (Good) | Direct: 63.9% (Good) | Direct: 69.4% (Good) | Direct: 806% (Excellent) | Direct: 778% (Excellent) |
| McKeon, Slevin [63]     | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Kaleth, Ang [64]        | NR          | NR                  | 75.0% (Good)        | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Tierney, Fraser [65]    | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Warner, Wolin [66]      | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Cust, Armstrong [41]    | NR          | NR                  | 77.3% (Excellent)   | NR                                       | NR                | NR               | Direct: 778% (Excellent) | Direct: 778% (Excellent) | Direct: 778% (Excellent) | Direct: 778% (Excellent) | Direct: 778% (Excellent) |
| Delbaere, Hauer [11]    | 844 (Excellent) | 75.0% (Good)       | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Chau, Van Der Ploeg [42]| NR          | 50.0% (Fair)        | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Jancey, Tye [79]        | NR          | 79.5% (Excellent)   | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Taylor, Lawton [43]     | NR          | 50.0% (Good)        | NR                  | 45.0% (Fair)                             | NR                | NR               | NR               | NR              | NR                  | NR                |
| Allison, Keller [67]    | 722 (Good)  | 75.0% (Good)        | NR                  | 800% (Excellent)                         | NR                | NR               | NR               | NR              | NR                  | NR                |
| DePew, Garofoli [28]    | NR          | 67.5% (Good)        | 70.5% (Good)        | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Ewald, McEvoy [68]      | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Garfield, Canavan [69]  | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Granger, Parry [70]     | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Harada, Chiu [71]       | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Martin, Rejeski [72]    | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Washburn, Smith [44]    | 694 (Good)  | 72.7% (Good)        | NR                  | 75.0% (Good)                            | NR                | NR               | NR               | NR              | NR                  | NR                |
| Washburn and Ficker [73]| NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Washburn, McAuley [74]  | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Zalewski, Smith [75]    | NR          | NR                  | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Timperio, Salmon [45]   | NR          | 71.5% (Good)        | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
| Loutcher, Mutrie [46]   | NR          | 45.0% (Fair)        | NR                  | NR                                       | NR                | NR               | NR               | NR              | NR                  | NR                |
### Table 6: Overview of the methodological quality assessment of usual-week and past-week physical activity questionnaires using the COSMIN checklist (Continued)

| Stanford 7-day Physical Activity Recall (PAR) | Ainsworth, Jacobs [76] | NR | 79.5% (Excellent) | NR | NR | Direct: 800% (Excellent) |
|---------------------------------------------|------------------------|----|------------------|----|----|-------------------------|
| Ainsworth, Richardson [77]                  | NR                     | NR | NR               | NR | NR | Direct: 806% (Excellent) |
| Dishman and Steinhardt [78]                 | 54.5 (Good)            | 63.6% (Good) | NR | NR | NR | Direct: 72.2% (Good) Indirect: 72.2% (Good) |
| Jacobs, Ainsworth [53]                      | NR                     | 72.7% (Good) | NR | NR | NR | Direct: 72.2% (Good) Indirect: 75.0% (Good) |
| TPAQ Past 7-days                            | Adams, Goad [47]       | NR | 77.1% (Excellent) | NR | 700% (Good) | Direct: 778% (Excellent) |

Notes.  
*All test-retest reliability tests; bDirect comparisons of physical activity measures (e.g., physical activity level between PAQ and other PAQs, diaries or objective measures) for convergent validity; cIndirect comparisons of physical activity measures (e.g., physical activity level between PAQ and physical fitness, given the assumption that individuals with greater level of physical activity would have a greater level of physical fitness) for construct validity.

EPAQ2 EPIC Physical Activity Questionnaire 2, EPIC PAQ EPIC Physical Activity Questionnaire, IPEC-WA Incidental and Planned Exercise Questionnaire for the Usual-week, IPEC-W Incidental and Planned Exercise Questionnaire for the Past-week, NHS II Nurse’s Health Study, SDANA Seven-day Adventists and non-Adventists, YPAS Yale Physical Activity Survey, AAS Active Australia Survey, CAQ-PAI College Alumnus QuestionnairePhysical Activity Index, GPPAQ General practice physical activity questionnaire, IPAQ-LF International Physical Activity Questionnaire – Long Form, IPAQ-SF International Physical Activity Questionnaire – Short Form, OSPAQ Occupational Sitting & Physical Activity Questionnaire, OSWEQ Online Self-reported Walking and Exercise Questionnaire, PASE Physical Activity Scale for the Elderly, SPAQ2 Scottish Physical Activity Questionnaire, PAR Stanford 7-day Physical Activity Recall, TPAQ Transport Physical Activity Questionnaire
Table 7 The weighted mean of the correlation coefficients (r-value) for reliability testing and validity of Past-week and Usual-week PAQs

| Instrument | r-values | Sample (n) |
|------------|----------|------------|
| EPAQ2      | 0.66     | 399        |
| Usual-week |          |            |
| EPIC-PAQ   | 0.65     | 270        |
| Usual-week |          |            |
| IPEQ-WA    | NR       | NR         |
| Usual-week |          |            |
| NHS II     | 0.51     | 231        |
| Usual-week |          |            |
| SDANA      | 0.69     | 112        |
| Usual-week |          |            |
| Stanford   | 0.46     | 59         |
| Usual-week |          |            |
| YPAS       | NR       | NR         |
| Usual-week |          |            |
| AAS        | 0.59     | 159        |
| Past-week  |          |            |
| CAQ-PAI    | 0.69     | 118        |
| Past-week  |          |            |
| Checklist  | NR       | NR         |
| Past-week  |          |            |
| IPAQ-LF    | NR       | NR         |
| Past-week  |          |            |
| IPAQ-SF    | NR       | NR         |
| Past-week  |          |            |
| IPAQ-SF-R  | 0.46     | 83         |
| Past-week  |          |            |
| IPEQ-W     | NR       | NR         |
| Past-week  |          |            |
| OSPAQ      | NR       | NR         |
| Past-week  |          |            |
| OSWEQ      | 0.74     | 49         |
| Past-week  |          |            |
| PASE       | 0.75     | 218        |
| Past-week  |          |            |
| PA Recall  | NR       | NR         |
| Past-week  |          |            |
| SPAQ       | 0.99     | 34         |
| Past-week  |          |            |
| Stanford   | 0.48     | 240        |
| Past-week  |          |            |
| TPAQ       | NR       | NR         |
| Past-week  |          |            |
| Average for Usual-week PAQs | 0.62 | 1071 |
| Average for Past-week PAQs | 0.62 | 901 |

Validity testing
| Instrument | r-value | Sample (n) |
|------------|---------|------------|
| EPAQ2      | 0.18    | 4386       |
| Usual-week |         |            |
| Direct & Indirect | 0.18 | 4386 |

Table 7 The weighted mean of the correlation coefficients (r-value) for reliability testing and validity of Past-week and Usual-week PAQs (Continued)

| Instrument | r-value | Sample (n) |
|------------|---------|------------|
| EPIC-PAC   | 0.03    | 173        |
| Usual-week |         |            |
| Direct & Indirect | 0.22 | 266 |
| Direct | 0.21 | 266 |
| Indirect | NR | NR |
| IPEQ-WA   | 0.82    | 50         |
| Usual-week |         |            |
| Direct & Indirect | 0.69 | 233 |
| Direct | 0.69 | 233 |
| Indirect | NR | NR |
| NHS II    | 0.69    | 233        |
| Usual-week |         |            |
| Direct & Indirect | 0.20 | 327 |
| Direct | 0.28 | 138 |
| Indirect | 0.16 | 296 |
| SDANA     | 0.19    | 69         |
| Usual-week |         |            |
| Direct & Indirect | 0.09 | 138 |
| Direct | 0.43 | 159 |
| Indirect | 0.09 | 138 |
| Stanford  | 0.43    | 159        |
| Usual-week |         |            |
| Direct & Indirect | 0.43 | 159 |
| Direct | 0.43 | 159 |
| Indirect | NR | NR |
| YPAS      | 0.09    | 138        |
| Usual-week |         |            |
| Direct & Indirect | 0.09 | 138 |
| Direct | 0.43 | 159 |
| Indirect | 0.09 | 138 |
| AAS       | 0.43    | 159        |
| Past-week |         |            |
| Direct & Indirect | 0.43 | 159 |
| Direct | 0.43 | 159 |
| Indirect | NR | NR |
| CAQ-PAI   | 0.14    | 1178       |
| Past-week |         |            |
| Direct & Indirect | 0.14 | 1178 |
| Direct | 0.28 | 297 |
| Indirect | 0.12 | 1064 |
| Checklist | 0.31    | 220        |
| Past-week |         |            |
| Direct & Indirect | 0.31 | 220 |
| Direct | 0.31 | 220 |
| Indirect | NR | NR |
greater for Past-week than Usual-week, particularly when PAQs were compared against direct measures with a moderately strong relationship for the Past-week ($r = 0.33$) versus a weak relationship for the Usual-week ($r = 0.20$) PAQs. When examining the weighted mean of the $r$-values between PAQs compared against direct measures and indirect measures, similar results were found for Usual-week PAQs ($r = 0.20$ and $0.13$, respectively) and when Usual-week and Past-week PAQs were combined ($r = 0.25$ and $0.22$, respectively). However, there was a moderate relationship between Past-week PAQs and direct measures ($r = 0.33$) compared to a weak relationship between Past-week PAQs and indirect measures ($r = 0.24$).

Table 8 provides the quality of psychometric properties of Usual-week and Past-week PAQs based on the quality
| Instrument                  | Study                        | Measurement properties of questionnaires | Content validity | Construct Validity | Hypothesis testing |
|-----------------------------|------------------------------|------------------------------------------|------------------|--------------------|-------------------|
|                            |                              | Reliability properties of questionnaires |                  |                    |                   |
|                            |                              | Internal Consistency | Reliability testing | Measurement Error |                    |                   |
| EPAQ2 Usual 7-days         | España-Romero, Golubic [48]  | NR                                       | NR               | NR                 | NR                |
|                            |                              |                                         |                  |                    | - (Direct)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | - (Direct)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | + (Discriminant)   |                   |
|                            |                              |                                         |                  |                    | (Discriminant)     |                   |
|                            | Golubic, Martin [49]         | NR                                       | NR               | NR                 | NR                |
|                            |                              |                                         |                  |                    | - (Direct)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | + (Discriminant)   |                   |
|                            | Waeham, Jakes [29]           | NR                                       | ±                | NR                 | ?                 |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Direct)         | (Indirect)         | (Discriminant)    |
| EPIC PAQ Usual 7-days      | Cust, Smith [27]             | NR                                       | -                | ?                  | NR                |
|                            |                              |                                         |                  |                    | - (Direct)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | + (Direct)         |                   |
|                            | Cust, Armstrong [41]         | NR                                       | ±                | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Direct)         | (Indirect)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | + (Discriminant)   |                   |
|                            | Waeham, Jakes [50]           | NR                                       | -                | NR                 | -                 |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Direct)         | (Indirect)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | + (Discriminant)   |                   |
|                            | Delbaere, Hauer [11]         | ?                                        | ±                | NR                 | NR                |
|                            |                              |                                         |                  |                    | +                  |
|                            |                              |                                         |                  |                    | (Direct)           |                   |
|                            |                              |                                         |                  |                    | + (Discriminant)   |                   |
|                            | Wolf, Hunter [51]            | NR                                       | -                | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | + (Direct)         | (Indirect)         | (Discriminant)    |
|                            | Singh, Tonstad [33]          | ?                                        | ±                | NR                 | +                 |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Indirect)       | (Indirect)         | (Discriminant)    |
|                            | Singh, Fraser [52]           | NR                                       | ±                | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | ± (Direct)         | (Indirect)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | - (Indirect)       |                   |
|                            |                              |                                         |                  |                    | (Indirect)         |                   |
|                            | Jacobs, Ainsworth [53]       | NR                                       | -                | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Direct)         | (Indirect)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | - (Direct)         |                   |
|                            | YPAS Usual 7 days            | Resnicow, McCarty [54]                  | NR               | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Indirect)       | (Indirect)         | (Discriminant)    |
|                            | AAS Past 7-days              | Brown, Burton [55]                      | NR               | -                  | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Direct)         | (Indirect)         | (Discriminant)    |
|                            |                              |                                         |                  |                    | - (Direct)         |                   |
|                            | AINSWORTH, Berry [56]        | NR                                       | NR               | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | ? (Direct)         | (Direct)           | (Discriminant)    |
|                            | Ainsworth, Leon [57]         | NR                                       | -                | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | ± (Direct)         | + (Indirect)       |                   |
|                            |                              |                                         |                  |                    | ± (Indirect)       |                   |
|                            | Albanes, Conway [58]         | ?                                        | NR               | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Direct)         | (Direct)           | (Discriminant)    |
|                            | Bassett, Cureton [59]        | NR                                       | NR               | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Direct)         | (Direct)           | (Discriminant)    |
|                            | Jacobs, Ainsworth [53]       | NR                                       | -                | NR                 | NR                |
|                            |                              |                                         |                  |                    | NR                |
|                            |                              |                                         |                  | - (Direct)         | (Direct)           | (Discriminant)    |
|                            |                              |                                         |                  |                    | - (Direct)         |                   |
|                            |                              |                                         |                  |                    | - (Direct)         |                   |
| Checklist Questionnaire | Resnicow, McCarty [54] | NR | NR | NR | NR | NR | - (Indirect) |
|------------------------|------------------------|----|----|----|----|----|-------------|
|                        | Strath, Bassett [60]   | NR | NR | NR | NR | NR | - (Direct)  |
|                        |                        |    |    |    |    |    | + (Discriminant) |
|                        | Washburn, Goldfield [61]| NR | NR | NR | NR | NR | - (Indirect) |
|                        | Masse, Fulton [38]     | NR | NR | NR | + | NR | - (Direct)  |
| GPPAQ Past 7-days      | Ahmad, Harris [62]     | NR | - | NR | NR | NR | ?           |
| IPAQ-LF Past 7-days    | McKeon, Stevin [63]    | NR | NR | NR | NR | NR | - (Direct)  |
| IPAQ-SF Past 7-days    | Kaleth, Ang [64]       | NR | - | NR | NR | NR | - (Direct)  |
|                        | Tierney, Fraser [65]   | NR | NR | NR | NR | NR | - (Direct)  |
|                        | Warner, Wolin [66]     | NR | NR | NR | NR | NR | - (Direct)  |
|                        | Cust, Armstrong [41]   | NR | - | NR | NR | NR | - (Direct)  |
|IPAQ-SF (recall confidence) | Delbaere, Hauer [11]  | ?  | ± | NR | NR | + | + (Direct) |
|                        | Chau, Van Der Ploeg [42]| NR | + | NR | NR | NR | - (Direct)  |
|                        | Jancey, Tye [79]       | NR | + | NR | NR | NR | + (Direct)  |
|OSPAQ Past 7-days       | Taylor, Lawton [43]    | NR | ± | NR | + | NR | ± (Direct)  |
|                        | Allison, Keller [67]   | +  | - | NR | + | NR | NR           |
|                        | DePew, Garofoli [28]   | NR | - | ? | NR | NR | NR           |
|                        | Ewald, McEvoy [68]     | NR | NR | NR | NR | NR | - (Direct)  |
|                        | Garfield, Canavan [69] | NR | NR | NR | NR | NR | + (Direct)  |
|                        | Granger, Parry [70]    | NR | NR | NR | NR | NR | + (Direct)  |
|                        | Harada, Chiu [71]      | NR | NR | NR | NR | NR | + (Direct)  |
|                        | Martin, Rejeski [72]   | NR | NR | NR | NR | NR | - (Indirect) |
|                        | Washburn and Ficker [73]| NR | NR | NR | NR | NR | - (Direct)  |
|                        | Washburn, McAuley [74] | NR | NR | NR | NR | NR | - (Indirect) |
|                        | Washburn, Smith [44]   | -  | - | NR | + | NR | - (Direct)  |
|                        | Zalewski, Smith [75]   | NR | NR | NR | NR | NR | - (Direct)  |
|                        | Timperio, Salmon [46]  | NR | - | NR | NR | NR | - (Direct)  |
|                        | Lowther, Mutrie [46]   | NR | + | NR | NR | NR | + (Direct)  |
|                       |                       |    |    |    |    |    | + (Discriminant) |
| | **Stanford 7-day Physical Activity Recall (PAR)** | **Ainsworth, Jacobs [76]** | NR | - | NR | NR | NR | - (Direct) |
| | **Ainsworth, Richardson [77]** | NR | NR | NR | NR | NR | NR | - (Direct) |
| | **Dishman and Steinhardt [78]** | + | - | NR | NR | NR | NR | + (Direct) - (Indirect) |
| | **Jacobs, Ainsworth [53]** | NR | - | NR | NR | NR | NR | - (Direct) - (Indirect) |
| | **TPAQ Post 7-days** | **Adams, Goad [47]** | NR | ± | NR | + | NR | ± (Direct) |

EPAAQ EPIC Physical Activity Questionnaire 2, EPIC-PAQ EPIC Physical Activity Questionnaire, IPEC-WA Incidental and Planned Exercise Questionnaire for the Usual-week, IPEC-W Incidental and Planned Exercise Questionnaire for the Past-week, SDANA Seven-day Adventists and non-Adventists, YPAS Yale Physical Activity Survey, AAS Active Australia Survey, CAQ-PAI College Alumnus Questionnaire Physical Activity Index, GPPAQ General practice physical activity questionnaire, IPAQ-LF International Physical Activity Questionnaire – Long Form, IPAQ-SF International Physical Activity Questionnaire – Short Form, OSWAQ Occupational Sitting & Physical Activity Questionnaire, OSWEQ Online Self-reported Walking and Exercise Questionnaire, PASE Physical Activity Scale for the Elderly, SPAQ2 Scottish Physical Activity Questionnaire, PAR Stanford 7-day Physical Activity Recall, TPAQ Transport Physical Activity Questionnaire.
criteria set out by [17]. Table 9 summarises the overall rating of psychometric properties for each PAQ using the levels of evidence by [18]. Overall, the majority of psychometric properties showed “moderate negative” to “strong negative” ratings for both Usual-week and Past-week PAQs. Of these, IPEQ-WA, SDANA, IPAQ-LF, IPEQ-W, OSPAQ, OSWEQ, SPAQ2 and TPAQ were PAQs that did not include psychometric properties with “negative” ratings. Both IPEQ-WA and IPEQ-W demonstrated “indeterminate” and “conflicting” ratings for internal consistency and reliability testing, respectively, with “moderate positive” ratings for structural validity and hypothesis testing. For SPAQ2, “limited positive” to “moderate positive” ratings were reported for reliability testing and hypothesis testing, respectively. When compared between different PAQ recall methods, Past-week PAQs had a greater proportion of “limited positive” to “strong positive” ratings (10 out of 36 ratings = 27.8%) than Usual-week PAQs (4 out of 20 ratings = 20.0%). However, Past-week PAQs had a greater proportion of “moderate negative” to “strong negative” ratings (14 out of 36 ratings = 38.9%) than Usual-week PAQs (7 out of 20 ratings = 35.0%). Only few studies reported on internal consistency, measurement error and structural validity. When compared between psychometric properties irrespective of PAQ recall methods, content validity had the greatest proportion of PAQs with “limited positive” to “strong positive” ratings (5 out of 7 ratings = 71.4%), whereas reliability testing had the greatest proportion of PAQs with “moderate negative” to “strong negative” ratings (10 out of 18 ratings = 55.6%). Overall, only few psychometric properties were reported with a majority of ratings having received ‘negative’ ratings.

Discussion

The current review examined the methodological quality of a large number of studies examining 7-day PAQs and the psychometric quality of included PAQs. We identified 21 PAQs, of which seven were Past-week PAQs and 14 were Usual-week PAQs, which led to the retrieval of 44 corresponding original articles reporting on the psychometric properties of the included PAQs. According to the COSMIN taxonomy, reliability and hypothesis testing were the most commonly reported psychometric properties, while internal consistency, measurement error, content validity and structural validity were seldom examined. The methodological quality of the studies for PAQs was good to excellent although the overall quality of a majority of psychometric properties of PAQs showed “negative” ratings. According to the magnitude of the weighted mean r-values, Past-week PAQs appeared to have better convergent validity compared to Usual-week PAQs, although the overall psychometric qualities of both Past-week PAQs and Usual-week PAQs were weak. Despite weak overall psychometric qualities, IPEQ-WA had the greatest number of “moderate positive” ratings with no “negative” ratings for Usual-week PAQ. For the Past-week PAQs, IPEQ-W had the greatest number of “moderate positive” ratings with no “negative” ratings and SPAQ2 had “limited positive” to “moderate positive” ratings with no “negative” ratings. The overall finding, however, is that a substantial number of psychometric properties were either not reported or showed “moderate negative” to “strong negative” ratings irrespective of PAQ type.

Quality of studies using the COSMIN taxonomy

According to the COSMIN taxonomy, the reliability domain consists of internal consistency, reliability testing and measurement error [15]. Of these psychometric properties, reliability testing was reported in a majority of PAQs, in the form of test-retest reliability, with the exception of three PAQs (YPAS, Checklist Questionnaire and IPAQ-LF). Internal consistency was only detailed in six PAQs (IPEQ-WA, SDANA, CAQ-PAI, IPEQ-W, PASE and PAR). Most of these PAQs showed moderate to excellent methodological quality for reliability testing, which are in line with previously published systematic reviews that have examined the methodological quality of self-reported PAQs in the adults [19] and elderly [21]. However, our current findings are in contrast to those reported by [16], where half of their ratings for the methodological quality of test-retest reliability were ‘fair’. These discrepancies could be due to the current review incorporating a modified COSMIN criteria by [26] which accounts for subtle differences in the psychometric quality of each study. Given that only few studies reported on internal consistency with 4 out of 7 COSMIN ratings scored as “indeterminate”, determining the quality of this psychometric property for Usual-week and Past-week PAQs is at present not possible in the current review.

Undoubtedly, the greatest deficiency for the reliability domain was the lack of examination of measurement error, which was only reported in two PAQs (EPIC PAQ and PASE) based on two studies[29, 30]. Not knowing the measurement error of a PAQ means that we cannot say with confidence that the reported PA level of a person is indeed accurate (i.e., a true reflection of the construct being measured). A framework to improve accuracy of PAQs has been published [10], although further studies are needed to determine the measurement errors of popular PAQs to provide practitioners and researchers with robust measures.

With respect to validity, hypothesis testing was reported in all PAQs with good to excellent study qualities. A majority of hypothesis testing involved studies assessing convergent validity of PAQs by comparing its
Table 9 Overall rating of psychometric properties for each PAQ using the levels of evidence by Schellingerhout et al. (2011)

| Assessment                                | Internal Consistency | Reliability Testing | Measurement Error | Content validity | Structural validity | Hypothesis testing |
|-------------------------------------------|----------------------|---------------------|-------------------|------------------|---------------------|--------------------|
| EPAQ2 Usual 7-days                        | NR                   | Conflicting         | NR                | Indeterminate    | NR                  | Strong (Negative)  |
| EPIC PAQ Usual 7-days                    | NR                   | Strong (Negative)   | Indeterminate     | Moderate (Negative) | NR                  | Conflicting        |
| IPEQ-WA Usual 7-days                     | Indeterminate        | Conflicting         | NR                | NR               | Moderate (Positive) | Moderate (Positive)  |
| NHS II Usual 7-days                      | NR                   | Moderate (Negative) | NR                | NR               | NR                  | Strong (Positive)  |
| SDANA Usual 7-days                       | Indeterminate        | Conflicting         | NR                | Moderate (Positive) | NR                  | Conflicting        |
| Stanford Usual Activity Questionnaire    | NR                   | Moderate (Negative) | NR                | NR               | NR                  | Moderate (Negative) |
| YPAS Usual 7 days                        | NR                   | NR                  | NR                | NR               | NR                  | Strong (Negative)  |
| AAS Past 7-days                          | NR                   | Strong (Negative)   | NR                | NR               | NR                  | Moderate (Negative) |
| CAQ-PAI Past 7-days                      | Indeterminate        | Strong (Negative)   | NR                | NR               | NR                  | Strong (Negative)  |
| Checklist Questionnaire                  | NR                   | NR                  | NR                | Strong (Positive) | NR                  | Moderate (Negative) |
| GPPAQ Past 7-days                        | NR                   | Strong (Negative)   | NR                | NR               | NR                  | Indeterminate      |
| IPAQ-LF Past 7-days                      | NR                   | NR                  | NR                | NR               | NR                  | Indeterminate      |
| IPAQ-SF Past 7-days                      | NR                   | Moderate (Negative) | NR                | NR               | NR                  | Strong (Negative)  |
| IPAQ-SF (recall confidence) Past 7-days  | NR                   | Strong (Negative)   | NR                | NR               | NR                  | Strong (Negative)  |
| IPEQ-W Past 7-days                       | Indeterminate        | Conflicting         | NR                | NR               | Moderate (Positive) | Moderate (Positive)  |
| OSQAQ Past 7-days                        | NR                   | Strong (Positive)   | NR                | NR               | NR                  | Conflicting        |
| OSWEQ Past 7-days                        | NR                   | Conflicting         | NR                | Limited (Positive) | NR                  | Conflicting        |
| PASE Past 7-days                         | Conflicting          | Strong (Negative)   | Indeterminate     | Strong (Positive) | NR                  | Conflicting        |
| PA Recall Instrument                     | NR                   | Moderate (Negative) | NR                | NR               | NR                  | Moderate (Negative) |
| SPAQ2 Past 7-days                        | NR                   | Limited (Positive)  | NR                | NR               | NR                  | Moderate (Positive) |
| Stanford 7-day Physical Activity Recall (PAR) Past 7-days | Moderate (Positive) | Strong (Negative)   | NR                | NR               | NR                  | Strong (Negative)  |
| TPAQ Past 7-days                         | NR                   | Conflicting         | NR                | Moderate (Positive) | NR                  | Conflicting        |

Notes: Level of Evidence: Strong evidence positive/negative result (consistent findings in multiple studies of good methodological quality OR in one study of excellent methodological quality); Moderate evidence positive/negative results (consistent findings in multiple studies of fair methodological quality OR in one study of good methodological quality); Limited evidence positive/negative result (one study of fair methodological quality); Conflicting findings; Indeterminate = only indeterminate ratings on the measurement property (i.e., score = ? in Table 8); NR not reported

EPAQ2 EPIC Physical Activity Questionnaire 2, EPIC PAQ EPIC Physical Activity Questionnaire, IPEC-WA Incidental and Planned Exercise Questionnaire for the Usual-week, IPEC-W Incidental and Planned Exercise Questionnaire for the Past-week, NHS II Nurse's Health Study, SDANA Seven-day Adventists and non-Adventists, YPAS Yale Physical Activity Survey, AAS Active Australia Survey, CAQ-PAI College Alumnus Questionnaire Physical Activity Index, GPPAQ General practice physical activity questionnaire, IPAQ-LF International Physical Activity Questionnaire – Long Form, IPAQ-SF International Physical Activity Questionnaire – Short Form, OSPAQ Occupational Sitting & Physical Activity Questionnaire, OSWEQ Online Self-reported Walking and Exercise Questionnaire, PASE Physical Activity Scale for the Elderly, SPAQ2 Scottish Physical Activity Questionnaire, PAR Stanford 7-day Physical Activity Recall, TPAQ Transport Physical Activity Questionnaire
properties with other comparator instruments (e.g., accelerometers). These results differ to those reported by previous reviews that examined the psychometric properties of PAQs in the adults and elderly [16, 19, 21] by reporting poor to fair study quality. Again, these discrepancies in findings may be attributed to differences in the types of criteria used to assess the psychometric qualities of PAQs. Content validity was seldom reported (only seven PAQs) although the study quality ranged from good to excellent. Structural validity was only assessed for two PAQs with good study qualities.

In the current review, the quality for structural validity was not assessed in a majority of studies given that the underlying constructs of PAQs were not assessed using statistical analyses to determine the uni-dimensionality of subscales (e.g., factor analysis, principle component analysis, Rasch analysis). Only the IPEQ [13] incorporated factor analyses and Rasch analyses to determine the overall structure and measurement properties of IPEQ. Subsequently, caution should be taken as assessment of internal consistency and structural validity are only relevant when instruments form a reflective model (i.e., when items are indicative of the same underlying constructs), rather than a formative model (i.e., when items together form the construct). When exploring the underlying constructs of various PAQs, future research should address whether studies are based on a formative or reflective model.

Quality of psychometric properties
A key aim of the current review was to examine the differences between Usual-week and Past-week PAQs. Previously, different recall versions of the IPEQ were examined in the one study [13] with IPEQ-WA (i.e., Usual-week PAQ) exhibiting greater test-retest reliability compared to the IPEQ-W (i.e., Past-week PAQ). This is not surprising, given that Usual-week PAQs control for week-to-week variation in PA patterns [10]. Interestingly, our findings showed comparable test-retest reliability between Usual-week PAQ and Past-week PAQ according to the magnitude of the weighted mean r-values. These discrepancies in findings between [13] (i.e., differences in test-retest reliability between IPEQ-W and IPEQ-WA) and the current review (i.e., similar test-retest reliability between Usual-week and Past-week PAQs) is possibly due to differences in acceptable cut-offs for test-retest reliability. For example, an ICC of ≥0.6 was considered as acceptable by [13], whereas ICC of ≤0.7 in the current review (based on use of the criteria by [17]) was below the acceptable cut-off and was therefore rated as “negative”.

Whilst comparable test-retest reliability was reported between Usual-week and Past-week PAQs in the current review, Past-week PAQs exhibited stronger convergent validity than Usual-week PAQs when compared against direct measures (e.g., accelerometers). Such findings are expected, since recall of Past-week PAQs typically coincide with data collected from direct measures during the past week. Subsequently, Past-week PAQs may be more accurate in reporting actual PA patterns than Usual-week PAQs. Whilst the magnitude of weighted r-values between PAQs with direct measures and PAQs with indirect measures were similar for Usual-week PAQs (both were in the weak range), there was a moderate relationship between Past-week PAQs and direct measures whilst a weak relationship shown between Past-week PAQs and indirect measures. Accordingly, while it would be expected that individuals who reported higher levels of physical activity would demonstrate greater physical fitness, determining the validity of PAQs with indirect measures may not be as appropriate as direct measures, given that the dimension of measures are different [31] (e.g., two different types of measures that report level of PA would be more similar than measures that report level of PA and physical fitness).

For the overall psychometric qualities, only minor differences were evident between the PAQs. However, for each recall method, the strongest PAQ identified according to psychometric quality was IPEQ-WA for Usual-week PAQs and IPEQ-W for Past-week PAQs given that 4 out of 6 psychometric properties were evaluated of which structural validity and hypothesis testing had “moderate positive” results. However, internal consistency and reliability had “indeterminate” and “conflicting” results, respectively, warranting further research in the psychometric properties of IPEQ-WA and IPEQ-W. Furthermore, SPAQ2 indicated positive ratings for reliability testing and hypothesis testing, demonstrating good validity and reliability of Past-week PAQ. However, only two psychometric properties were assessed for SPAQ2 which appears to be a common limitation for all included PAQs. Subsequently, future studies should assess other psychometric properties to determine the overall quality of PAQs.

While a majority of PAQs consisted of reliability testing and hypothesis testing, irrespective of recall methods, these psychometric properties also had the most number of “moderate negative” to “strong negative” ratings. These findings are in line with findings from other systematic reviews that have reported the psychometric qualities of self-reported PAQs, even though these reviews were smaller in scope [16, 19, 21]. Interestingly, the findings from the current systematic review, and of others [16, 19, 21], conflict with interpretations of the quality of reported validity and reliability values of PAQs as reported and interpreted by the authors themselves in a majority of included studies. This is because many of the authors in the included studies have interpreted test-
retest reliability and convergent validity as being acceptable based on associations reported at a statistically significant level, with minimal regard to the strength of the relationship. According to previously established and accepted criteria \([17, 18, 26]\), acceptable test-retest reliability for correlations \((r \text{ or } \rho)\) and ICC were 0.8 and 0.7, respectively. Furthermore, convergent validity of a questionnaire is acceptable if the correlation with its comparator instrument is at a statistically significant level \((p \leq 0.05)\) and the strength of the correlation is at least moderate \((r \geq 0.5)\) \([17, 18, 26]\). Accordingly, whilst the included studies reported associations at a statistically significant level for both reliability testing and hypothesis testing, the results were classified as “negative” ratings in the current review given that the magnitude of the association was not met in accordance to the psychometric criteria \((i.e., r \geq 0.5)\). Consideration for the strength of the relationship is essential, given that a large sample size will exhibit associations at a statistically significant level, despite weak associations, as reported in a number of studies included in the current review. Indeed, an appropriate sample size must be met for studies exploring psychometric properties of instruments in order to reach clinically relevant conclusions, given that a limited sample size may not be generalisable to a wider population \([32]\). Furthermore, future studies should interpret correlations based on the magnitude of the correlation, rather than the statistical significance \((i.e., p \leq 0.05)\) when determining validity of PAQs \([32]\). Subsequently, interpretation regarding validity and reliability of PAQs should consider both the statistical significance and the corresponding magnitude of the association between measured variables.

Limitation

There are a number of limitations that should be elaborated upon. First, the PAQs with recall timeframes other than 7-days were outside the scope of this systematic review and may have different psychometric properties. Second, the PAQs in the current review were limited to those used by English speaking adults and those that were self-reported. Future studies may compare different recall methods of PAQs using other populations \((e.g., children, individuals from non-English speaking backgrounds, etc.)\) and different PA collection methods \((e.g., PAQs with recall time frames other than 7-day periods, studies that administered PAQs as interviews etc.)\). Fourth, the PAQs selected for the current review is one of energy expenditure. It is important to acknowledge that PA level can be influenced by social, physical and policy environments \([33, 34]\). Subsequently, further research is warranted to analyse the psychometric properties of other PAQs that account for these factors. Finally, while evaluation of responsiveness was beyond the scope of the current review, comparison of this psychometric property between different PAQ types may support the suitability of PAQs to assess PA level.

Conclusion

In conclusion, the current review identified that most PAQs did not report on several psychometric properties. Based upon well-defined analyses, the overall psychometric quality of PAQs showed multiple “negative” ratings, indicating that current 7-day PAQs are rather weak and caution should be taken when interpreting PA level using these PAQs. When comparing different recall methods, Past-week PAQs showed a stronger correlation with direct measures compared to that of Usual-week PAQs, suggesting that Past-week PAQs may be a more accurate measure of PA patterns. However, minimal differences were noted between the Usual-week and Past-week PAQs for the overall psychometric quality. While IPEQ-W and IPEQ-WA demonstrated the strongest psychometric properties with positive ratings, followed by SPAQ, there were still a substantial number of psychometric qualities that were not assessed which limits the usability of these PAQs. To resolve the issues identified in the current review, future studies are encouraged to investigate a greater range of psychometric properties for those 7-day PAQs that are promising \((e.g., IPEQ-WA, IPEQ-W and SPAQ)\). However, further investigation is warranted for all 7-day PAQs with ‘negative’ ratings by incorporating item response theory.

Abbreviations

AAAS: Active Australia survey; CAQ-PAI: College alumnus questionnaire; physical activity index; COSMIN: Consensus-based standards for the selection of health measurement instrument; EPAQ2: EPIC physical activity questionnaire 2; EPIC PAQ: EPIC physical activity questionnaire; GPPAQ: General practice physical activity questionnaire; ICC: Intra-class correlation coefficient; IPAQ-LF: International physical activity questionnaire – long form; IPAQ-SF: International physical activity questionnaire – short form; IPEC-W: Incidental and planned exercise questionnaire for the past-week; IPEC-WA: Incidental and planned exercise questionnaire for the usual-week; IPEQ: Incidental and planned exercise questionnaire; NE: Not evaluated; NHS II: Nurse’s health study; OSPAQ: Occupational sitting & physical activity questionnaire; OSWEQ: Online self-reported walking and exercise questionnaire; PA: Physical activity; PAQ: Physical activity questionnaire; PAR: Stanford 7-day physical activity recall; PASE: Physical activity scale for the elderly; SDANA: Seven-day activity recall; SPAQ2, there were still a substantial number of psychometric properties with positive ratings, followed by SPAQ, there were still a substantial number of psychometric qualities that were not assessed which limits the usability of these PAQs. To resolve the issues identified in the current review, future studies are encouraged to investigate a greater range of psychometric properties for those 7-day PAQs that are promising \((e.g., IPEQ-WA, IPEQ-W and SPAQ)\). However, further investigation is warranted for all 7-day PAQs with ‘negative’ ratings by incorporating item response theory.

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