VALIDITY AND RELIABILITY OF THE DAILY ACTIVITY BEHAVIOURS QUESTIONNAIRE (DABQ) FOR THE ASSESSMENT OF 24-H MOVEMENT BEHAVIOURS AMONG ADOLESCENTS

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Abstract:

Measurement of the time spent in sleep, sedentary behaviour, and physical activity across the full 24-h day (i.e. 24-h movement behaviours) is essential for time-use research among adolescents. However, self-reported questionnaires for the assessment of 24-h movement behaviours are scarce. The aim of this study was to examine the validity and reliability of recently developed Daily Activity Behaviours Questionnaire (DABQ) for the assessment of time spent in sleep, sedentary behaviour, light physical activity, and moderate-to-vigorous physical activity among adolescents. A convenience sample of 59 high-school students (34 female, age range: 15–18 years) was recruited. Participants were asked to complete a web-based DABQ at two occasions (two-weeks apart) to examine test-retest reliability of the DABQ, and to wear activPAL accelerometer to examine convergent validity of the DABQ. The test-retest reliability correlation coefficients (ICC) for the durations of sleep, sedentary behaviour, light physical activity, and moderate-to-vigorous physical activity were 0.49, 0.64, 0.51, and 0.66, respectively. Convergent validity correlation coefficients (Spearman's ρ) were 0.51, 0.38, 0.25, and 0.53, respectively. Our findings are comparable with the reliability and validity of most existing sleep, sedentary behaviour, or physical activity questionnaires among adolescents. However, DABQ is one of the first validated questionnaires that resonates with the emerging 24-h movement paradigm. The observed reliability and validity are indicating satisfactory measurement properties of the DABQ to be used in time-use research among adolescents.

Key words: *time-use questionnaire, time-use composition, physical behaviours, time-use epidemiology*

Introduction

It has been almost a decade since Pedišić (2014) proposed *Activity Balance Model* – a theoretical framework for epidemiological research on the combined effects of physical activity, sedentary behaviour (SB), and sleep with health outcomes. This framework was motivated by the fact that the durations of time spent in physical activity, SB, and sleep are perfectly related to each other, and that they are all associated with health. Given the current definitions (Tremblay et al., 2017), the daily time spent in physical activity, SB, and sleep (i.e. 24-h movement behaviours) always sum to exactly 24-h. Therefore, data on movement behaviours are compositional in nature, and it is methodologically sound that we consider them in a combination (Dumuid et al., 2020; Pedišić, Dumuid, & Olds, 2017).

The introduction of the *Activity Balance Model* was followed by the explosion of empirical studies that considered this integrated approach (Feng, Zheng, Sit, Reilly, & Huang, 2021; Rollo, Antsygina, & Tremblay, 2020; Sampasa-Kanyinga et al., 2020). Moreover, several countries (Australian Government, 2019; Jurakić & Pedišić, 2019; New Zeland Government, 2017; Tremblay et al., 2016), as well as the World Health Organisation (WHO, 2019), has released their first public health guidelines that integrate recommendations on time spent in physical activity, SB, and sleep. This new field of research that integrates physical activity epidemiology, SB epidemiology, and sleep epidemiology, is now considered as a part of time-use epidemiology (Pedišić et al., 2017).

Measurement of the 24-h movement behaviours is essential for time-use research, and population surveillance. The data could be collected using self-reported (e.g. questionnaires) and/or device-based methods (e.g. accelerometers). However, most of the methods available were initially developed for the assessment of a single movement behaviour, which resonate with the traditional paradigm on exploring the health effects of a single behaviour in isolation. For example, most of the existing questionnaires assess only physical activity, SB, or sleep time (Hidding, Altenburg, Mokkink, Terwee, & Chinapaw, 2017; Hidding, Chinapaw, van Poppel, Mokkink, & Altenburg, 2018; Lubans et al., 2011; Matricciani, 2013; Nascimento-Ferreira et al., 2016). Regarding accelerometers, the development of hip-worn accelerometry was initially focused on accurate assessment of physical activity (Migueles et al., 2017), while thigh-worn accelerometry for SB (Kang & Rowe, 2015), and wrist-worn accelerometry for sleep assessment (Sadeh, 2011).

To assess movement behaviours across the full 24-h day (ideally using a single tool) there is a need for development of new methods or improvement of the existing ones. In this regard, we have seen greater progress for the device-based methods (Migueles et al., 2017; Pulakka et al., 2018; Stevens et al., 2020) than for self-reported questionnaires (Rodrigues, Encantado, Carraça, Martins, et al., 2022; Rodrigues, Encantado, Carraça, Sousa-Sá, et al., 2022). Despite being somewhat less valid and reliable than most device-based methods, questionnaires have important advantages in terms of lower burden and cost, and higher compliance and comprehensiveness (Pedišić & Bauman, 2015; Sattler et al., 2021). Therefore, it is important to develop and validate questionnaires that resonates with the emerging 24-h movement paradigm. One such questionnaire has been recently developed and validated among adult population (Kastelic, Šarabon, Burnard, & Pedišić, 2022). It enables the assessment of time spent in moderate-to-vigorous physical activity (MVPA), light physical activity (LPA), SB, and sleep, while their sum is always exactly 24-h.

However, the findings on the validity of the novel questionnaire (i.e. Daily Activity Behaviours Questionnaire (DABQ)) among adults cannot be directly generalizable to younger populations. Self-reported questionnaires rely on responder's cognitive abilities (e.g. comprehension, recall ability) and are prone to social desirability bias, which might vary between different population groups. Therefore, the aim of this study was to examine the reliability and validity of the DABQ among adolescents. We hypothesized that DABQ will show satisfactory measurement properties to be used in time-use research among adolescents.

Methods

Study sample

A convenience sample of adolescents was recruited from several high schools in Slovenia. Participants had to be generally healthy, without mobility limitations, and should understand Slovenian language. We aimed for a sample of at least 50 participants, which was based on findings from the meta-analysis showing that samples between 50 to 99 participants are adequately powered samples for validation studies of physical activity questionnaires among paediatric populations (Nascimento-Ferreira et al., 2018). The study was approved by the Republic of Slovenia National Medical Ethics committee (number: 0120-63172017/2). All participants and their guardians signed an informed consent before they were enrolled to the study.

Study design

Participants were asked to wear activPAL activity monitor, and to keep a sleep diary for a period of two weeks. Activity monitor was placed by the researcher on participant's right thigh, midway between the anterior superior iliac spine and the knee. Participants were instructed how to change the adhesive dressing (Tegaderm) after seven days of wear. They were also asked to complete the web-based self-reported questionnaire on 24-h movement behaviours, and to provide the socio-demographic information (age, sex, body weight, body height, socio-economic status, and place of residence).

After the period of activPAL data collection, participants were again asked to complete a web-based self-reported questionnaire on 24-h movement behaviours. Afterward, they returned the activity monitor and the completed sleep diary. Researcher downloaded the data using the proprietary software (PALconnect, version 8.11.5.64, PAL Technologies Ltd., Glasgow, UK).

Self-reported questionnaire: Daily Activity Behaviours Questionnaire

Daily Activity Behaviours Questionnaire (DABQ) is a self-reported questionnaire on 24-h movement behaviours, including sleep time, SB, LPA, and MVPA. It showed reasonable reliability (ICC = 0.59–0.65) and validity (ρ = 0.38–0.66) among adult population (Kastelic et al., 2022). DABQ have a seven-day recall period, and it consists of four sections of questions asking about movement behaviours during (1) sleep time period, (2) occupational time, (3) commuting time, and (4) other non-occupational time. However, nonworking responders (i.e. student, unemployed individual, retired individual) only complete the first, and the fourth section of questions, and are therefore asked about their movement behaviours during sleep time period and during wake time period. The questionnaire is currently available in four European languages: Croatian, English, German, and Slovenian (at link: www.healthytimeuse.com/en/pages/7, accessed on 28 November 2022). In this study, we used web-based Slovenian version of the DABQ.

Reference measure: accelerometer activPAL

Accelerometer activPAL (PAL Technologies Ltd., Glasgow, Scotland) is small and light activity monitor that is worn on the anterior aspect of the thigh. It enable accurate assessment of 24-h movement behaviours, including sleep time, SB, LPA, and MVPA (Carlson et al., 2021; Lyden, Keadle, Staudenmayer, & Freedson, 2017). For this study we used activPAL4 micro that was initialized using proprietary software (PALconnect version 8.11.4.89, PAL Technologies Ltd., Glasgow, Scotland) with a default recording mode.

Data curation

Data from DABQ were downloaded from the server as .csv file, and processed using proprietary Microsoft Excel tool for DABQ data cleaning and processing (DABQanalyser version 3.0, University of Primorska, Izola, Slovenia) (Kastelic & Šarabon, 2022). For this study, we extracted average durations of sleep time, SB, LPA, and MVPA, as well as sleep indicators (i.e. time in bed, sleep latency, wake after sleep onset, napping time), and other physical activity and SB estimates (i.e. walking, sport participation, other demanding activity, screen time, muscle-strengthening exercise).

Data from activPAL were processed using the proprietary software (PALanalysis, version 8.11.5.64, PAL Technologies Ltd., Glasgow, UK) with CREA classification algorithm. A 24-h protocol that allow for four hours of non-wear time was applied to define a valid day. Sleep onset and offset was manually determined within the software based on the visual inspection of the activPAL data and the sleep diary (details on this procedure were described elsewhere (Kastelic et al., 2022)). Processed data were then downloaded using the proprietary software (PALbatch, version 8.10.9.46, PAL Technologies Ltd., Glasgow, Scotland) in a format of "daily summaries" and "time-stamped events" (as .csv files).

The "time-stamped events" files were further processed in R studio using the *activpalProcessing* package (Lyden, 2016) to obtain estimates on time spent in MVPA. The "daily summaries" file was imported into Microsoft Excel for further data curation. Diary reported napping time was added to primarily sleep time to calculate total sleep time, and deducted from SB to calculate total SB. LPA was calculated using the formula: 24-h – sleep time – SB – MVPA – non-wear time. Non-wear time was then proportionally reallocated to SB, LPA, and MVPA, as proposed previously (Haszard et al., 2020). Finally, we included last seven days of activPAL data to calculate average durations of daily sleep time, SB, LPA, and MVPA.

Statistical analysis

All statistical analyses were performed in R version 4.0.5 (R Core Team, 2020) and R Studio 1.4.1106 (R Studio Team, 2020) using the packages *BlandAltmanLeh* (Lehnert, 2020), *DescTools* (Signorell et al., 2020), *psych* (Revelle, 2020), *summarytools* (Comtois, 2022), and *tidyverse* (Wickham et al., 2019). Data on movement behaviours were presented as means and standard deviations (SD). For exploring test-retest reliability, we compared DABQ estimates obtained on the first and the second occasion. Test-retest reliability was explored using the two-way mixed model intraclass correlation coefficient for absolute agreement (ICC) and their 95% confidence interval (CI). For exploring convergent validity, we compared DABQ estimates obtained on the second occasion and activPAL estimates. Convergent validity was explored using Spearman's correlation coefficient (Spearman's ρ) and their 95% CI. Further on, Bland-Altman plots were constructed to visualise the agreement between DABQ and activPAL.

Results

Characteristics of study sample

Fifty-eight participants completed DABQ on two occasions, and fifty-five of them provided also activPAL data. The mean (± SD) age of our sample was 16.4 ± 1.0 years (ranging from 15 to 18 years). There were somewhat more girls (59 %) than boys (41 %) in our sample (Table 1). Most of them had normal BMI, middle socio-economic status, and lived in an urban areas.

Test-retest reliability of the DABQ

The absolute agreement ICCs for the time spent in sleep, SB, and physical activity ranged from 0.49 to 0.66 (Table 2). Similar test-retest reliability was also observed for most sleep indicators, except for the duration of wake after sleep onset (ICC = 0.12, 95% CI: -0.08, 0.32). The highest test-retest reliability was found for time spend engaging in sport activities (ICC = 0.92, 95% CI: 0.88, 0.95), time spent engaging in other demanding activities (ICC = 0.92, 95% CI: 0.88, 0.95), and screen time (ICC = 0.78, 95% CI: 0.69, 0.85).

Table 1. Study sample characteristics (n = 58)

Characteristic	*n* (%)
Sex	
Female	34 (59)
Male	24 (41)
zBMI	1 (2)
Thinness	
Normal	50 (86)
Overweight	7 (12)
Socio-economic status	
Lower	6 (10)
Middle	34 (59)
Higher	18 (31)
Residence	
Urban	33 (57)
Rural	25 (43)

Abbreviation: zBMI, body mass index

Convergent validity of the DABQ

The Spearman's correlation coefficients for the time spent in sleep, MVPA, and total physical activity ranged between 0.50 and 0.53 (Table 3), while they were lower for SB (ρ = 0.38, 95% CI: 0.13, 0.59), and LPA (ρ = 0.25, 95% CI: -0.02, 0.48). When compared against activPAL, no significant systematic difference for the sleep time estimate from DABQ was observed (8 min/day, 95% CI: -6, 23) (Figure 1). However, DABQ underestimated SB for 156 min/day (95% CI: -199, -112), and MVPA for 23 min/day (95% CI: -36, -11), while overestimated LPA for 171 min/day (95% CI: 124, 217). Limits of agreement (i.e. random differences) could be observed on the Bland-Altman plots on Figure 1.

Table 2. Test-retest reliability of the Daily Activity Behaviours Questionnaire (DABQ) among adolescents (n = 58)

Movement behaviour	DABQ1 mean (SD), min/day	DABQ2 mean (SD), min/day	ICC (95% CI)
Average day			
Sleep	484 (76)	460 (64)	0.49 (0.32, 0.63)
SB	514 (178)	552 (187)	0.64 (0.50, 0.74)
LPA	374 (165)	377 (180)	0.51 (0.35, 0.65)
MVPA	69 (68)	52 (57)	0.66 (0.57, 0.78)
Total PA	443 (179)	428 (190)	0.62 (0.48, 0.73)
Sleep indicators			
Time in bed	511 (75)	486 (62)	0.55 (0.39, 0.68)
Sleep latency	23 (20)	23 (25)	0.52 (0.36, 0.66)
Wake after sleep onset	4 (9)	4 (13)	0.12 (-0.08, 0.32)
Napping time	16 (24)	11 (20)	0.55 (0.39, 0.67)
School day			
Sleep on school day	459 (82)	433 (75)	0.51 (0.34, 0.64)
SB on school day	532 (203)	558 (200)	0.59 (0.44, 0.71)
PA on school day	449 (200)	449 (205)	0.56 (0.40, 0.68)
Non-school day			
Sleep on non-school day	545 (105)	526 (75)	0.49 (0.32, 0.62)
SB on non-school day	468 (197)	536 (203)	0.49 (0.32, 0.63)
PA on non-school day	427 (203)	377 (209)	0.54 (0.38, 0.67)
Other behaviours			
Walking	67 (60)	53 (42)	0.45 (0.28, 0.60)
Sport participation	41 (58)	35 (64)	0.92 (0.88, 0.95)
Other demanding activity	10 (19)	5 (13)	0.92 (0.88, 0.95)
Screen time	201 (129)	210 (152)	0.78 (0.69, 0.85)
MSE[1]	2 (2)	1 (2)	0.67 (0.48, 0.85)

Abbreviations: DABQ1, Daily Activity Behaviours Questionnaire completed on the first occasion; DABQ2, Daily Activity Behaviours Questionnaire completed on the second occasion; Sleep, sleep duration; SB, time spent in sedentary behaviour; PA, time spent in physical activity; LPA, time spent in light physical activity; MVPA, time spent in moderate-vigorous physical activity; MSE, muscle-strengthening exercise; [1], weighted kappa was calculated for the number of days engaging in MSE.

Table 3. Convergent validity of the Daily Activity Behaviours Questionnaire (DABQ) when compared against activPAL among adolescents (n = 55)

Movement behaviour	DABQ2 mean (SD), min/day	activPAL mean (SD), min/day	Spearman's ***ρ*** (95% CI)
Sleep	459 (62)	451 (48)	0.51 (0.28, 0.68)
SB	563 (177)	719 (77)	0.38 (0.13, 0.59)
LPA	365 (175)	194 (47)	0.25 (-0.02, 0.48)
MVPA	53 (58)	76 (32)	0.53 (0.31, 070)
Total physical activity	418 (188)	271 (69)	0.50 (0.28, 0.68)

Abbreviations: DABQ2, Daily Activity Behaviours Questionnaire completed on the second occasion; LoA, limits of agreement; Sleep, sleep duration; SB, time spent in sedentary behaviour; LPA, time spent in light physical activity; MVPA, time spent in moderate-vigorous physical activity.

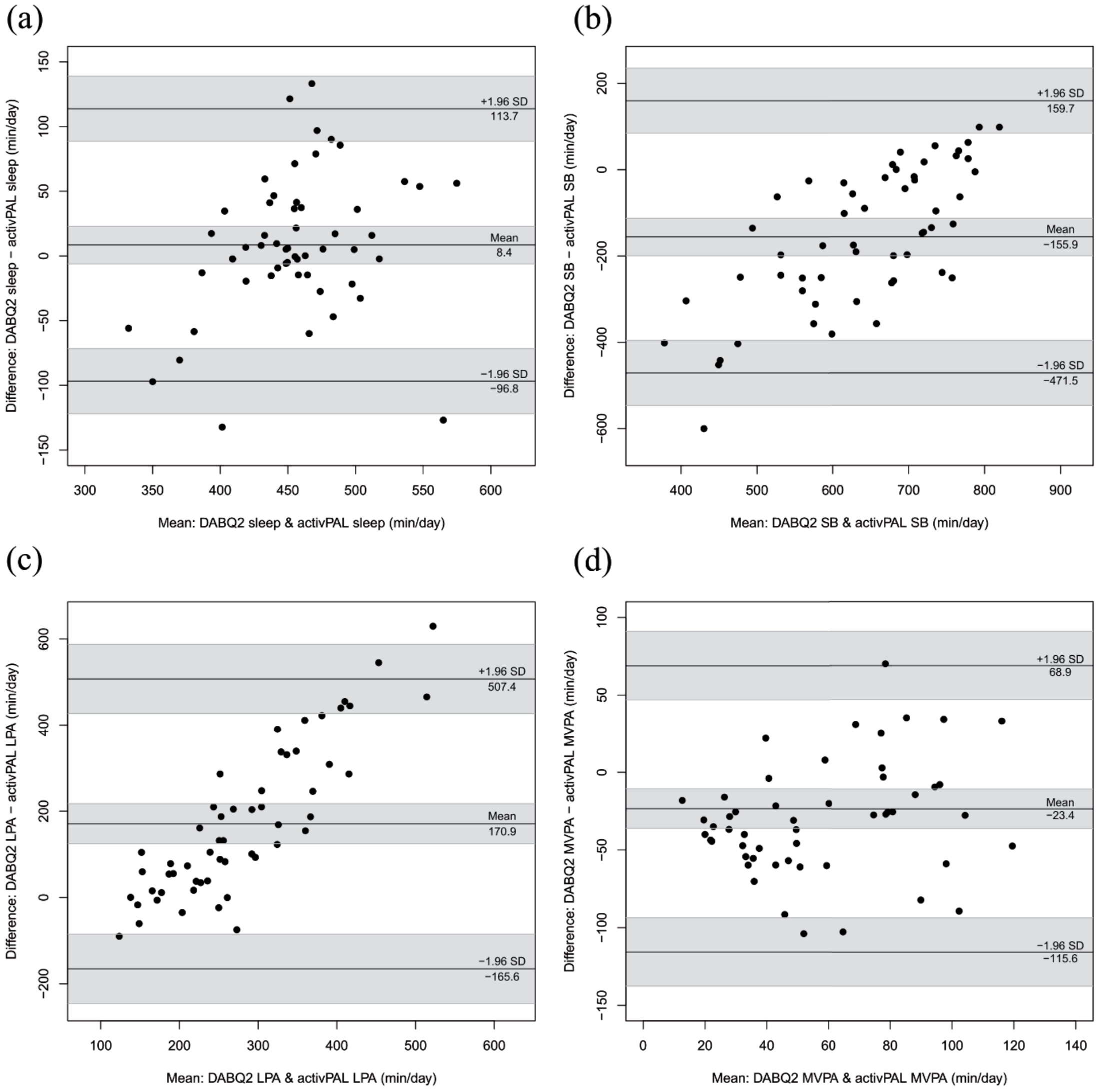

Figure 1. Bland–Altman plots on the time spent in (a) sleep, (b) sedentary behaviour (SB), c) light physical activity (LPA), and d) moderate-vigorous physical activity (MVPA) when comparing DABQ and activPAL estimates. Mean differences, lower and upper limits of agreement, and their 95% confidence intervals (grey bands) could be observed.

Discussion and conclusions

We explored test-retest reliability and convergent validity of the DABQ among adolescents. The findings from this study are that test-retest reliability correlation coefficients for the durations of sleep, SB, LPA, and MVPA were 0.49, 0.64, 0.51, and 0.66, respectively. Also, we found similar reliability for most sleep indicators (e.g. time in bed, sleep latency), while higher reliability for some specific types of movement behaviours (e.g. sport participation, screen time). Convergent validity correlation coefficients for the durations of sleep, SB, LPA, and MVPA were 0.51, 0.38, 0.25, and 0.53, respectively. Our findings are indicating satisfactory measurement properties of the DABQ to be used in time-use research among adolescents.

The reliability of the DABQ for estimating sleep duration (and most other sleep indicators) among adolescents was somewhat lower that was previously reported for adult population (Kastelic et al., 2022). This discrepancy might be because sleep is a highly variable behaviour during adolescence (Dahl & Lewin, 2002; Thorleifsdottir, Björnsson, Benediktsdottir, Gislason, & Kristbjarnarson, 2002). The later might also explain somewhat lower validity of the sleep duration estimate, since it may be more difficult to accurately recall behaviours that are highly variable. The evidence on the reliability and validity of existing questionnaires for the assessment of sleep duration among adolescents are scarce (Matricciani, 2013; Nascimento-Ferreira et al., 2016). Wolfson and colleagues (2003) reported validity of a single-item question on sleep duration that is comparable with the DABQ, while Gaina and colleagues (2005) reported somewhat lower validity (r = 0.38). This discrepancy might be due to the response options (Matricciani, 2013); Gaina used categorical response option, while continuous response option was used in a study of Wolfson and in our study. Also, Gaina and colleagues (2005) reported reliability (κ range: 0.41–0.63) for several sleep indicators (e.g. sleep duration, sleep latency, bedtime start) that is comparable with our findings.

Regarding SB estimates, the reliability and validity of the DABQ among adolescents shown to be comparable with findings for adult population (Kastelic et al., 2022). Also, the reliability was comparable with most existing questionnaires for the assessment of SB among adolescents, while validity was somewhat higher (Hidding et al., 2017; Lubans et al., 2011). The later might be due to the differences in the questioning technique on how SB is assessed. Most existing questionnaires ask about the absolute length of time spent in SB (e.g. how many minutes per day did you spent in SB), while DABQ ask about the relative length of time (i.e. what proportion of your wake time did you spent in SB). It was reported previously that percentage-based technique showed higher validity of the SB estimate among adult populations (Chastin et al., 2018; Matsuo, Sasai, So, & Ohkawara, 2016). SB is highly fragmented behaviour that occur habitually or incidentally throughout the day, and it might be easier for a responder to recall the duration of SB as a percentage of time rather than the absolute duration of time. However, we still observed a substantial underestimation of self-reported SB (for 2.6 h/day) when compared against activPAL. Similar level of underestimation was also found for other SB questionnaires (Chastin et al., 2018; Hidding et al., 2017; Prince et al., 2020), and it was proposed previously that underestimation might be because asking about time spent in SB is less accessible cognitive representation of sedentary activities (Gardner et al., 2019). People mentally represent activities by their purpose (e.g. watching TV) and less by the details on how activities were done (e.g. in a sitting position), and therefore, many bouts of SB can be overlooked when asking responder to recall time spent in SB. Since activPAL is considered a gold standard for the assessment of SB (Kang & Rowe, 2015), this finding needs to be taken into account when interpreting data on the levels of SB assessed using the DABQ. To improve the accuracy of the group level estimates of SB (Chastin et al., 2018; Kastelic & Šarabon, 2019), one may consider applying a correction factor of +28% (activPAL produced 1.28 times higher sedentary time than DABQ in our sample of adolescents).

For physical activity estimates, we found a reliability correlation coefficients between approximately 0.50 and 0.90, which is similarly to what was previously reported for the adult population (Kastelic et al., 2022). The reliability of LPA and time spent walking were somewhat lower than reliability of MVPA, while sport participation showed highest reliability coefficients. Those findings are also in accordance with most existing physical activity questionnaires for adolescents (Hidding et al., 2018). It might be that the duration of physical activity at the lower end of the intensity spectrum (e.g. LPA) is more variable behaviour than physical activity at the higher end of the intensity spectrum (e.g. vigorous physical activity). The validity of the DABQ for the assessment of MVPA is also similar to most existing physical activity questionnaires for adolescents (correlation coefficients ranging from approximately 0.30 to 0.50) (Hidding et al., 2018). Further on, the validity of the DABQ for the assessment of LPA showed to be somewhat lower compared to MVPA. This might be because LPA is assessed by calculating the remaining time to 24-h (i.e. LPA = 24-h – sleep – SB – MVPA), and therefore, its validity is subjected to the combined impact of the measurement errors of self-reported sleep, SB, and MVPA. However, this method of assessing LPA might even perform better than directly asking responders to recall LPA (= 0.11) (Chinapaw, Slootmaker, Schuit, van Zuidam, & van Mechelen, 2009).

A key strength of our study is that we used activPAL accelerometer as the reference measure, and that high wear time compliance was achieved (all but four participants provided full seven days of activPAL data with no non-wear time). Several limitations should also be acknowledged. First, due to the limited sample size in our study, the observed CIs were relatively wide. Our *a priory* sample size estimate was based on findings for several physical activity estimates (e.g. moderate physical activity, total physical activity), but not for LPA (Nascimento-Ferreira et al., 2018). Given that validity correlation coefficient for LPA was relatively lower than for other estimates, it might be that our sample size was underpowered for examining validity of LPA. Future validation studies can conduct *a priory* sample size estimate for LPA based on our findings**.** Second, the age of our sample ranged between 15 and 18 years, therefore, data collected with DABQ among adolescents younger than 15 years of age should be interpreted with caution. Third, some participants in our study completed DABQ with a few days of delay from the study protocol (they did not respond to our request to complete DABQ timely). As our participants attended classes at school only every other week (Starbek, Kastelic, & Šarabon, 2022) – and we aimed to collect DABQ and activPAL data for this study only for such weeks – the delay in completing DABQ might compromise our findings on the reliability and validity.

In conclusion, the observed reliability and validity are indicating satisfactory measurement properties of the DABQ to be used in time-use research among adolescents. The reliability and validity correlation coefficients of the DABQ were similar to most existing questionnaires for the assessment of adolescents' sleep time, SB, or physical activity. However, DABQ is one of the first validated questionnaires that resonates with the emerging 24-h movement paradigm – it could be used for the assessment of adolescents' movement behaviours across the full 24-h day.

References

Australian Government, Department of Health (2019). *Australian 24-Hour Movement Guidelines for Children and Young People (5-17 years) – An Integration of Physical Activity, Sedentary Behaviour and Sleep. 2019.* Retrieved August 20, 2022 from: https://www1.health.gov.au/internet/main/publishing.nsf/Content/health-24-hours-phys-act-guidelines

Carlson, A. J., Tuz-Zahra, F., Bellettiere, J., Ridgers, D. N., Steel, C., Bejarano, C., . . . Natarajan, L. (2021). Validity of Two Awake Wear-Time Classification Algorithms for activPAL in Youth, Adults, and Older Adults. *Journal for the Measurement of Physical Behaviour, 4*(2), 151-162. doi:10.1123/jmpb.2020-0045

Chastin, S. F. M., Dontje, M. L., Skelton, D. A., Cukic, I., Shaw, R. J., Gill, J. M. R., . . . Dall, P. M. (2018). Systematic comparative validation of self-report measures of sedentary time against an objective measure of postural sitting (activPAL). *The International Journal of Behavioral Nutrition and Physical Activity, 15*(1), 21. doi:10.1186/s12966-018-0652-x

Chinapaw, M. J. M., Slootmaker, S. M., Schuit, A. J., van Zuidam, M., & van Mechelen, W. (2009). Reliability and validity of the Activity Questionnaire for Adults and Adolescents (AQuAA). *BMC Medical Research Methodology, 9*(1), 58. doi:10.1186/1471-2288-9-58

Comtois, D. (2022). summarytools: Tools to Quickly and Neatly Summarize Data. R package version 1.0.0. Retrieved August 10, 2022 from: https://cran.r-project.org/web/packages/summarytools/index.html

Dahl, R. E., & Lewin, D. S. (2002). Pathways to adolescent health sleep regulation and behavior. *Journal of Adolescent Health, 31*(6, Supplement), 175-184. doi:https://doi.org/10.1016/S1054-139X(02)00506-2

Dumuid, D., Pedišić, Ž., Palarea-Albaladejo, J., Martín-Fernández, J. A., Hron, K., & Olds, T. (2020). Compositional Data Analysis in Time-Use Epidemiology: What, Why, How. *International Journal of Environmental Research and Public Health, 17*(7), 2220. doi:10.3390/ijerph17072220

Feng, J., Zheng, C., Sit, C. H., Reilly, J. J., & Huang, W. Y. (2021). Associations between meeting 24-hour movement guidelines and health in the early years: A systematic review and meta-analysis. *Journal of Sports Sciences, 39*(22), 2545-2557. doi:10.1080/02640414.2021.1945183

Gaina, A., Sekine, M., Chen, X., Hamanishi, S., & Kagamimori, S. (2005). Weekly variation in sleep patterns: Estimates of validity in Japanese schoolchildren. *Sleep and Biological Rhythms, 3*(2), 80-85.

Gardner, B., Flint, S., Rebar, A. L., Dewitt, S., Quail, S. K., Whall, H., & Smith, L. (2019). Is sitting invisible? Exploring how people mentally represent sitting. *International Journal of Behavioral Nutrition and Physical Activity, 16(1),* 85. doi:10.1186/s12966-019-0851-0

Haszard, J. J., Meredith-Jones, K., Farmer, V., Williams, S., Galland, B., & Taylor, R. (2020). Non-Wear Time and Presentation of Compositional 24-Hour Time-Use Analyses Influence Conclusions About Sleep and Body Mass Index in Children. *Journal for the Measurement of Physical Behaviour, 3*(3), 204-210. doi:10.1123/jmpb.2019-0048

Hidding, L. M., Altenburg, T. M., Mokkink, L. B., Terwee, C. B., & Chinapaw, M. J. M. (2017). Systematic Review of Childhood Sedentary Behavior Questionnaires: What do We Know and What is Next? *Sports Medicine, 47*(4), 677-699. doi:10.1007/s40279-016-0610-1

Hidding, L. M., Chinapaw, M. J. M., van Poppel, M. N. M., Mokkink, L. B., & Altenburg, T. M. (2018). An Updated Systematic Review of Childhood Physical Activity Questionnaires. *Sports Medicine, 48*(12), 2797-2842. doi:10.1007/s40279-018-0987-0

Jurakić, D., & Pedišić, Ž. (2019). Croatian 24-Hour Guidelines for Physical Activity, Sedentary Behaviour, and Sleep: A Proposal Based on a Systematic Review of Literature. *Medicus, 28*(2), 143-143.

Kang, M., & Rowe, D. A. (2015). Issues and Challenges in Sedentary Behavior Measurement. *Measurement in Physical Education and Exercise Science, 19*(3), 105-115. doi:10.1080/1091367X.2015.1055566

Kastelic, K., & Šarabon, N. (2022). DABQanalyser 3.0: a tool for Daily Activity Behaviours Questionnaire (DABQ) data cleaning and processing. Retrieved August 10, 2022 from: https://healthytimeuse.com/DABQ_Analyser.xlsx

Kastelic, K., & Šarabon, N. (2019). Comparison of Self-Reported Sedentary Time on Weekdays with an Objective Measure (activPAL). *Measurement in Physical Education and Exercise Science, 23(3),* 227-236. doi:10.1080/1091367X.2019.1603153

Kastelic, K., Šarabon, N., Burnard, M. D., & Pedišić, Ž. (2022). Validity and Reliability of the Daily Activity Behaviours Questionnaire (DABQ) for Assessment of Time Spent in Sleep, Sedentary Behaviour, and Physical Activity. *International Journal of Environmental Research and Public Health, 19*(9). doi:10.3390/ijerph19095362

Lehnert, B. (2020). BlandAltmanLeh: Plots (Slightly Extended) Bland-Altman Plots. R package version 0.3.1. Retrieved August 10, 2022 from: https://cran.r-project.org/web/packages/BlandAltmanLeh/index.html

Lubans, D. R., Hesketh, K., Cliff, D. P., Barnett, L. M., Salmon, J., Dollman, J., . . . Hardy, L. L. (2011). A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. *Obesity Reviews, 12*(10), 781-799. doi:10.1111/j.1467-789X.2011.00896.x

Lyden, K. (2016). activpalProcessing: Process activPAL Events Files. R package version 1.0.2. Retrieved August 10, 2022 from: http://cran.nexr.com/web/packages/activpalProcessing/index.html

Lyden, K., Keadle, S. K., Staudenmayer, J., & Freedson, P. S. (2017). The activPALTM Accurately Classifies Activity Intensity Categories in Healthy Adults. *Medicine and Science in Sports and Exercise, 49*(5), 1022-1028. doi:10.1249/MSS.0000000000001177

Matricciani, L. (2013). Subjective reports of children's sleep duration: does the question matter? A literature review. *Sleep Medicine, 14*(4), 303-311. doi:10.1016/j.sleep.2013.01.002

Matsuo, T., Sasai, H., So, R., & Ohkawara, K. (2016). Percentage-Method Improves Properties of Workers' Sitting- and Walking-Time Questionnaire. *Journal of Epidemiology, 26*(8), 405-412. doi:10.2188/jea.JE20150169

Migueles, J. H., Cadenas-Sanchez, C., Ekelund, U., Delisle Nyström, C., Mora-Gonzalez, J., Löf, M., . . . Ortega, F. B. (2017). Accelerometer Data Collection and Processing Criteria to Assess Physical Activity and Other Outcomes: A Systematic Review and Practical Considerations. *Sports Medicine, 47*(9), 1821-1845. doi:10.1007/s40279-017-0716-0

Nascimento-Ferreira, M. V., Collese, T. S., de Moraes, A. C., Rendo-Urteaga, T., Moreno, L. A., & Carvalho, H. B. (2016). Validity and reliability of sleep time questionnaires in children and adolescents: A systematic review and meta-analysis. *Sleep Medicine Reviews, 30*, 85-96. doi:10.1016/j.smrv.2015.11.006

Nascimento-Ferreira, M. V., De Moraes, A. C. F., Toazza Oliveira, P. V., Rendo-Urteaga, T., Gracia-Marco, L., Forjaz, C. L. M., . . . Carvalho, H. B. (2018). Assessment of physical activity intensity and duration in the paediatric population: evidence to support an a priori hypothesis and sample size in the agreement between subjective and objective methods. *Obesity Reviews, 19*(6), 810-824. doi:10.1111/obr.12676

New Zeland Government (2017). *Sit Less, Move More, Sleep Well : Physical Activity Guidelines for Children and Young People*. Retrieved May 10, 2022 from: https://www.health.govt.nz/system/files/documents/pages/physical-activity-guidelines-for-children-and-young-people-may17.pdf

Pedišić, Ž. (2014). Measurement issues and poor adjustments for physical activity and sleep undermine sedentary behaviour research - The focus should shift to the balance between sleep, sedentary behaviour, standing and activity. *Kinesiology, 46*(1), 135-146.

Pedišić, Ž., & Bauman, A. (2015). Accelerometer-based measures in physical activity surveillance: current practices and issues. *British Journal of Sports Medicine, 49*(4), 219-223. doi:10.1136/bjsports-2013-093407

Pedišić, Ž., Dumuid, D., & Olds, T. S. (2017). Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology, 49*(2), 252-269.

Prince, S. A., Cardilli, L., Reed, J. L., Saunders, T. J., Kite, C., Douillette, K., . . . Buckley, J. P. (2020). A comparison of self-reported and device measured sedentary behaviour in adults: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity, 17(1),* 31. doi:10.1186/s12966-020-00938-3

Pulakka, A., Shiroma, E. J., Harris, T. B., Pentti, J., Vahtera, J., & Stenholm, S. (2018). Classification and Processing of 24-Hour Wrist Accelerometer Data. *Journal for the Measurement of Physical Behaviour, 1*(2), 51-59. doi:10.1123/jmpb.2017-0008

R Core Team. (2020). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved August 10, 2022 from: https://www.r-project.org/

R Studio Team. (2020). RStudio: Integrated Development Environment for R. Boston, MA. Retrieved August 10, 2022 from: http://www.rstudio.com/

Revelle, W. (2020). psych: A package for personality, psychometric, and psychological research. R package version 2.1.6. Retrieved August 10, 2022 from: https://cran.r-project.org/web/packages/psych/index.html

Rodrigues, B., Encantado, J., Carraça, E., Martins, J., Marques, A., Lopes, L., . . . Santos, R. (2022). Questionnaires Measuring 24-Hour Movement Behaviors in Childhood and Adolescence: Content Description and Measurement Properties-A Systematic Review. *Journal of Physical Activity and Health*, 1-27. doi:10.1123/jpah.2022-0399

Rodrigues, B., Encantado, J., Carraça, E., Sousa-Sá, E., Lopes, L., Cliff, D., . . . Santos, R. (2022). Questionnaires measuring movement behaviours in adults and older adults: Content description and measurement properties. A systematic review. *PloS One, 17*(3), e0265100. doi:10.1371/journal.pone.0265100

Rollo, S., Antsygina, O., & Tremblay, M. S. (2020). The whole day matters: Understanding 24-hour movement-guideline adherence and relationships with health indicators across the lifespan. *Journal of Sport and Health Science, 9*(6), 493-510. doi:https://doi.org/10.1016/j.jshs.2020.07.004

Sadeh, A. (2011). The role and validity of actigraphy in sleep medicine: An update. *Sleep Medicine Reviews, 15*(4), 259-267. doi:https://doi.org/10.1016/j.smrv.2010.10.001

Sampasa-Kanyinga, H., Colman, I., Goldfield, G. S., Janssen, I., Wang, J., Podinic, I., . . . Chaput, J. P. (2020). Combinations of physical activity, sedentary time, and sleep duration and their associations with depressive symptoms and other mental health problems in children and adolescents: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1), 72. doi:10.1186/s12966-020-00976-x

Sattler, M. C., Ainsworth, B. E., Andersen, L. B., Foster, C., Hagströmer, M., Jaunig, J., . . . van Poppel, M. N. M. (2021). Physical activity self-reports: past or future? *British Journal of Sports Medicine, 55*(16), 889-890. doi:10.1136/bjsports-2020-103595

Signorell, A., Aho, K., Alfons, A., Anderegg, N., Aragon, T., Arachchige, C., & al., e. (2020). DescTools: Tools for Descriptive Statistics. R package version 0.99.42. Retrieved from https://cran.r-project.org/web/packages/DescTools/index.html

Starbek, P., Kastelic, K., & Šarabon, N. (2022). The Impact of Online-Schooling during COVID-19 on Device-Measured 24-Hour Movement Behaviours among High School Students: A Compositional Data Analysis. *Children, 9*(5), 667. doi:10.3390/children9050667

Stevens, M. L., Gupta, N., Inan Eroglu, E., Crowley, P. J., Eroglu, B., Bauman, A., . . . Stamatakis, E. (2020). Thigh-worn accelerometry for measuring movement and posture across the 24-hour cycle: a scoping review and expert statement. *BMJ Open Sport & Exercise Medicine, 6*(1), e000874. doi:10.1136/bmjsem-2020-000874

Thorleifsdottir, B., Björnsson, J. K., Benediktsdottir, B., Gislason, T., & Kristbjarnarson, H. (2002). Sleep and sleep habits from childhood to young adulthood over a 10-year period. *Journal of Psychosomatic Research, 53*(1), 529-537. doi:https://doi.org/10.1016/S0022-3999(02)00444-0

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., . . . Chinapaw, M. J. M. (2017). Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 75. doi:10.1186/s12966-017-0525-8

Tremblay, M. S., Carson, V., Chaput, J. P., Connor Gorber, S., Dinh, T., Duggan, M., . . . Zehr, L. (2016). Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Applied Physiology, Nutrition, and Metabolism, 41*(6 Suppl 3), S311-327. doi:10.1139/apnm-2016-0151

WHO (2019). *Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children under 5 Years of Age*. Retrieved August 5, 2022 from: https://apps.who.int/iris/handle/10665/311664

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L., François, R., . . . Yutani, H. (2019). Welcome to the Tidyverse. *Journal of Open Source Software, 4*, 1686. doi:10.21105/joss.01686

Wolfson, A. R., Carskadon, M. A., Acebo, C., Seifer, R., Fallone, G., Labyak, S. E., & Martin, J. L. (2003). Evidence for the validity of a sleep habits survey for adolescents. *Sleep, 26*(2), 213-216. doi:10.1093/sleep/26.2.213

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