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Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF) as a measure of physical activity (PA) in young people with cerebral palsy: A cross-sectional study

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Abstract

Objectives The aim of this study was to examine the validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF) as a measure of physical activity (PA) in young people with cerebral palsy (CP).
Design Cross-sectional.
Setting Participants were recruited through 8 National Health Service (NHS) trusts, one school, one university and through organisations that provide services for people with disabilities in England.
Participants Sixty-four, ambulatory young people aged 10–19 years with CP [Gross Motor Function Classification System (GMFCS) levels I–III] participated in this study.
Main outcome measure The IPAQ-SF was administered to participants. Participants were then asked to wear a wGT3X-BT triaxial accelerometer (ActiGraph, Pensacola, FL) for 7 days to objectively assess PA. Time spent in sedentary behaviour, in moderate to vigorous PA (MVPA) and in total PA (TPA) was compared between measures.
Results Young people with CP self-reported less time in sedentary behaviour and underestimated the time spent in TPA, when compared to accelerometer measurements. Bland–Altman plots demonstrated poor agreement between the measures for MVPA, with upper and lower 95% limits of agreement of −147 to 148.9 minute. After adjusting for gender and GMFCS level, age was a predictor of the difference between measures for MVPA ($P < 0.001$) and TPA ($P < 0.001$).
Conclusions These findings suggest that the IPAQ-SF is not a valid method of measuring TPA or sedentary behaviour in young people with CP and it is not appropriate for use when assessing an individual's time in MVPA. Therefore, where feasible, an objective measure of PA should be used.

Clinical trial registration number ISRCTN90378161.

Keywords: Accelerometry; Cerebral palsy; Physical activity; Self-report; Validity

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Introduction

Cerebral Palsy (CP) is a non-progressive, neurodevelopmental condition defined as ‘a group of permanent disorders of the development of movement and posture, causing activity limitation that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain’ [1]. It is the most common form of childhood physical disability, with an incidence of 1.5–3.8 per 1000 births reported worldwide [2]. CP is a life-long condition and the transition into adolescence and adulthood is often accompanied by a decline in physical function [3], which may be associated with reduced participation in physical activity (PA). Children and adolescents with CP participate in less PA and spend more time in sedentary behaviour compared to their typically developing peers [4,5]. Given recent evidence of the increased prevalence of non-communicable diseases (NCDs), such as stroke and ischaemic heart disease, among people with CP [6,7], monitoring PA levels among people with CP is paramount. Despite the importance of promoting PA, as a potential modifiable risk factor for the prevention of NCDs and functional decline over time, there is a paucity of validated self-report measures of PA among young people with CP.

Self-reported measures of PA include questionnaires, activity diaries, logs and interviews. Many of these subjective measures are used as population screening tools as they are relatively cheap and easy to administer. In an effort to improve consistency in the monitoring of PA using self-report measures, a number of standardised PA questionnaires have been developed and validated in a range of participant cohorts. These include the Bouchard 3-day Physical Activity Record [8], the Minnesota Leisure-time Physical Activity Questionnaire [9] and the International Physical Activity Questionnaire (IPAQ) [10]. These PA questionnaires ask individuals to recall the PA they have engaged in over a set time frame, ranging from periods of 3 days [8] to 1 year [9].

The International Physical Activity Questionnaire Short-Form (IPAQ-SF) is one of the most widely used self-report questionnaires to assess PA. It consists of seven questions to capture average daily time spent sitting, walking, and engaging in moderate and vigorous PA over the last seven days. Developed by an International Consensus Group in 1998, the test-retest reliability, and concurrent and criterion validity, of the IPAQ were examined across 12 countries, among people aged 16–69 years of age [10]. However, less is known about its validity in younger adolescents and it has not been validated for use in people with CP. The most recent systematic review to examine the validity of the IPAQ-SF included 23 studies, of which only 2 studies included people with a mean age of less than 18 years [11]. The review concluded that, based on weak correlations between the IPAQ and measures of objective PA (e.g. accelerometry), the IPAQ was not a valid measure of PA. Since the publication of this review, two studies have examined the validity of the IPAQ-SF in younger populations. However, these studies were carried out in healthy pre pubertal boys [12] and young people with juvenile dermatomyositis and juvenile systematic lupus erythematosus [13], respectively. Both studies demonstrated that the IPAQ-SF was not a valid measure of assessing moderate-to-vigorous PA (MVPA) at an individual level. While the IPAQ-SF is widely used and may present as a feasible method of assessing PA in young people with CP, evidence of its validity in this population is required. The aim of this study was therefore to examine the validity of the IPAQ-SF as a measure of PA in young people with CP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement checklist guided the reporting of this study [14].

Methods

Design & participants

This study was nested within a randomised controlled trial (RCT) examining the feasibility, acceptability and efficacy of resistance training for adolescents with cerebral palsy. The recruitment and selection criteria have already been previously reported elsewhere [15]. The data for this study was collected as part of the routine assessments of this larger RCT. Ambulatory young people with CP were invited to take part in this study. Adolescents with CP were recruited from 8 National Health Service (NHS) trusts in England, a special education needs school, a university, a primary care organisation, national organisations for people with disabilities and through word of mouth. Informed written consent was obtained from participants aged 16 years and older, and informed written assent was obtained from participants less than 16 years, prior to participation in the study. For participants less than 16 years, parental/guardian written consent was also obtained. Inclusion criteria were: (1) spastic CP aged 10–19 years; (2) the ability to walk independently with or without a mobility aid (USA. Gross Motor Function Classification System [GMFCS] levels I–III) and (3) the ability to activate the ankle plantarflexors (a criteria relating to inclusion in the RCT). Exclusion criteria were: (1) orthopaedic surgery of the lower extremities in the past 12 months; (2) botulinum toxin type A injections in the past 6 months; (3) serial casting in the past 6 months and (4) insufficient cognitive understanding to comply with the assessment procedures.

Testing procedures

Participants and/or their parents completed a demographic questionnaire providing information on age, gender, and GMFCS level. Parent reported GMFCS level was reviewed and verified by retrospective video analysis of participants by two physiotherapists (WL, JR). Participants’ body mass was measured to the nearest 0.1 kg using either a standing (SECA, Hamburg, Germany) or seated (Marsden, Rotherham, UK) scales, depending on the participants’ ambulatory status. Height was also recorded to the 0.1 cm using a Leicester portable height measure (Marsden, Rotherham, UK).

The IPAQ-SF was self-administered to all participants using the standardised instructions accompanying the IPAQ. Assistance was provided by the researcher to read the questions if required. Further, the young person was allowed to ask their parent/guardian or researcher for assistance to answer the questions if required. Data were largely cleaned according to the IPAQ scoring protocol [16], with the exception of the guidance relating to the normalisation of the distribution of levels of activity [10] as follows: (1) high values were not truncated to 4 hours; (2) outliers were not excluded without a valid reason; (3) reported durations of less than 10 minutes were not removed. If applied, these guidelines would have changed the original responses given by participants, which was deemed inappropriate given that the aim of the study was to validate self-reported PA as measured by the IPAQ-SF. Data from the moderate and vigorous activity domains were summed to generate a MVPA variable. Finally, total PA (TPA) was calculated by summing time spent walking and in MVPA, in accordance with the scoring protocol [16].

Participants were asked to wear a wGT3X-BT triaxial accelerometer (ActiGraph, Pensacola, FL) for 7 days to objectively assess PA. This accelerometer was chosen as it has shown to be a reliable and valid measure of habitual physical activity in ambulant children and adolescents with CP [17,18]. The monitor was worn on the waist above the right hip or least affected side in the case of significant asymmetry, in the midaxillary line. Standardised written and verbal instructions were provided to participants during their assessment. The monitor was worn during waking hours and data were collected at a sampling rate of 30 Hz. Participants were asked to remove the monitor during periods of sleeping, bathing or swimming, and to note the time it was put on and taken off each day in an activity log.

Data was exported from the device in 15 second epochs using ActiLife software, Version 16.3.3 (ActiGraph, Pensacola, FL). Participants with at least two days of monitoring were included in the final analysis, as two days of data is necessary to achieve a reliability coefficient of 0.70 for adolescents with CP [17]. Furthermore, a valid day was classified as at least 8 hours of wear time [17]. Participants not meeting these criteria were removed from the analysis. An algorithm developed by Choi *et al.* [19] was applied to identify periods when the monitor was not worn (i.e. non-wear time). Non-wear time was defined as a period ≥90 minutes of no movement with a spike tolerance of 2 minutes (i.e. ≥90 consecutive 0's, until more than 2 minutes of non-zeros are detected). Where available, activity logs were used to verify non-wear time. Non wear-time was removed before analysing the data.

The wGT3X-BT accelerometer generates a variable output voltage signal, proportional to acceleration in three orthogonal planes (vertical, anteroposterior and mediolateral), which are converted to vector magnitude activity counts that are then stored on the device. PA was classified time spent in sedentary behaviour, light physical activity (LPA) and MVPA, using previously validated cut-points for adolescents with CP [18]. For people in GMFCS level I, II and III, sedentary behaviour was <72 counts per 15 second. For people in GMFCS level I LPA was 72–723 counts per 15 second, and MVPA was ≥724 counts per 15 second. For people in GMFCS level II, LPA was 72–684 counts per 15 second, and MVPA was ≥685 counts per 15 second. For people in GMFCS level III, LPA was 72–668 counts per 15 second, and MVPA was ≥669 counts per 15 second. The average time spent at each PA intensity (sedentary behaviour, LPA and MVPA) per day was calculated by dividing total time in each intensity by the number of days on which the accelerometer was worn. TPA was calculated by summing time in LPA and MVPA.

Data analysis

The distribution of data was examined using histograms, Q-Q plots and cross-tabulations. Descriptive statistics were used to report participant characteristics and PA data. As wear time for the accelerometer and MVPA and TPA recorded by the IPAQ were not normally distributed, medians, interquartile ranges and ranges were reported. Means, standard deviations and ranges were reported for accelerometer data and for sedentary time data from the IPAQ-SF, as they were normally distributed. There was no evidence that the difference between accelerometer and IPAQ-SF measured PA variables was not normally distributed, and therefore the mean differences and associated 95% confidence intervals are presented. Bland–Altman plots were plotted [20] and 95% limits of agreement (LOA) were calculated to evaluate agreement between accelerometer and IPAQ-SF measured PA variables. Finally, a multivariable linear regression model was fitted to examine if age, gender or GMFCS level were associated with the difference between self-reported and objectively measured PA. Scatter plots of residuals against fitted values, and histograms and Q-Q plots of residuals were used to examine if the assumptions of linear regression were met. There was no evidence that assumptions were not met for regression models.

Results

Sixty-four young people participated in this study. Of these, four did not have valid accelerometer data, one person did not complete the IPAQ-SF, and a further person was missing both accelerometer and IPAQ-SF data. Fifty-eight people were included in the analysis. Descriptive characteristics are presented in Table 1. Some participants did not provide answers for all questions on the IPAQ-SF; 55 participants reported sitting time and walking time, respectively, and 56 reported MVPA. Tables 2 and 3 report the average daily minutes spent in each PA domain from the accelerometer and the IPAQ-SF, respectively.

Table 1
Participant characteristics ($n = 58$).

Variable	
Gender	
Male, *n* (%)	33 (57)
Female, *n* (%)	25 (43)
Age, yr	
Mean (SD)	13.6 (2.5)
Range	10 to 19
Height, cm	
Mean (SD)	154.2 (12.5)
Range	131.5 to 180.9
Mass, kg	
Mean (SD)	49.1 (13.6)
Range	27.4 to 78.5
Distribution	
Unilateral, *n* (%)	27 (47)
Bilateral, *n* (%)	31 (53)
GMFCS	
Level I, *n* (%)	25 (43)
Level II, *n* (%)	23 (40)
Level III, *n* (%)	10 (17)
Education level	
Primary, *n* (%)	11 (19)
Secondary, *n* (%)	42 (72)
University, *n* (%)	3 (5)
Other, *n* (%)	2 (4)

GMFCS: Gross Motor Function Classification System.

Participants reported less time in sedentary behaviour compared to accelerometer data (mean diff: 133 minute, 95% CI 85 to 182). Mean time spent in MVPA and TPA, respectively, was also lower when reported using the IPAQ-SF in comparison to accelerometer data (mean diff in MVPA: 1 minute, 95% CI −19 to 21; mean diff in TPA: 137 minute, 95% CI 103 to 170). Bland–Altman plots demonstrated poor agreement between the two measures when measuring MVPA, with upper and lower 95% LOA of −147 to 149 minute (Fig. 1). LOA for sedentary behaviour were −223 to 489 minute.

Individual differences between the wGT3X-BT and the IPAQ-SF ranged from −206 to 686 minute for sedentary behaviour, −336 to 131 minute for MVPA and −174 to 380 minute for TPA. When examining predictors of the difference between measures, there was strong evidence that age was associated with the difference in MVPA and TPA between measures, after adjusting for gender and GMFCS level. For every additional year in age, the difference in MVPA and TPA, respectively, between the wGT3X-BT and the IPAQ-SF reduced by 18 minute (95% CI 11 to 25, $P < 0.001$) and 23 minute (95% CI 11 to 35, $P < 0.001$). On average, participants aged 10 years underestimated MVPA and TPA, respectively, by 53 minute (95% CI 18 to 89) and 249 minute (95% CI 188 to 311). The magnitude of this underestimation reduced with age for both MVPA and TPA. However, this resulted in participants age 19 years, on average, overestimating MVPA by 107 minute (95% CI 59 to 155), while there was no difference between measures for TPA at 19 years (mean diff: 43, 95% CI −40 to 126). Finally, there was very weak evidence that regardless of age and gender, people in GMFCS level III underestimated MVPA by 50 minute (95% CI −0.25 to 100) when using the IPAQ-SF, compared to people in GMFCS level I. There was no difference between people in GMFCS levels I and II ($P = 0.57$) or in GMFCS levels II and III ($P = 0.13$).

Discussion

This is the first study to examine the validity of the IPAQ-SF in young people with CP. While young people with CP self-reported less time in sedentary behaviour, they also underestimated the time spent in TPA when compared to objective PA data. The mean of the difference between time in self-reported and objectively-measured MVPA was small. However, agreement between the IPAQ-SF and accelerometer was poor, with LOA suggesting that, at an individual level, MVPA may be underestimated by 149 minute or overestimated by 147 minute when assessed with the IPAQ-SF. After adjusting for gender and GMFCS level, age was a pre-

Table 2
Summary of physical activity data as measured by wGT3X-BT accelerometer and IPAQ-SF, respectively.

	n	Mean (SD)	Median (IQR)	Range
wGT3X-BT accelerometer				
Wear time (days)[a]	58		7 (6 to 7)	2 to 7
Wear time (minute)[a]	58		769 (687 to 829)	555 to 1420
Sed (minute)	58	522 (144)		277 to 1081
MVPA (minute)	58	54 (29)		4 to 140
TPA (minute)	58	242 (76)		75 to 427
IPAQ-SF				
Sed (minute)	55	393 (151)		10 to 720
MVPA (minute)[a]	56		29 (17 to 64)	0 to 360
TPA (minute)[a]	54		63 (30 to 148)	9 to 407

IPAQ-SF: International Physical Activity Questionnaire-Short Form; Sed: sedentary; MVPA: moderate to vigorous physical activity; TPA: total physical activity; SD: standard deviation; IQR: interquartile range.
[a] Not normally distributed.

Table 3
Multivariable regression analyses examining associations with the difference between wGT3X-BT accelerometer and IPAQ-SF measured physical activity, respectively.

Independent variable	β (95% confidence interval)	*P* value
Dependent variable: difference in sedentary behaviour (wGT3X-BT – IPAQ-SF), *n* = 55		
Age	13 (−7 to 33)	0.194
Gender (reference: male)	−58 (−156 to 41)	0.244
GMFCS (reference: level I)		
Level II	51 (−57 to 159)	0.350
Level III	38 (−104 to 180)	0.595
Dependent variable: difference in MVPA (wGT3X-BT – IPAQ-SF), *n* = 56		
Age	−18 (−25 to −11)	<0.001
Gender (reference: male)	−1 (−35 to 34)	0.972
GMFCS (reference: level I)		
Level II	10 (−27 to 48)	0.574
Level III	50 (−0.25 to 100)	0.051
Dependent variable: difference in TPA (wGT3X-BT – IPAQ-SF), *n* = 54		
Age	−23 (−35 to −11)	<0.001
Gender (reference: male)	−19 (−81 to 42)	0.524
GMFCS (reference: level I)		
Level II	−37 (−103 to 29)	0.264
Level III	−44 (−132 to 44)	0.317

IPAQ-SF: International Physical Activity Questionnaire-Short Form; Sed: sedentary; LPA: light physical activity; MVPA: moderate to vigorous physical activity; TPA: total physical activity.

dictor of the difference between measures. However, there was no evidence that gender was an independent predictor of the difference between measures, and very weak evidence that GMFCS level was a predictor, after adjusting for age and gender.

The results of this study are unsurprising given evidence from previous studies that self-report tools provide imprecise information on PA [21]. A review of 130 PA questionnaires from 96 different studies determined that median validity coefficients ranged from as low as 0.25–0.41 for newly devised questionnaires [22]. The most recent review of the validity of the IPAQ-SF included 23 studies and found that the IPAQ-SF overestimated PA by, on average, 84%, when compared to an objective criterion. In this same review Lee *et al.* [11] found that the correlations between the IPAQ-SF and criterion measures for TPA were very weak (ranging from 0.09 to 0.39).

Overall, the IPAQ-SF was not a valid measure of TPA when compared to accelerometry in this sample of young people with CP. This agrees with previous studies of the IPAQ-SF in Chinese [23], Norweigan [24], Vietnamese [25] and Estonian [12] adolescents with typical development, which reported poor validity of the IPAQ-SF. We only found one study that examined the validity of the IPAQ-SF in a “clinical” population of adolescents [13], which found weak correlations (r = 0.03–0.33) between the IPAQ-SF and accelerometry data in young people with rheumatic conditions. Similar to the findings in young people with CP, the IPAQ-SF highly underestimated sedentary time in people with juvenile dermatomyositis and juvenile systematic lupus erythematosus (mean bias 106 and 36 minute, respectively).

Although the mean differences for MVPA was small, there was poor agreement between measures in young people with

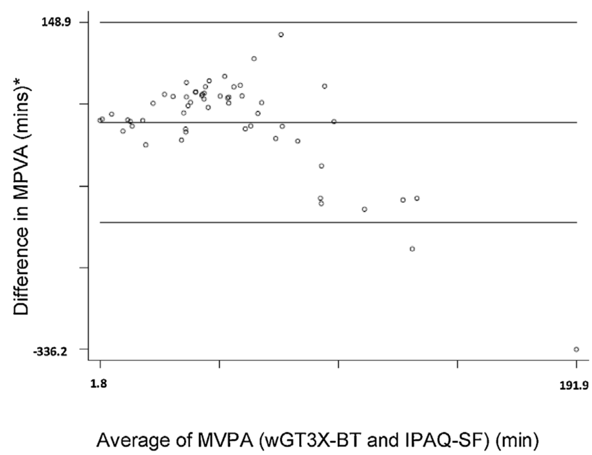

Fig. 1. Bland–Altman plots of MVPA measured using IPAQ-SF and wGT3X-BT accelerometer.
*wG3TX-BX minus IPAQ-SF.

CP, suggesting that it is not an appropriate measure of an individual’s MVPA activity levels. This is supported by highly variable mean bias (−59 to 90 minute) of MVPA found in a previous study, between IPAQ-SF and accelerometry in those with rheumatic conditions [13]. Likewise, Raask *et al.* [12], also concluded that the IPAQ-SF should not be used as an individual-level estimate of MVPA in healthy male adolescents.

It is interesting to note that although young people with CP underestimated their self-reported time spent in sedentary activity and therefore were more sedentary than perceived, TPA was also underestimated, using the IPAQ-SF. This emphasises that the IPAQ-SF is neither a valid measure of sedentary time nor of total physical activity. Conscious and/or unconscious under reporting of activity performed, or a failure to recall PA or time spent sedentary accurately (i.e. recall bias) may be provided as rationale for the observed findings. However the findings of poor agreement between measures may also be attributed to the wording of the IPAQ-SF. Erroneous interpretation of some questions and duplicity of entries across domains for the same single bout of activity performed may be a source of error. The IPAQ-SF asks individuals to separate walking time and moderate activity. However, it is likely that some individuals achieve moderate intensity activity through walking, which may be particularly true for people with CP [26]. This concern has also been cited by others researchers, who argue separating walking and moderate activity leads to confusion for the reader [27]. In addition to the unavoidable recall bias inherent with PA questionnaires, the examples given on the IPAQ-SF for each PA domain may also contribute to the significant differences observed. For example, moderate activity examples include carrying light loads, bicycling at a regular pace, or doubles tennis. These examples may also be misleading for the age group studied if they do not engage in these activities.

It is also interesting to note that there was strong evidence that age was associated with the difference in MVPA and TPA between measures, after adjusting for gender and GMFCS level. It may be suggested that perhaps older participants are more capable of estimating TPA or potentially have reduced recall bias, but not necessarily able to differentiate between walking and MVPA. Additionally, older participants may be more cognisant of the level of MVPA that they should be engaged in, and therefore are more likely to overestimate the time they have spent in MVPA when completing the IPAQ-SF. Another point to note is that the aim of the IPAQ-SF is to measure activity bouts of 10 minute or longer, as is reflected in the wording of the questions; while an accelerometer will collect data of any duration and indicate a corresponding intensity level. This is another partial explanation for the discrepancies between the readings between measures.

A major strength of this study is the inclusion of a previously validated accelerometer for young people with CP, which was used as the objective comparison measure. However, it must also be noted that there are limitations when using and analysing accelerometer data. A major drawback of such devices is their inability to capture the metabolic cost associated with standing, static work, upper body movements and vertical lifting [28]. It is also not an accurate measure of complex movements e.g. cycling. Upper body movement is often underestimated as the device is worn at hip level and the device cannot be worn for water-based activities. The latter two limitations are particularly noteworthy given that some of the participants in this study use a wheelchair on occasion to mobilise and that swimming is often the preferred sport of choice for people with CP. Further, while the actigraph has been used as the criterion measure of PA in this study, it is not considered a gold standard measure of PA. However, gold standard measures of PA (e.g. doubly labelled water, indirect calorimetry) were not feasible to use to measure habitual PA over 7 days in this study. While the results of this study provide an insight on age, gender and GMFCS level as predictors of the magnitude of the difference between the two measures it is acknowledged that other factors (e.g. sociodemographic and environmental factors) which we have not examined, may have an influence and should be considered in future studies.

Conclusion

In conclusion, the findings of this study suggest that the IPAQ-SF is not a valid method of measuring TPA or sedentary behaviour in young people with CP. While the mean differences were small between measures for MVPA poor agreement was demonstrated, indicating that the IPAQ is not appropriate for use when assessing an individual's time in MVPA. Therefore, where feasible, an objective measure of PA should be used. Future research should focus on the development of a valid measure of self-report PA for use in adolescents with CP, given the importance of promoting PA in this population. However, it may be unrealistic to expect any self-report measure to provide an accurate indication of an individual's time spent in MVPA or sedentary time; it may be more appropriate to use self-report measures to obtain a summary of an individual's overall activity status.

Key messages

- Despite the importance of promoting physical activity (PA), as a potential modifiable risk factor for the prevention of non-communicable diseases and functional decline over time, there is a paucity of validated self-report measures of PA among young people with CP.
- This is the first study to examine the validity of a self-report physical activity (PA) questionnaire [International Physical Activity Questionnaire Short Form (IPAQ-SF)] as a measure of PA in young people with cerebral palsy (CP), when compared to objectively gathered accelerometer data.
- This work highlights that the IPAQ-SF is not a valid method of measuring total PA or sedentary behaviour in young people with CP. Additionally, poor agreement between measures was observed for moderate to vigorous PA. This study highlights that where feasible an objective measure of PA should be used to monitor activity levels in young people with CP.

Conflict of interest: None declared.

Ethical Approval: This study has ethical approval from Brunel University London's Department of Clinical Sciences' Research Ethics Committee and a National Research Ethics Service (NRES) Committee London—Surrey Borders.

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References

[1] Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, Dan B, Jacobsson B. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl 2007;109:8–14.

[2] Prevalence and characteristics of children with cerebral palsy in Europe, Dev Med Child Neurol, 2002;44(9):633–40.

[3] Opheim A, Jahnsen R, Olsson E, Stanghelle JK. Walking function, pain, and fatigue in adults with cerebral palsy: a 7-year follow-up study. Dev Med Child Neurol 2009;51(5):381–8.

[4] Nooijen CF, Slaman J, Stam HJ, Roebroeck ME, Berg-Emons RJ. Inactive and sedentary lifestyles amongst ambulatory adolescents and young adults with cerebral palsy. J Neuroeng Rehabil 2014;11:49.

[5] Ryan JM, Forde C, Hussey JM, Gormley J. Comparison of patterns of physical activity and sedentary behavior between children with cerebral palsy and children with typical development. Phys Ther 2015;95(12):1609–16.

[6] Whitney DG, Hurvitz EA, Ryan JM, Devlin MJ, Caird MS, French ZP, Ellenberg EC, Peterson MD. Noncommunicable disease and multimorbidity in young adults with cerebral palsy. Clin Epidemiol 2018;10:511–9.

[7] Ryan JM, Allen E, Gormley J, Hurvitz EA, Peterson MD. The risk, burden, and management of non-communicable diseases in cerebral palsy: a scoping review. Dev Med Child Neurol 2018;60(8):753–64.

[8] Bouchard C, Tremblay A, Leblanc C, Lortie G, Savard R, Theriault G. A method to assess energy expenditure in children and adults. Am J Clin Nutr 1983;37(3):461–7.

[9] Taylor HL, Jacobs Jr DR, Schucker B, Knudsen J, Leon AS, Debacker G. A questionnaire for the assessment of leisure time physical activities. J Chronic Dis 1978;31(12):741–55.

[10] Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, Oja P. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003;35(8):1381–95.

[11] Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. Int J Behav Nutr Phys Act 2011;8:115.

[12] Raask T, Maestu J, Latt E, Jurimae J, Jurimae T, Vainik U, Konstabel K. Comparison of ipaq-sf and two other physical activity questionnaires with accelerometer in adolescent boys. PLoS One 2017;12(1):e0169527.

[13] Pinto AJ, Roschel H, Benatti FB, de Sa Pinto AL, Sallum AM, Silva CA, Gualano B. Poor agreement of objectively measured and self-reported physical activity in juvenile dermatomyositis and juvenile systemic lupus erythematosus. Clin Rheumatol 2016;35(6):1507–14.

[14] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, for the STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Int J Surg 2014;12(12):1495–9.

[15] Ryan JM, Theis N, Kilbride C, Baltzopoulos V, Waugh C, Shortland A, Lavelle G, Noorkoiv M, Levin W, Korff T. Strength Training for Adolescents with cerebral palsy (STAR): study protocol of a randomised controlled trial to determine the feasibility, acceptability and efficacy of resistance training for adolescents with cerebral palsy. BMJ Open 2016;6(10):e012839.

[16] IPAQ Research Committee. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Short and Long Forms; 2005. Available from: https://sites.google.com/site/theipaq/scoring-protocol. [Last viewed 24 June 2019].

[17] Mitchell LE, Ziviani J, Boyd RN. Variability in measuring physical activity in children with cerebral palsy. Med Sci Sports Exerc 2015;47(1):194–200.

[18] Trost SG, Fragala-Pinkham M, Lennon N, O'Neil ME. Decision trees for detection of activity intensity in youth with cerebral palsy. Med Sci Sports Exerc 2016;48(5):958–66.

[19] Choi L, Liu Z, Matthews CE, Buchowski MS. Validation of accelerometer wear and nonwear time classification algorithm. Med Sci Sports Exerc 2011;43(2):357–64.

[20] Bland JM, Altman DG. Statistical methods for assessing agreement between 2 methods of clinical measurement. Lancet 1986:307–10.

[21] Dowd KP, Szeklicki R, Minetto MA, Murphy MH, Polito A, Ghigo E, van der Ploeg H, Ekelund U, Maciaszek J, Stemplewski R, Tomczak M, Donnelly AE. A systematic literature review of reviews on techniques for physical activity measurement in adults: a DEDIPAC study. Int J Behav Nutr Phys Act 2018;15(1):15.

[22] 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.

[23] Wang C, Chen P, Zhuang J. Validity and reliability of International Physical Activity Questionnaire-Short Form in Chinese youth. Res Q Exerc Sport 2013;84(Suppl. 2):S80–6.

[24] Rangul V, Holmen TL, Kurtze N, Cuypers K, Midthjell K. Reliability and validity of two frequently used self-administered physical activity questionnaires in adolescents. BMC Med Res Methodol 2008; 8:47.

[25] Lachat CK, Verstraeten R, Khanh le NB, Hagstromer M, Khan NC, Van Ndo A, Dung NQ, Kolsteren PW. Validity of two physical activity questionnaires (IPAQ and PAQA) for Vietnamese adolescents in rural and urban areas. Int J Behav Nutr Phys Act 2008;5:37.

[26] Dallmeijer AJ, Brehm MA. Physical strain of comfortable walking in children with mild cerebral palsy. Disabil Rehabil 2011;33(15–16):1351–7.

[27] Kim Y, Park I, Kang M. Convergent validity of the international physical activity questionnaire (IPAQ): meta-analysis. Public Health Nutr 2013;16(3):440–52.

[28] Bassett Jr DR. Validity and reliability issues in objective monitoring of physical activity. Res Q Exerc Sport 2000;71(2 Suppl):S30–6.