Nutrición Hospitalaria

Revisión

Impact of methodological approaches in the agreement between subjective and objective methods for assessing screen time and sedentary behavior in pediatric population: a systematic review

Impacto de las decisiones metodológicas en la concordancia entre métodos subjetivos y objetivos para valorar el tiempo de comportamiento sedentario en la población pediátrica: una revisión sistemática

Marcus Vinicius Nascimento-Ferreira[1,2], Augusto César Ferreira de Moraes[1,3], Tara Rendo-Urteaga[1], Paulo Vinicius Toazza Oliveira[1], Luis A. Moreno[1,2] and Heráclito Barbosa Carvalho[1]

[1]Youth/Child Cardiovascular Risk and Environmental (YCARE) Research Group. School of Medicine. University of Sao Paulo. Sao Paulo, Brazil. [2]Growth, Exercise, Nutrition and Development (GENUD) Research Group. IA2, IIS Aragón, CIBERObn. Faculty of Health Sciences. Universidad de Zaragoza. Zaragoza, Spain. [3]Department of Epidemiology. School of Public Health. University of Sao Paulo. SP, Brazil

Abstract

Introduction: sedentary behavior is an important target for health promotion. In this systematic review, we aimed to provide evidence to support decisions about measurement approach choices for subjectively assessing sedentary behavior in pediatric population, adopting objective methods as the reference.

Methods: in this systematic review with meta-analysis, published studies were retrieved from electronic databases: Medline (PubMed), Web of Science, Embase, SPORTDiscus, BioMed Central and SCOPUS. We considered studies evaluating sedentary behavior agreement through questionnaire and/or diary in comparison with an objective measure. A total of six inclusion criteria were used. We synthesized the data using correlation coefficients (r) as an indicator of agreement estimates. The review protocol is registered in the PROSPERO database (CRD42014015138).

Results: a total of 14 studies met the inclusion criteria with ages ranging from 3 to 17.5 years and provided 17 agreement analyses. Thirteen of these agreement analyses (76.5%) reported correlation coefficients. We found two major groups of sedentary activities: screen time (47.1%) and sedentary behaviors (52.9%). The pooled agreement between questionnaires and accelerometers for assessing self-reported screen time was negative (r = -0.15; CI 95%: -0.17 to -0.13). Conversely, when the sedentary behavior was assessed by questionnaires and accelerometers, the pooled agreement was positive for parent-reporting (r = 0.09; CI 95%: 0.04 to 0.13) and self-reporting (r = 0.43; CI 95%: 0.40 to 0.47) in children and adolescents, respectively.

Conclusion: questionnaires have positive agreement with accelerometers for assessing sedentary behavior, whereas the agreement is negative for assessing screen time. Self-reported questionnaires are recommended methods to measure sedentary behavior in adolescents.

Key words:

Children. Adolescents. Sedentary behavior. Questionnaire. Measurement.

Resumen

Introducción: el comportamiento sedentario es un objetivo importante para la promoción de la salud. En esta revisión sistemática, nuestro objetivo fue proporcionar evidencia para apoyar las decisiones sobre las opciones metodológicas acerca de los instrumentos para medición subjetiva del comportamiento sedentario en la población pediátrica, adoptando métodos objetivos como referencia.

Métodos: en esta revisión sistemática con metaanálisis, fueron recuperados estudios publicados en las bases de datos electrónicas Medline (PubMed), Web of Science, Embase, SPORTDiscus, BioMed Central y SCOPUS. Consideramos estudios que evalúan el acuerdo de comportamiento sedentario a través del cuestionario y/o diario en comparación con una medida objetiva. Se utilizaron un total de seis criterios de inclusión. Sintetizamos los datos utilizando coeficientes de correlación (r) como un indicador de las estimaciones de la concordancia. El protocolo de revisión está registrado en la base de datos PROSPERO (CRD42014015138).

Resultados: un total de 14 estudios cumplieron los criterios de inclusión con edades comprendidas entre 3 y 17,5 años y proporcionaron 17 análisis de concordancia. Trece de estos análisis de concordancia (76,5%) informaron coeficientes de correlación. Encontramos dos grupos principales de actividades sedentarias: tiempo de pantalla (47,1%) y comportamiento sedentario (52,9%). La concordancia entre cuestionarios y acelerómetros para evaluar el tiempo de pantalla autorreportado fue negativa (r = -0,15; IC 95%: -0,17 a -0,13). Sin embargo, cuando se evaluó el comportamiento sedentario mediante cuestionarios y acelerómetros, el acuerdo fue positivo para el reporte de los padres (r = 0,09; IC 95%: 0,04 a 0,13) y el reporte (r = 0,43; IC 95%: 0,40 a 0.47) de niños y adolescentes, respectivamente.

Conclusión: los cuestionarios tienen un acuerdo positivo con los acelerómetros para evaluar el comportamiento sedentario, mientras que el acuerdo es negativo para evaluar el tiempo de pantalla. Los cuestionarios autorreportados son métodos recomendados para medir el comportamiento sedentario en adolescentes.

Palabras clave:

Niños. Adolescentes. Comportamiento sedentario. Cuestionario. Medición.

Received: 12/05/2018 • Accepted: 16/09/2018

Nascimento-Ferreira MV, de Moraes ACF, Rendo-Urteaga T, Oliveira PVT, Moreno LA, Carvalho HB. Impact of methodological approaches in the agreement between subjective and objective methods for assessing screen time and sedentary behavior in pediatric population: a systematic review. Nutr Hosp 2019;36(2):449-462

DOI: http://dx.doi.org/10.20960/nh.2038

Correspondence:

Marcus Vinicius Nascimento-Ferreira. Youth/Child Cardiovascular Risk and Environmental (YCARE) Research Group. Faculty of Medicine. University of Sao Paulo. Av. Doutor Arnaldo, 455. 01246-904 Cerqueira César, São Paulo
e-mail: marcusnascimientoe@gmail.com

INTRODUCTION

Sedentary behavior is defined as activities performed in a seated or lying posture with very low energy expenditure (1). In youth, these activities are associated with health outcomes, such as obesity (2,3), cardiovascular disease and metabolic syndrome (4-7). Currently, it is estimated that children spend 1.5-3.0 hours per day in front of a screen (e.g., television, video games) (8). Children considered to be "high users" at young ages are likely to maintain this status when they are older (8). In this sense, the control of sedentary time (e.g., screen time, sedentary behavior) has been shown to be a promising approach to maintaining health (9,10).

Quality instruments for assessing sedentary time with well-known accuracy in youth are vital for understanding dose-response relationships between sedentary activities and health outcomes as well as health monitoring, estimating prevalence and trends, and determining the correlates and predictors of these activities and the impact of health interventions (11,12). Sedentary time can be estimated using objective methods (13,14). However, they are often not available for epidemiological studies (11,15,16), primarily because of the logistic and economic costs.

In this scope, questionnaires and diaries (subjective methods) have emerged as feasible alternatives (12,15). These methods rely on information obtained from parents for collecting data on their children, or directly from adolescents (2,11,15). These methods are low cost, easy to administer, and they are usually applied in large-scale studies (11). Questionnaires and diaries also have the advantage of capturing the type (e.g., TV viewing) and context (e.g., at home) of activities, which may identify potential key targets for designing effective interventions (11-13,15).

Because the application of questionnaires and diaries to evaluate sedentary time in children and adolescents has increased, several systematic and descriptive reviews have compared the agreement between subjective and objective methods (11-13,17), which were interpreted as constructs, criteria and/or convergent validity (13). The current literature indicates there is limited agreement between questionnaires and diaries for assessing sedentary time (11,15,17). Although the methodological challenges of measuring sedentary time have been thoroughly discussed (12,15,17), the literature provides little empirical evidence of how to design subjective methods and formats (e.g., questionnaire or diary) as well as what reference method and strategies for data recording can improve the agreement (13). In this systematic review, we aimed to provide evidence to support decisions about measurement approach choices for subjectively assessing sedentary time in children and adolescents, adopting objective methods as the reference.

METHODS

SEARCH STRATEGY

Searches were performed using the electronic databases Medline (PubMed), Web of Science, Embase, SPORTDiscus, BioMed Central and SCOPUS. These databases were searched for records from their inception up until the most recently published articles in January 2016. The present review is registered in the PROSPERO database (CRD42014015138).

Descriptors and the MeSH terms "sedentary behavior", "questionnaire", "diary" and "validity" were used as search terms in the databases. The search strategy was applied twice, once for children (adding descriptors for "children") and once for adolescents (adding descriptors for "adolescents"), as seen in supplementary table I. Additionally, the references listed from the articles found in these databases were reviewed, and the corresponding authors of unavailable articles were directly contacted. We also checked the reference lists of other relevant studies, key articles and previous reviews (11,12,15,18).

ELIGIBILITY AND EXCLUSION CRITERIA

The inclusion criteria were as follows: a) studies defining sedentary activity as any waking behavior characterized by activities with an intensity less than 1.5 metabolic equivalent (MET, a resting energy expenditure set at 3.5 ml of oxygen/kg of body mass/min) (1) or a combination of low-intensity activities (≤ 1.5 MET) conducted in a seated or reclining posture (19); b) studies with participant populations composed of children (2-10 years) and/or adolescents (11-19 years), as defined by the World Health Organization (WHO) (20); c) studies containing original research; d) studies performed with at least one subjective measurement and one objective measurement for sedentary activity; e) studies reporting at least one agreement measure for subjective and objective methods; and f) publications written in English, Spanish or Portuguese.

The exclusion criteria were as follows: a) studies considering sedentary activity to be physical inactivity; b) participants aged out of 2 to 19 years; c) study participants with different diseases or disturbances that could interfere with sedentary behavior; d) studies including only children and/or adolescents with disabilities or developmental delays that may impact their ability to accurately recall subjective information; and e) studies that reviewed articles or books. These criteria were set to increase inter-study comparability.

SCREENING PROTOCOL

In the screening phase, potentially relevant papers were selected first by screening the titles and then by screening the abstracts, and if the abstract did not provide sufficient data, then we retrieved and screened the entire article. Two authors (Nascimento-Ferreira, M. and Toazza, P.) independently performed the literature screening using a pre-defined study extraction form. The results were compared and if a disagreement occurred, then the article was evaluated by a third researcher (De Moraes, AC.) (Fig. 1).

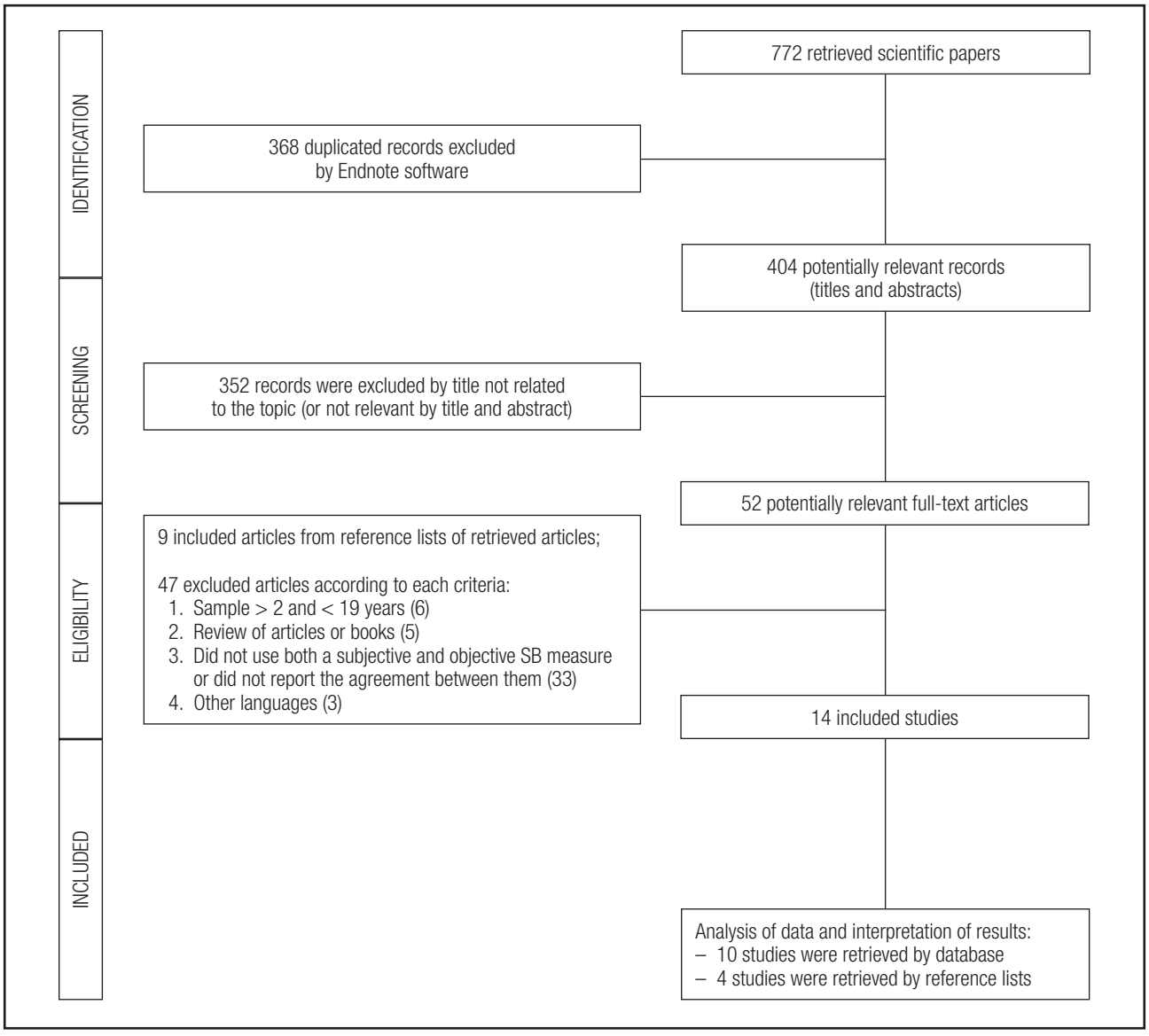


Figure 1.
Search strategy and results.

DATA EXTRACTION

The extracted publication data form included study characteristics (such as the authors, tool assessed, location, publication year, population, respondent), the sample size, the duration of sedentary activity recording, the test-retest interval, the subjective and objective methods, the measurement units, the test-rest reliability assessed (if conducted) and the estimated effect for agreement between subjective and objective method.

We considered the estimated effect for agreement of the key variable (indicated in each study aim) of the subjective method, or we selected the variable associated with the largest set of sedentary activities. We considered more than one validity estimate effect *per* study if global estimate effects were not provided. In studies with stratified validity estimate effects, a pre-specified priority order of study population (children, adolescents), type of measurement (e.g., screen time, sedentary behavior), subjective method (questionnaire, diary), objective method (e.g., accelerometer, direct observation) and type of report (e.g., parent-report, self-report) was used to assess inclusion.

DATA SYNTHESIS

The Pearson correlation coefficient and the Spearman (rank) correlation coefficient were selected as the operationalization for the agreement estimate effects in the meta-analysis. At least three agreement measures from two different studies were required

in each meta-analysis. Agreement measures that used other statistical estimate effects (e.g., Bland-Altman, t-test, limits of agreement) were retrieved, and the estimate effects were identified. However, these estimate effects were not included in the meta-analysis (21).

OUTCOMES AND INDEPENDENT VARIABLES

Agreement is the degree to which scores or ratings are identical (22). We adopted the correlation coefficients of the agreement between the subjective and objective methods (reference method) that were assessed at the same time as the outcome. The independent variables were the measurement approaches: type of measurement, subjective method, objective method and type of report.

ASSESSMENT OF METHODOLOGICAL QUALITY

We used the checklist proposed by Kmet, Lee and Cook (23) to examine methodological quality. Studies were scored according to eleven items (items 5, 6 and 7 were not applicable) from 14 items, depending on the degree to which the specific criteria (item) were met ("yes" = 2 points, "partial" = 1 point, "no" = 0). Then, the sum of all scores was divided by the highest possible score (28 points), which yielded quality scores ranging from 1 (best) to 0 (worst). Items not applicable to a particular study design were excluded from the calculation of the summary score. Two authors (Nascimento-Ferreira, M. and Toazza, P.) independently performed the methodological quality assessment and disagreements were discussed with a third author (Rendo-Urteaga, T.).

STATISTICAL ANALYSIS

The Stata 14 (Stata Corp., College Station, TX, US) program was used for statistical analysis. The sensitivity analyses between total agreement estimates and estimates that reported correlation coefficients were performed by Chi-square goodness of fit test. The significance level was set at $p \leq 0.05$. The pooled correlation coefficient was performed by meta-analysis with a random-effects model for moderate-to-high heterogeneity and a fixed-effects model for low heterogeneity (24). Additionally, forest plots were constructed. We calculated the coefficient with corresponding 95% confidence interval (CI) across individual studies, which were organized according to sedentary activity group. The heterogeneity of studies was evaluated using an I^2 test (values of $p < 0.05$ were considered significant). To verify potential publication bias (i.e., systematically positive or negative results) and small-study effects, the Egger test was performed (25). In this regression, a bias value of $p < 0.05$ indicates the presence of asymmetry, and the sign of the coefficient indicates the direction (26). Funnel plots were generated to examine the potential bias graphically.

A value of 0% indicates no observed heterogeneity, whereas values of 25%, 50% and 75% were considered as low, moderate and high, respectively (27). To estimate the strength of the agreement, the correlation coefficient (Pearson correlation and/or Spearman rank) cut-off points were defined using the following classification: 0-0.19, very weak; 0.2-0.39, weak; 0.40-0.59, moderate; 0.6-0.79, strong; 0.8- 0.9, very strong; and 1.0, perfect correlation (28).

RESULTS

The literature search yielded 772 titles of potentially relevant articles (98.8% from electronic databases and 1.2% from references or other reviews). Of those titles, 14 studies (29-42) were eligible according to the established inclusion/exclusion criteria (Fig. 1). All of the included studies were published after 1984. The number of papers about the agreement between questionnaires and diaries with objective methods increased after the year 2010. A small portion of the retrieved studies were performed only in one sex (14.3%). A total of 5,703 youth (mean per *s*tudy = 312; range = 34-2,048) with ages ranging from 3 to 17.5 years were evaluated. The methodological quality scores of the studies were acceptable (≥ 0.64 in all studies) (Supplementary Table II) (23).

Two major groups of sedentary activities were found: screen time and sedentary behaviors (i.e., several sedentary activities including screen time). Sedentary behaviors varied from only one sedentary activity (29) to 13 sedentary activities (33) that were measured. Additionally, three objective methods were used, including direct observation, accelerometers and pedometers, along with two subjective methods: questionnaires and diaries (Table I).

The most common study characteristics were that the studies were performed after 2010 in North America and focused on adolescents. In addition, the most common methodological approaches included sedentary behavior (comprising screen time) as the main measurement, which was assessed through self-reported questionnaire and compared with accelerometer (Table I).

Regarding the sensitivity analysis, significant differences were found among independent variable proportions between studies that reported or did not report correlation coefficients (Table I). Seventeen agreement measures were found from 14 studies. Of these measurements, 13 agreements were measured by coefficients of correlation (Pearson or Spearman coefficient) from ten studies (76.5%). In addition, two agreement measures from only one study were based on adjusted results for sex, school and maternal education and four agreement measures from four studies were presented by other statistical estimated effects (Bland-Altman plots; and t-test and Kruskal-Wallis mean differences), and they were not included in the meta-analysis (Supplementary Table II).

Two meta-analyses based on data synthesis inclusion criteria with methodological quality scores of ≤ 0.71 and ≤ 0.68 for screen time and other for sedentary behavior, respectively, were performed. A negative pooled correlation coefficient of

Table I. Descriptive characteristics of the agreement estimates

Independent variables	Agreement estimates* (Data from 14 studies)		Correlation coefficient agreement estimates (Data from 10 studies)		p-value†
	k = 17	%	k = 13	%	
Year of publication					
1985-2010	7	41.2	6	47.1	0.422
2011-2015	10	58.8	7	52.9	
Geographic location					
North America	6	35.3	4	30.8	0.282
Oceania	4	23.5	3	23.1	
Europe	4	23.5	4	30.8	
South America	1	5.9	0	0.0	
Asia	2	11.8	2	15.4	
Study population					
Children	6	35.3	5	38.5	0.219
Adolescents	10	58,8	7	52.9	
Children and adolescents	1	5.9	1	7.7	
Type of measurement					
Screen time	8	47.1	5	38.5	0.586
Sedentary behavior‡	9	52.9	8	64.7	
Subjective method					
Diary	4	23.5	3	23.1	0.662
Questionnaire	13	76.5	10	77.0	
Objective method					
Direct observation	2	11.8	2	15.4	
Accelerometer	14	82.3	10	77.0	
Pedometer	1	5.9	1	7.7	
Type of report					
Parent	6	35.3	6	47.1	0.081
Self	11	64.7	7	52.9	

*k: number of agreement analyses. Significant values (p < 0.05) are in bold. *Total agreement estimates, including other statistical test as t-test, ANOVA, linear regression and Bland-Altman method. †Chi-square goodness of fit (p-value) for comparison between total studies (k = 17) and studies that reported correlation coefficients (k = 13). ‡Including screen time.*

-0.15 (n = 1,690; CI 95%: -0.17 to -0.13) was identified for the agreement between questionnaires and accelerometers for assessing self-reported screen time. Conversely, positive correlation coefficients of agreement were found between questionnaires and accelerometers for assessing parent-reported (n = 201; r = 0.09, CI 95%: 0.04 to 0.13) and self-reported (n = 551; r = 0.43, CI 95%: 0.40 to 0.47) sedentary behavior (Fig. 2). The meta-analysis showed significant heterogeneity ($I^2 \leq 84.3\%$) across studies for the assessment of sedentary behavior.

No asymmetric distribution was found because the *intercept* (bias) was near zero ($p \leq 0.05$), and we did not find any significant small-study effects ($p \leq 0.05$) (25). These potential biases were also tested graphically in the funnel plots that are shown in the supplementary file (Supplementary Fig. 1) and similar findings were observed.

DISCUSSION

In our opinion, the selection of the design for agreement studies will be primarily driven by the study's aim and the resources available. However, the findings from this systematic review should be considered as the beginning of what we expect will be a body of evidence regarding the impact of decisions about election of type of measurement, subjective method, objective method and type of report in the agreement between subjective and objective methods for assessing sedentary time in children and adolescents. The novel finding based on our evidence is that questionnaires have positive agreement with accelerometers for assessing sedentary behavior, whereas the agreement is negative for the assessment of screen time. In this sense, self-reported questionnaires may be considered to be useful methods when the main goal is to assess sedentary behavior, especially in adolescents.

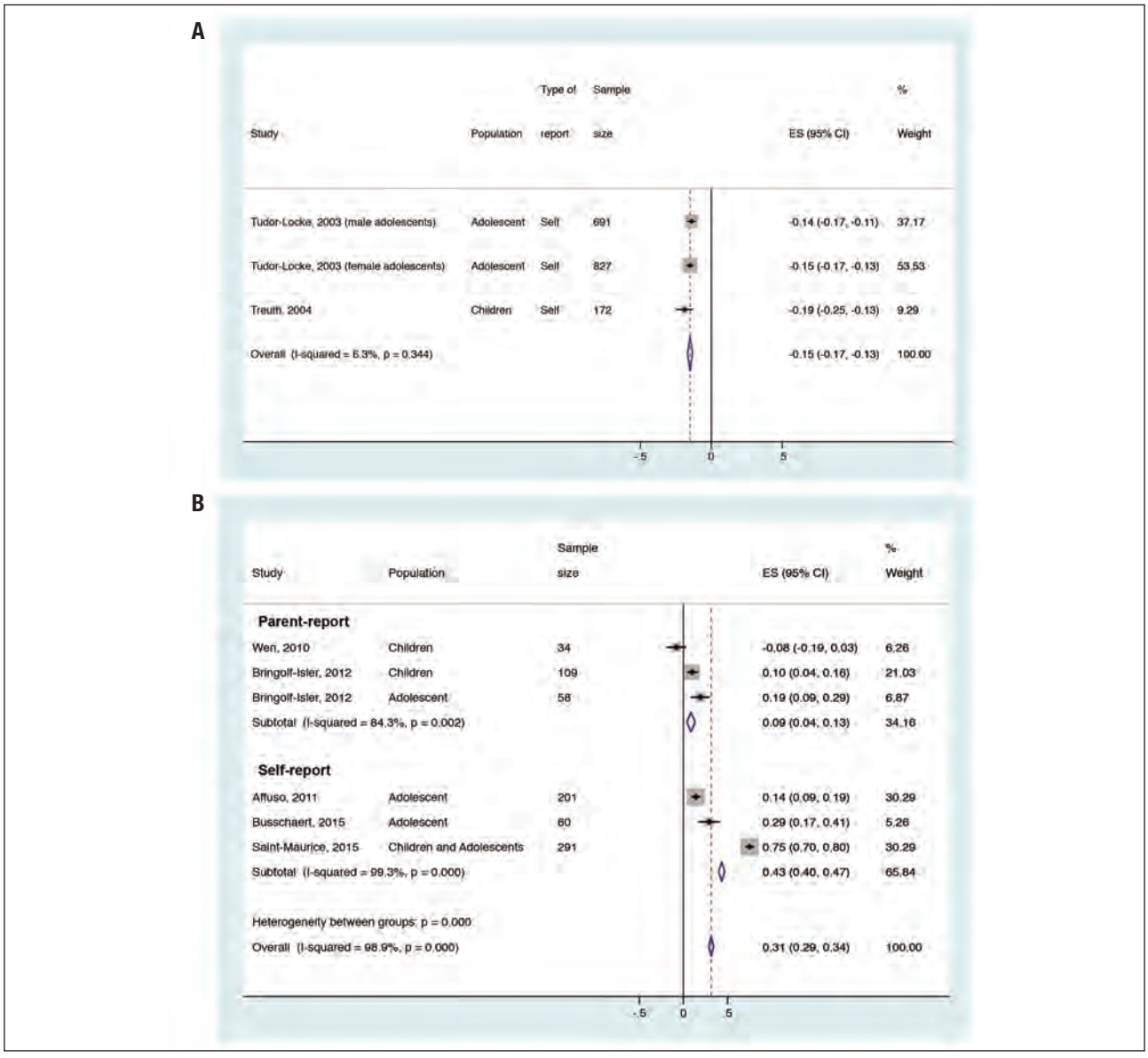


Figure 2.

Meta-analysis summary for screen time (self-reported, A) and sedentary behavior (parent- and self-reported, B) assessed by questionnaires and accelerometers (ES: effect size of correlation coefficient; CI: confidence interval; I-squared (I^2): statistical index of heterogeneity).

SUMMARY OF FINDINGS

We identified agreement measurements from five continents, and all those studies were written in English and published after 1984. There has been a substantial increase in these types of publications over the last ten years. Historically, sedentary time was conceptualized as a part of the physical activity spectrum (5,43). In this sense, the recent increase in the number of sedentary time method agreement studies could be explained by the consideration of sedentary time as a behavior that is separate from physical activity (5).

We found publications that used direct observation, accelerometers and pedometers as reference methods to assess sedentary time. Prior to 2006, we found studies evaluating only screen time (e.g., watching TV, using a computer, playing video games). After this period, other behaviors (e.g., reading, talking on the phone, sitting, music practice, travelling in a car) were included in the sedentary behavior questionnaires and diaries, which provided a more comprehensive understanding of this behavior beyond screen time (9,10) because screen time alone did not appear to be representative of the overall sedentary time (44).

MAJOR FINDINGS FROM THE META-ANALYSIS: AGREEMENT BETWEEN QUESTIONNAIRES AND ACCELEROMETERS FOR ASSESSING SCREEN TIME

Based on the meta-analysis correlation coefficients, our findings showed that the agreement between questionnaires and accelerometers for the assessment of self-reported screen time in children and adolescents was negative. These findings are similar to a previous systematic review that showed that agreement for self-reported screen time was r = 0.07 (15). However, in this review, the authors included direct observation as a reference method, which could improve the results.

Two other recent reviews of the literature (11,15) indicate that the agreement of children's self-reported TV viewing with objective methods is highly variable (r = -0.19 to 0.88) (12). The negative agreement found in our review could be partially explained because accelerometers, in general, assess the absence of movements with limitations to evaluate aspects related to the type of sedentary activity that is being performed (12,13). On the other hand, the questionnaires cover specific questions (15) about TV viewing, computer use and playing video games. Thus, studies drawing inferences about total sedentary time (from accelerometers) compared to a set of behaviors relative to screen time (from questionnaires or diaries) should be interpreted with caution.

Alternatively, the literature suggests direct observation as the gold standard for assessing screen time (15). We found two studies (which were not meta-analyzed) that compared questionnaires (32) and diaries (29) with direct observation, and they found moderate (r = 0.49) to strong (r = 0.60) correlation, respectively. However, this methodology could be invasive and not practical for large-scale research studies (11,15). In this sense, we speculate that the poor agreement between questionnaire and accelerometer for assessing screen time found in the meta-analysis could be likely due to the choice of accelerometers as a reference method rather than the subjective method *per se*.

MAJOR FINDINGS FROM THE META-ANALYSIS: AGREEMENT BETWEEN QUESTIONNAIRES AND ACCELEROMETERS FOR ASSESSING SEDENTARY BEHAVIOR

Our results suggest that there is positive agreement between questionnaires and accelerometers for assessing sedentary behavior. In addition, we found moderate correlation when the information was self-reported by adolescents. In this topic, the literature has no a clear line, although one systematic review (17) indicates that there is no acceptable agreement between objective and subjective methods due to the low methodological quality of the included studies or to poorly developed questionnaires. On the other hand, a classic systematic review (11) states that subjective methods provide reliable estimates of sedentary behavior and accelerometers can accurately classify participants' behavior as sedentary. There, the authors recommend the use of accelerometers in conjunction with subjective measures to assess sedentary behavior.

In our systematic review, all questionnaires assessed the time spent in sedentary behavior. One potential explanation for the findings in the current review and which can complement previous reviews (11,17) is based on a recent study by Kelly et al. (13), who hypothesized that there is no single "gold standard" for sedentary behavior measurement and measurement depends primarily on the aspect of interest that there will be different best reference methods. Therefore, for total volume (or absence) of activity, accelerometers may be the most adequate reference method (13,45), which could have approximate the measures from questionnaires and accelerometers providing positive correlation.

However, it is important that researchers, practitioners and policy makers understand the strength and limitation of the methods (46). In general, accelerometers do not assess changes in posture (47), but they capture the lack of movement (13) or the accumulation of low movement counts at specified cut-points (12). Additionally, there are different cut-points, axes, degrees of data reduction, and data management applied to identify sedentary time (15).

Furthermore, we found that the questionnaires, especially for adolescents, were frequently answered by the participant, whereas for children, the questions were answered by their parents. In addition, according to the literature, self-reporting may not be appropriate for children due to their limited cognitive capacity, which may hinder accurate recall (12). Under such circumstances, parental reports may be used to gather information on children's sedentary behavior (48). Regarding adolescents, some original studies have shown that parents can overestimate the behaviors of adolescents (49,50). However, few studies have examined the psychometric properties of sedentary behavior self-reports of children or adolescents compared to parental reports (12).

HETEROGENEITY AND POTENTIAL BIAS IN THE META-ANALYSIS

An important heterogeneity was found for assessing sedentary behavior, which was commonly observed in other meta-analyses that addressed this or similar topics (5,51). The heterogeneity can be partially explained by the large age range of the subjects as well as the different questionnaires and accelerometers that were adopted, the number of days that accelerometers were worn, different accelerometer cut-off and axis points, questionnaire attributes (e.g., length of recording period, number of items), and the different geographic populations. For these reasons, we were not able to perform a meta-regression to assess potential sources of heterogeneity due to differences among study methodologies (52).

Regarding bias, although the scientific community seems to be resistant to published studies with negative and non-significant results (25), our analysis did not indicate a potential risk of bias towards publications with significant and positive results. Additionally, we did not find small-study effects for the agreement

measures. However, we can speculate there were two potential biases, including publication bias and location bias. Although we observed an increase in the number of published studies, these studies were published only in English, and the majority of these studies were performed in high-income continents (North America and Europe) (53).

STRENGTHS AND LIMITATIONS

The present study has several strengths. This review was systematically conducted by multiple reviewers. We retrieved a large number of studies from different continents using a thorough search procedure that covered a period greater than 30 years. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (54) was adopted, and a methodological quality rating was performed separately to assist with interpreting the findings. In addition, based on a cross-reference search of published reviews, studies that were not found in the electronic database searches were included. Another strength of this review was that two independent authors conducted the data extraction and the methodological quality assessment.

We are confident that our findings were able to obtain an adequate representation of the literature available on the agreement of sedentary behavior questionnaires and diaries with objective methods. Additionally, this is the first time that results on the agreement between questionnaires and accelerometers for assessing screen time and sedentary behavior, respectively, were summarized in a meta-analysis as well as the first assessment of how measurement approaches can be associated with the referred agreements.

The limitations of this review include some different classifications of sedentary behavior among the questionnaires (5,19), especially because sedentary behavior was considered to be part of the physical activity spectrum for several years (5). To avoid these potential misclassifications, we included only subjective methods that used two accepted definitions of sedentary behavior (19). Due to the nature of the measurements, the agreement between questionnaires and accelerometers for assessing screen time and sedentary behavior found in our meta-analyses cannot be extrapolated for metrics (e.g., energy expenditure, metabolic rates) other than sedentary time.

Studies addressing other types of agreement analyses, such as subjective or health outcomes, as reference methods were not assessed. The variations in methods in studies comparing subjective and objective methods should be considered as a limitation, such as differences in the cut-off points, axis or vector magnitude used to analyze accelerometer data and the fact that subjective (reported time in behavior) and objective (total time in absence of movement) methods did not measure exactly the same parameters. Other potential limitations can be the agreement analyses restricted to data from published studies. No data was retrieved from gray literature or similar sources.

Other important limitation comprises correlation coefficients as agreement estimates. Summarizing the findings on agreement between methods is complex (55), especially because several statistical procedures were adopted. In our meta-analyses, only correlation coefficients were considered, which implies that caution should be taken when accepting agreement with only a supporting statistical test (56). However, correlation coefficients are the most common estimated effects used to examine agreement between medical methods (57), and they are considered as good indicators of the relationship between two instruments (28). In addition, we have no meta-analyzed findings about diaries, as well as we have no meta-analyzed addressing other objective method as reference method than accelerometer.

Despite all these limitations, the results of the present study were the best estimate that could be produced with the available evidence on the agreement between subjective and objective methods for assessing screen time and sedentary behavior. Finally, our systematic review was not designed to indicate an ideal methodological approach for agreement studies in sedentary behavior but rather to provide an initial discussion based on evidence about the impact of methodological decisions in the agreement studies.

CONCLUSIONS

There are two major groups of activities used to measure sedentary time subjectively: screen time and sedentary behavior. Questionnaires have positive agreement with accelerometers for assessing sedentary behavior. Conversely, the agreement between the questionnaires and accelerometers for screen time is negative. Self-reported questionnaires are recommended methods to measure sedentary behavior in adolescents.

FUNDING

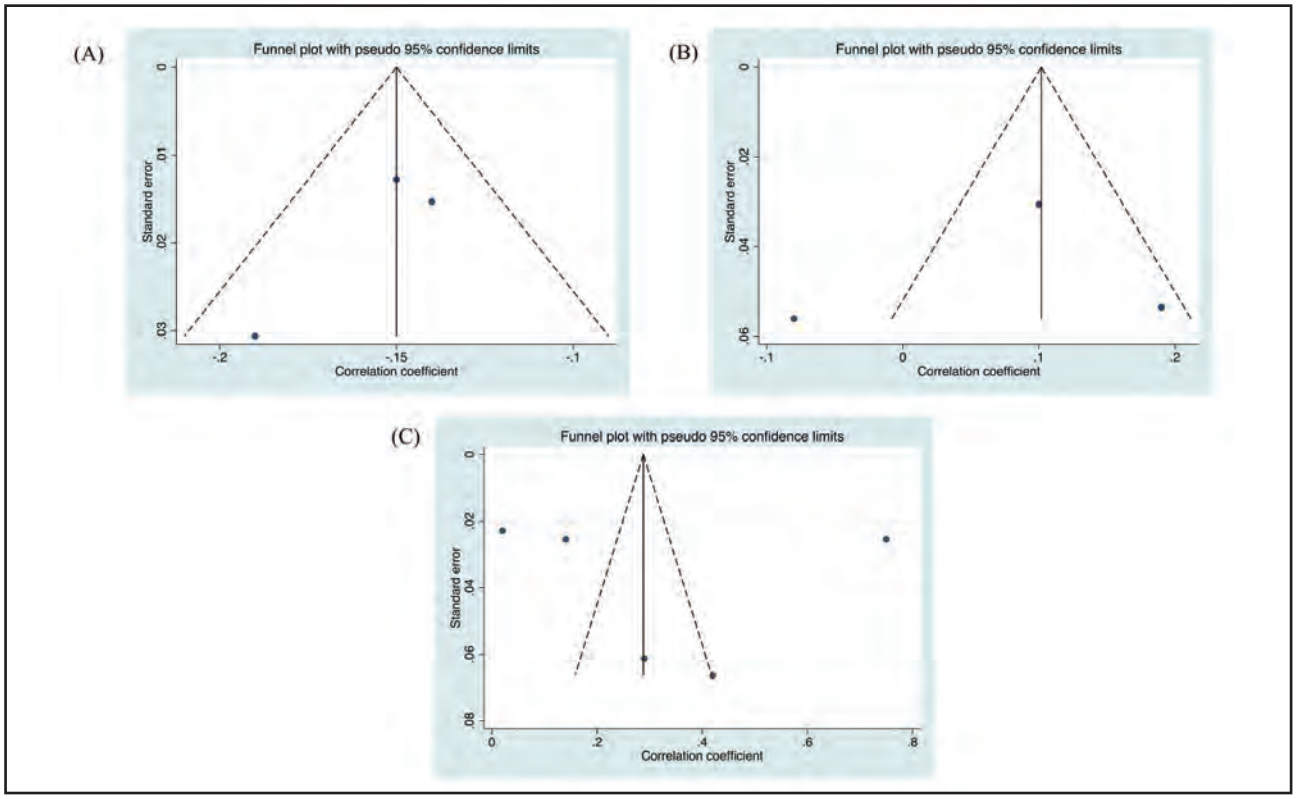
This study has no specific support. Marcus V. Nascimento-Ferreira received a PhD Student Internships Abroad scholarship from the National Counsel of Technological and Scientific Development (CNPq; proc.200340/2015-8) and a Brazilian PhD Student scholarship from the São Paulo Research Foundation (FAPESP) (proc. 2016/18436-8 and 2017/11732-3). Augusto De Moraes received a scholarship from the National Counsel of Technological and Scientific Development (CNPq, proc. 313772/2014-2), the FAPESP (proc. 2014/13367-2 and 2015/14319-4) and FAPESP Young Investigator Award (proc. 2017/20317-0 and 2019/02617-1). Tara Rendo-Urteaga, Luis Moreno and Heráclito Barbosa received funding from FAPESP (proc. 2014/25233-0, 2015/11406-3 and 2014/11468-6, respectively). Paulo Toazza received a scholarship from CNPq. Heráclito B Carvalho received an advanced scientist scholarship from the National Counsel of Technological and Scientific Development (CNPq, proc. 300951/2015-9). The GENUD Research Group was co-financed by the European Regional Development Fund (MICINN-FEDER).

AUTHORS CONTRIBUTIONS

Marcus Vinicus Nascimento-Ferreira, Augusto César Ferreira de Moraes and Paulo Vinicius Toazza designed the study and conducted its implementation. Augusto César Ferreira de Moraes and Tara Rendo-Urteaga supervise the study activities (e.g., database search, data extraction), including the quality assurance and control of the systematic review protocol. Heráclito Barbosa Carvalho e Luis A Moreno supervise the statistical analysis and text writing, as well as, the paper final review.

Supplementary Table I. Descriptors used in electronic database searches

Age group	Descriptors adopted
Children	("early childhood" OR "child" OR "preschool" OR "children" OR "preschoolers" OR "childhood") AND ("sedentary behavior" OR "physical inactivity" OR "sedentary" OR "sedentarism" OR "sitting" OR "TV" OR "television" OR "screen" OR "computer" OR "electronic games" OR "video" OR "DVD" OR "video games" OR "electronic media") AND ("instrument" OR "survey" OR "diary" OR "questionnaire" OR "self-report" OR "proxy report" OR "log") AND ("accelerometer" OR "accelerometry" OR "direct observation" OR "pedometer" OR "motion sense" OR "heart rate" OR "inclinometer" OR "activity monitor" OR "ActiGraph" OR "GENEActiv") AND ("agreement" OR "validity of results" OR "validities" OR "valid" OR "validation" OR "validity")
Adolescents	("adolescence" OR "adolescents" OR "youth" OR "teen" OR "teenager") AND ("sedentary behavior" OR "physical inactivity" OR "sedentary" OR "sedentarism" OR "sitting" OR "TV" OR "television" OR "screen" OR "computer" OR "electronic games" OR "video" OR "DVD" OR "video games" OR "electronic media") AND ("instrument" OR "survey" OR "diary" OR "questionnaire" OR "self-report" OR "proxy report" OR "log") AND ("accelerometer" OR "accelerometry" OR "direct observation" OR "pedometer" OR "motion sense" OR "heart rate" OR "inclinometer" OR "activity monitor" OR "ActiGraph" OR "GENEActiv") AND ("agreement" OR "validity of results" OR "validities" OR "valid" OR "validation" OR "validity")



Supplementary figure 1.

Funnel plot for the correlation coefficients addressing screen time (A) and sedentary behavior (B: parent-report; C: self-report) measured by questionnaires in comparison with accelerometers.

Supplementary Table II. Extracted data about demographic characteristics, methodological approach, correlation coefficients and methodological quality assessment of the studies

Study (author, year, country)	Tool assessed	Demographic characteristics	Type of report (length of test in validation)	Instrument		Variable/ unit of measurement	Test-retest reliability assessed (interval period)	Correlation coefficient	Quality assessment
				Subjective	Objective (data management)				
Anderson et al., 1985 (29), US	Home TV viewing diary	334 children, 50.6% girls	Parental-report (10 unspecified days)	Diary	Direct (video) observation	Screen time[a] - hours or minutes/day	Yes (31 days)	r = 0.60*	0.71
Tudor-Locke et al., 2003 (30), Philippines	Own questionnaire	1,518 adolescents, 54.5% girls	Self-report (1 week day)	Question	Accelerometer[I] worn in a waist belt, centered over either leg[†] (data reduction [56])	Screen time[a] - hours/day	No	r = -0.14* (Males) r = -0.15* (Females)	0.79
Treuth et al., 2004 (31), US	GEMS Activity Questionnaire (GAQ)	172 children, 100.0% girls	Self-report (3 unspecified days)	Question	Accelerometer[II] worn in the waist (cut-points [51])	Screen time[b] -hours/week	Yes (14 days)	r = -0.19*	0.75
Robinson et al., 2006 (32), US	Own questionnaire	80 children, 47.5% girls	Parental-report (15 week and 6 weekend days)	Question	Direct (video) observation	Screen time[b] -hours/week	No	r = 0.49*	0.64
Hardy et al., 2007 (33), Australia	Sedentary behaviour questionnaire	172 adolescents, 100.0% girls	Self-report (5 week and 2 weekend days)	Question	Accelerometer[I,†] worn side was not specified (equation [50])	Sedentary behavior[c] -hours/week	No	Not applied**	0.71
Trost et al., 2007 (34), Australia	Physical Activity Recall (PDPAR-24)	122 adolescents, 53.3% girls	Self- report (1 week day)	Diary	Pedometer[III,†] worn side not specified (data reduction [56])	Screen time[d] METs (30-Min/ blocks)	No	ρ = -0.19*	0.71

*HELENA: Healthy Lifestyle in Europe by Nutrition in Adolescence; Question.: questionnaire; SB: sedentary behavior; US; United States. [a]TV viewing. [b]TV viewing and using a computer. [c]TV viewing, playing video games, using a computer, doing homework/study, reading, talking on the phone, sitting, doing hobbies, music practice, travelling in a car, bus ferry or train and going to the cinema. [d]TV viewing, playing games and using a computer. [e]TV viewing, playing games, using a computer, playing indoors in a stationary way, reading, sitting and sleeping or napping during the day. [f]TV viewing, playing games, using a computer and talking on the phone. [g]TV viewing, playing games, using a computer, doing homework, reading, playing a musical instrument, playing quietly and performing other quiet activities. [h]TV viewing, playing games (consoles and computer), internet for study (and non-study) and study. [i]TV viewing, playing (video)games, using a computer, using a cell phone, and also include an overall sedentary time item. [j]TV viewing, playing games, using a computer, in motorized transport and school. [I]Caltrac, Muscle Dynamics, California, US. [II]Actigraph, MTI, Florida, US. [III]Digiwalker, Yamax, Japan. [IV]ActivPAL™ 3MHealthcare, Minnesota, US. [V]Actical, Philips Respironics, Oregon, US. [VI]SenseWear Armband Pro3 (SWA), BodyMedia, Pittsburgh, US. [†]Device was removed when sleeping or in a water activity. [††]Device was removed when in water activity. [†††]Device was used in full time. [¥]7 days in winter of 2004 and 7 days in spring of 2005. [¥¥]Austria, Belgium, France, Germany, Greece, Hungary, Italy, Spain, Sweden. [ŦŦ]Values adjusted by sex, maternal education and school grade. [ŦŦ]Values adjusted by sex and maternal education. *p < 0.05. **In this study the criterion validity was analyzed based on Bland-Atman plots (level of agreement). ***In this study the criterion validity was analyzed based on Kruska-Wallis (mean difference). ****In this study the criterion validity was analyzed based on paired t-test (mean difference).*

(Continue in the next page)

Supplementary Table II (Cont.). Extracted data about demographic characteristics, methodological approach, correlation coefficients and methodological quality assessment of the studies

Study (author, year, country)	Tool assessed	Demographic characteristics	Type of report (length of test in validation)	Instrument		Variable/ unit of measurement	Test-retest reliability assessed (interval period)	Correlation coefficient	Quality assessment
				Subjective	Objective (data management)				
Affuso et al., 2011 (35), US	Modified version of the Self-Administered Physical Activity Checklist (SAPAC) (50)	201 adolescents, 63.7% girls	Self-report (2 week and 1 weekend days)	Question	Accelerometer[II,†] worn side was not specified (cut-points [35])	Sedentary behavior[f] - total minutes of activity	No	$\rho = 0.14$	0.68
Wen et al., 2007 (36), Australia	Brief Survey on Activity Preferences (unsp) and 7-Day Diary on Children's Physical Activity and Sedentary º Behavior (unsp)	34 children, 38.7% girls	Parental-report (5 week and 2 weekend days) Diary	Question	Accelerometer[II,†] worn in right hip (cut-points [55]) Sedentary behavior[e] - minutes/day	Sedentary behavior[e] - minutes/day	No No	$\rho = -0.08$ $\rho = 0.24$	0.71
Bringolf-Isler et al., 2012 (37), Switzerland	Adapted of the activity-based (AB) approach (51)	109 children, 51.3% girls	Parental-report (10 week[¥] and 4 weekend[¥] days)	Question	Accelerometer[II] worn side was not specified (cut-points [52])	Sedentary behavior[h] - minutes/day	Yes (31 and 86 days)	$\rho = 0.10^{\text{ŦŦ}}$	0.86
		58 adolescents, 51.3% girls	Parental-report (10 week[¥] and 4 weekend[¥] days)	Question	Sedentary behavior[h] - minutes/day	Sedentary behavior[h] - minutes/day	Yes (31 and 86 days)	$\rho = 0.19^{\text{ŦŦ}}$	

*HELENA: Healthy Lifestyle in Europe by Nutrition in Adolescence; Question.: questionnaire; SB: sedentary behavior; US; United States. [a]TV viewing. [b]TV viewing and using a computer. [c]TV viewing, playing video games, using a computer, doing homework/study, reading, talking on the phone, sitting, doing hobbies, music practice, travelling in a car, bus ferry or train and going to the cinema. [d]TV viewing, playing games and using a computer. [e]TV viewing, playing games, using a computer, playing indoors in a stationary way, reading, sitting and sleeping or napping during the day. [f]TV viewing, playing games, using a computer and talking on the phone. [g]TV viewing, playing games, using a computer, doing homework, reading, playing a musical instrument, playing quietly and performing other quiet activities. [h]TV viewing, playing games (consoles and computer), internet for study (and non-study) and study. [i]TV viewing, playing (video)games, using a computer, using a cell phone, and also include an overall sedentary time item. [j]TV viewing, playing games, using a computer, in motorized transport and school. [I]Caltrac, Muscle Dynamics, California, US. [II]Actigraph, MTI, Florida, US. [III]Digiwalker, Yamax, Japan. [IV]ActivPAL™ 3MHealthcare, Minnesota, US. [V]Actical, Philips Respironics, Oregon, US. [VI]SenseWear Armband Pro3 (SWA), BodyMedia, Pittsburgh, US. [†]Device was removed when sleeping or in a water activity. [††]Device was removed when in water activity. [†††]Device was used in full time. [¥]7 days in winter of 2004 and 7 days in spring of 2005. [¥¥]Austria, Belgium, France, Germany, Greece, Hungary, Italy, Spain, Sweden. [Ŧ]Values adjusted by sex, maternal education and school grade. [ŦŦ]Values adjusted by sex and maternal education. *$p < 0.05$. **In this study the criterion validity was analyzed based on Bland-Atman plots (level of agreement). ***In this study the criterion validity was analyzed based on Kruska-Wallis (mean difference). ****In this study the criterion validity was analyzed based on paired t-test (mean difference).*

(Continue in the next page)

Supplementary Table II (Cont.). Extracted data about demographic characteristics, methodological approach, correlation coefficients and methodological quality assessment of the studies

Study (author, year, country)	Tool assessed	Demographic characteristics	Type of report (length of test in validation)	Instrument		Variable/ unit of measurement	Test-retest reliability assessed (interval period)	Correlation coefficient	Quality assessment
				Subjective	Objective (data management)				
Anderson et al., 1985 (29), US	Home TV viewing diary	334 children, 50.6% girls	Parental-report (10 unspecified days)	Diary	Direct (video) observation	Screen time[a] - hours or minutes/day	Yes (31 days)	r = 0.60*	0.71
Rey-Lopez et al., 2012 (38), 8 European countries[¥¥]	HELENA screen time-based sedentary behavior questionnaire	2,048 adolescents, 59.2% girls	Self-report (5 week and 2 weekend days)	Question	Accelerometer[II,††] worn at the lower back (cut-points [53])	Sedentary behavior[h] - minutes/day (summarized on weekdays and weekend days)	Yes (7 days)	Not applied***	0.79
Verstraeten et al. 2013 (39), Ecuador	Simplified version of the PA record (52)	140 adolescents, 51.3% girls	Self-report (5 week and 2 weekend days)	Question	Accelerometer[II,†] worn on the right side of the hip (cut-points [54])	Sedentary behavior based in Bouchard et al. 1983 [48] - minutes/day	Yes (21 days)	Not applied**	0.75
Busschaert et al. 2015 (49), Belgium	Own questionnaire	60 adolescents, 58.1% girls	Self-report (5 week and 2 weekend days)	Question	Accelerometer[IV,†††] worn on the thigh (SB equation: [(total SB on a weekday x 5) + (total SB on a weekend day x 2)]/7)	Sedentary behavior[i] - minute/day on a weekday, weekend day and an average day	Yes (16 ± 9 days)	ρ = 0.29* (average day)	0.64
Mandich et al. 2015 (41), Canada	Child Sedentary Behaviour Questionnaire (CSBQ) (53)	60 adolescents, 45.9% girls	Self-report (2 week and 2 weekend days)	Question	Accelerometer[V] worn on the hip (cut-points [51])	Screen time[d] - minutes and hours/ day	No	Not applied****	0.68
Saint-Maurice et al. 2015 (42), US	Youth Activity Profile (YAP)	291 children and adolescents, 56.0% girls	Self-report (10 week and 4 weekend days)	Question	Accelerometer[VI] worn side was not specified (SB cut-point, < 2.0 METs)	Sedentary behavior[i] - minutes and hours/ day	No	r = 0.75*	0.71

*HELENA: Healthy Lifestyle in Europe by Nutrition in Adolescence; Question.: questionnaire; SB: sedentary behavior; US; United States. [a]TV viewing. [b]TV viewing and using a computer. [c]TV viewing, playing video games, using a computer, doing homework/study, reading, talking on the phone, sitting, doing hobbies, music practice, travelling in a car, bus ferry or train and going to the cinema. [d]TV viewing, playing games and using a computer. [e]TV viewing, playing games, using a computer, playing indoors in a stationary way, reading, sitting and sleeping or napping during the day. [f]TV viewing, playing games, using a computer and talking on the phone. [g]TV viewing, playing games, using a computer, doing homework, reading, playing a musical instrument, playing quietly and performing other quiet activities. [h]TV viewing, playing games (consoles and computer), internet for study (and non-study) and study. [i]TV viewing, playing (video)games, using a computer, using a cell phone, and also include an overall sedentary time item. [j]TV viewing, playing games, using a computer, in motorized transport and school. [I]Caltrac, Muscle Dynamics, California, US. [II]Actigraph, MTI, Florida, US. [III]Digiwalker, Yamax, Japan. [IV]ActivPAL™ 3MHealthcare, Minnesota, US. [V]Actical, Philips Respironics, Oregon, US. [VI]SenseWear Armband Pro3 (SWA), BodyMedia, Pittsburgh, US. [†]Device was removed when sleeping or in a water activity. [††]Device was removed when in water activity. [†††]Device was used in full time. [¥]7 days in winter of 2004 and 7 days in spring of 2005. [¥¥]Austria, Belgium, France, Germany, Greece, Hungary, Italy, Spain, Sweden. [T]Values adjusted by sex, maternal education and school grade. [TT]Values adjusted by sex and maternal education. *p < 0.05. **In this study the criterion validity was analyzed based on Bland-Atman plots (level of agreement). ***In this study the criterion validity was analyzed based on Kruska-Wallis (mean difference). ****In this study the criterion validity was analyzed based on paired t-test (mean difference).*

REFERENCES

1. Sedentary-Behaviour-Research-Network. Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". Appl Physiol Nutr Metab 2012;37:540-2.
2. Marshall SJ, Biddle SJ, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. Int J Obes Relat Metab Disord 2004;28:1238-46.
3. Must A, Parisi SM. Sedentary behavior and sleep: paradoxical effects in association with childhood obesity. Int J Obes (Lond) 2009;33(Suppl 1):S82-6.
4. Tremblay MS, LeBlanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act 2011;8:98.
5. Ford ES, Caspersen CJ. Sedentary behaviour and cardiovascular disease: a review of prospective studies. Int J Epidemiol 2012;41:1338-53.
6. Pulsford RM, Stamatakis E, Britton AR, Brunner EJ, Hillsdon M. Associations of sitting behaviours with all-cause mortality over a 16-year follow-up: the Whitehall II study. Int J Epidemiol 2015;44:1909-16.
7. Xiao J, Shen C, Chu MJ, Gao YX, Xu GF, Huang JP, et al. Physical activity and sedentary behavior associated with components of metabolic syndrome among people in rural China. PLoS One 2016;11:e0147062.
8. Marshall SJ, Gorely T, Biddle SJ. A descriptive epidemiology of screen-based media use in youth: a review and critique. J Adolesc 2006;29:333-49.
9. Ekelund U, Steene-Johannessen J, Brown WJ, Fagerland MW, Owen N, Powell KE, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. Lancet 2016;388:1302-10.
10. Thorp AA, Owen N, Neuhaus M, Dunstan DW. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. Am J Prev Med 2011;41:207-15.
11. Lubans, Hesketh K, Cliff DP, Barnett LM, Salmon J, Dollman J, et al. A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. Obes Rev 2011;12:781-99.
12. Atkin AJ, Gorely T, Clemes SA, Yates T, Edwardson C, Brage S, et al. Methods of measurement in epidemiology: sedentary behaviour. Int J Epidemiol 2012;41:1460-71.
13. Kelly P, Fitzsimons C, Baker G. Should we reframe how we think about physical activity and sedentary behaviour measurement? Validity and reliability reconsidered. Int J Behav Nutr Phys Act 2016;13:32.
14. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR, Tudor-Locke C, et al. 2011 Compendium of Physical Activities: a second update of codes and MET values. Med Sci Sports Exerc 2011;43:1575-81.
15. Bryant MJ, Lucove JC, Evenson KR, Marshall S. Measurement of television viewing in children and adolescents: a systematic review. Obes Rev 2007;8:197-209.
16. Helmerhorst HJ, Brage S, Warren J, Besson H, Ekelund U. A systematic review of reliability and objective criterion-related validity of physical activity questionnaires. Int J Behav Nutr Phys Act 2012;9:103.
17. Hidding LM, Altenburg TM, Mokkink LB, Terwee CB, Chinapaw MJ. Systematic review of childhood sedentary behavior questionnaires: what do we know and what is next? Sports Med 2017;47(4):677-99.
18. Marshall AL, Miller YD, Burton NW, Brown WJ. Measuring total and domain-specific sitting: a study of reliability and validity. Med Sci Sports Exerc 2010;42:1094-102.
19. Gibbs BB, Hergenroeder AL, Katzmarzyk PT, Lee IM, Jakicic JM. Definition, measurement, and health risks associated with sedentary behavior. Med Sci Sports Exerc 2015;47:1295-300.
20. World Health Orgazination (WHO). Growth reference data for 5-19 years. Geneva: WHO; 2007.
21. Egger M, Smith G, Altman D. Systematic reviews in health care: meta-analysis in context. London: BMJ Books; 2011.
22. Kottner J, Audige L, Brorson S, Donner A, Gajewski BJ, Hróbjartsson A, et al. Guidelines for Reporting Reliability and Agreement Studies (GRRAS) were proposed. Int J Nurs Stud 2011;48:661-71.
23. Kmet LM, Lee RC, Cook LS. Standard quality assessment criteria for evaluating primary research papers from a variety of fields. Edmonton: Alberta Heritage Foundation for Medical Research (AHFMR), HTA Initiative #13; 2004.
24. Greco T, Zangrillo A, Biondi-Zoccai G, Landoni G. Meta-analysis: pitfalls and hints. Heart Lung Vessel 2013;5:219-25.
25. Sterne JA, Egger M, Smith GD. Systematic reviews in health care: investigating and dealing with publication and other biases in meta-analysis. BMJ 2001;323:101-5
26. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ 1997;315:629-34.
27. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003;327:557-60.
28. Walker J, Almond P. Interpreting statistical findings: a guide for health professionals and students. Berkshire, UK: Open University Press, McGraw-Hill Education, McGraw-Hill House; 2010.
29. Anderson DR, Field DE, Collins PA, Lorch EP, Nathan JG. Estimates of young children's time with television: a methodological comparison of parent reports with time-lapse video home observation. Child Dev 1985;56:1345-57.
30. Tudor-Locke C, Ainsworth BE, Adair LS, Popkin BM. Objective physical activity of filipino youth stratified for commuting mode to school. Med Sci Sports Exerc 2003;35:465-71.
31. Treuth MS, Sherwood NE, Baranowski T, Butte NF, Jacobs DR, McClanahan B, et al. Physical activity self-report and accelerometry measures from the Girls health Enrichment Multi-site Studies. Prev Med 2004;38 Suppl:S43-9.
32. Robinson JL, Winiewicz DD, Fuerch JH, Roemmich JN, Epstein LH. Relationship between parental estimate and an objective measure of child television watching. Int J Behav Nutr Phys Act 2006;3:43.
33. Hardy LL, Bass SL, Booth ML. Changes in sedentary behavior among adolescent girls: a 2.5-year prospective cohort study. J Adolesc Health 2007;40:158-65.
34. Trost SG, Marshall AL, Miller R, Hurley JT, Hunt JA. Validation of a 24-h physical activity recall in indigenous and non-indigenous Australian adolescents. J Sci Med Sport 2007;10:428-35.
35. Affuso O, Stevens J, Catellier D, McMurray R, Ward D, Lytle L, et al. Validity of self-reported leisure-time sedentary behavior in adolescents. Pediatr Exerc Sci 2010;22:408-20.
36. Wen LM, Van der Ploeg HP, Kite J, Cashmore A, Rissel C. A validation study of assessing physical activity and sedentary behavior in children aged 3 to 5 years. Pediatr Exerc Sci 2010;22:408-20.
37. Bringolf-Isler B, Mäder U, Ruch N, Kriemler S, Grize L, Braun-Fahrländer C. Measuring and validating physical activity and sedentary behavior comparing a parental questionnaire to accelerometer data and diaries. Pediatr Exerc Sci 2012;24:229-45.
38. Rey-López JP, Ruiz JR, Ortega FB, Verloigne M, Vicente-Rodríguez G, Gracia-Marco L, et al. Reliability and validity of a screen time-based sedentary behaviour questionnaire for adolescents: the HELENA study. Eur J Public Health 2012;22:373-7.
39. Verstraeten R, Lachat C, Ochoa-Avilés A, Hagströmer M, Huybregts L, Andrade S, et al. Predictors of validity and reliability of a physical activity record in adolescents. BMC Public Health 2013;13:1109.
40. Busschaert C, De Bourdeaudhuij I, Van Holle V, Chastin SF, Cardon G, De Cocker K. Reliability and validity of three questionnaires measuring context-specific sedentary behaviour and associated correlates in adolescents, adults and older adults. Int J Behav Nutr Phys Act 2015;12:117.
41. Mandich G, Burke S, Gaston A, Tucker P. The physical activity levels and sedentary behaviors of Latino children in London (Ontario, Canada). Int J Environ Res Public Health 2015;12:5528-39.
42. Saint-Maurice PF, Welk GJ. Validity and calibration of the youth activity profile. PLoS One 2015;10:e0143949.
43. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. Exerc Sport Sci Rev 2010;38:105-13.
44. Biddle SJ, Gorely T, Marshall SJ. Is television viewing a suitable marker of sedentary behavior in young people? Ann Behav Med 2009;38:147-53.
45. Cordero M, López A, Barrilao R, Blanque R, Segovia J, Cano M. Accelerometer description as a method to assess physical activity in different periods of life; systematic review. Nutr Hosp 2014;29:1250-61.
46. Dollman J, Okely AD, Hardy L, Timperio A, Salmon J, Hills AP. A hitchhiker's guide to assessing young people's physical activity: deciding what method to use. J Sci Med Sport 2009;12:518-25.
47. Grant PM, Ryan CG, Tigbe WW, Granat MH. The validation of a novel activity monitor in the measurement of posture and motion during everyday activities. Br J Sports Med 2006;40:992-7.
48. Brown JE, Broom DH, Nicholson JM, Bittman M. Do working mothers raise couch potato kids? Maternal employment and children's lifestyle behaviours and weight in early childhood. Soc Sci Med 2010;70:1816-24.
49. Martínez SM, Greenspan LC, Butte NF, Gregorich SE, De Groat CL, Deardorff J, et al. Mother-reported sleep, accelerometer-estimated sleep and weight status in Mexican American children: sleep duration is associated with increased adiposity and risk for overweight/obese status. J Sleep Res 2014;23:326-34.

50. Reichert FF, Menezes AM, Araújo CL, Hallal PC. Self-reporting versus parental reporting of physical activity in adolescents: the 11-year follow-up of the 1993 Pelotas (Brazil) birth cohort study. Cad Saude Publica 2010;26:1921-7.
51. Nascimento-Ferreira MV, Collese TS, De Moraes AC, Rendo-Urteaga T, Moreno LA, Carvalho HB. Validity and reliability of sleep time questionnaires in children and adolescents: a systematic review and meta-analysis. Sleep Med Rev 2015;30:85-96.
52. Murad MH, Montori VM, Ioannidis JP, Jaeschke R, Devereaux PJ, Prasad K, et al. How to read a systematic review and meta-analysis and apply the results to patient care: users' guides to the medical literature. JAMA 2014; 312:171-9.
53. World Bank web page. Country and lending groups. 2015.
54. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015 statement. Syst Rev 2015;4:1.
55. Trikalinos TA, Balion CM. Chapter 9: options for summarizing medical test performance in the absence of a "gold standard". J Gen Intern Med 2012;27(Suppl 1):S67-75.
56. Ludbrook J. Statistical techniques for comparing measurers and methods of measurement: a critical review. Clin Exp Pharmacol Physiol 2002;29:527-36.
57. Zaki R, Bulgiba A, Ismail R, Ismail NA. Statistical methods used to test for agreement of medical instruments measuring continuous variables in method comparison studies: a systematic review. PLoS One 2012;7:e37908.