

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

Kaja Kastelic^{1,2} and Nejc Šarabon^{2,3}

¹*Andrej Marušič Institute, University of Primorska, Koper, Slovenia*

²*InnoRenew CoE, Izola, Slovenia*

³*Faculty of Health Sciences, University of Primorska, Izola, Slovenia*

Original scientific paper

DOI: 10.26582/k.55.2.12

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 the 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 on 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 duration 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 for adolescents. However, the DABQ is one of the first validated questionnaires that resonates with the emerging 24-h movement paradigm. The observed reliability and validity indicate 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 on health outcomes. This framework was motivated by the fact that time periods 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 Zealand Government, 2017; Tremblay, et al., 2016), as well as the World Health Organization (WHO, 2019), have 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 was used 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), new methods need to be developed or the existing ones should be improved. 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, et al., 2022a; Rodrigues, et al., 2022b). 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 generalized to younger populations. Self-reported questionnaires rely on responders' 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 and 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 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 on the participant's right thigh by the researcher (PS), 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. Afterwards, they returned the activity monitor and the completed sleep diary. Researcher (PS) 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 ($\rho = 0.38–0.66$) 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, non-working responders (i.e., students, unemployed individuals, retired individuals) only complete the first and the fourth section of the questionnaire 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 the following 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 a small and light activity monitor that is worn on the anterior aspect of the thigh. It enables 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 processing

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 processing. 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:

$$24\text{-h} - \text{sleep time} - \text{SB} - \text{MVPA} - \text{non-wear time}.$$

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 intra-class 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 the study sample

Fifty-eight participants completed DABQ on two occasions, and fifty-five of them provided also activPAL data. The mean (\pm 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 urban areas.

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)

Note. zBMI – body mass index.

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 the time spent 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 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)

Note. 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, 0.70)
Total physical activity	418 (188)	271 (69)	0.50 (0.28, 0.68)

Note. 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.

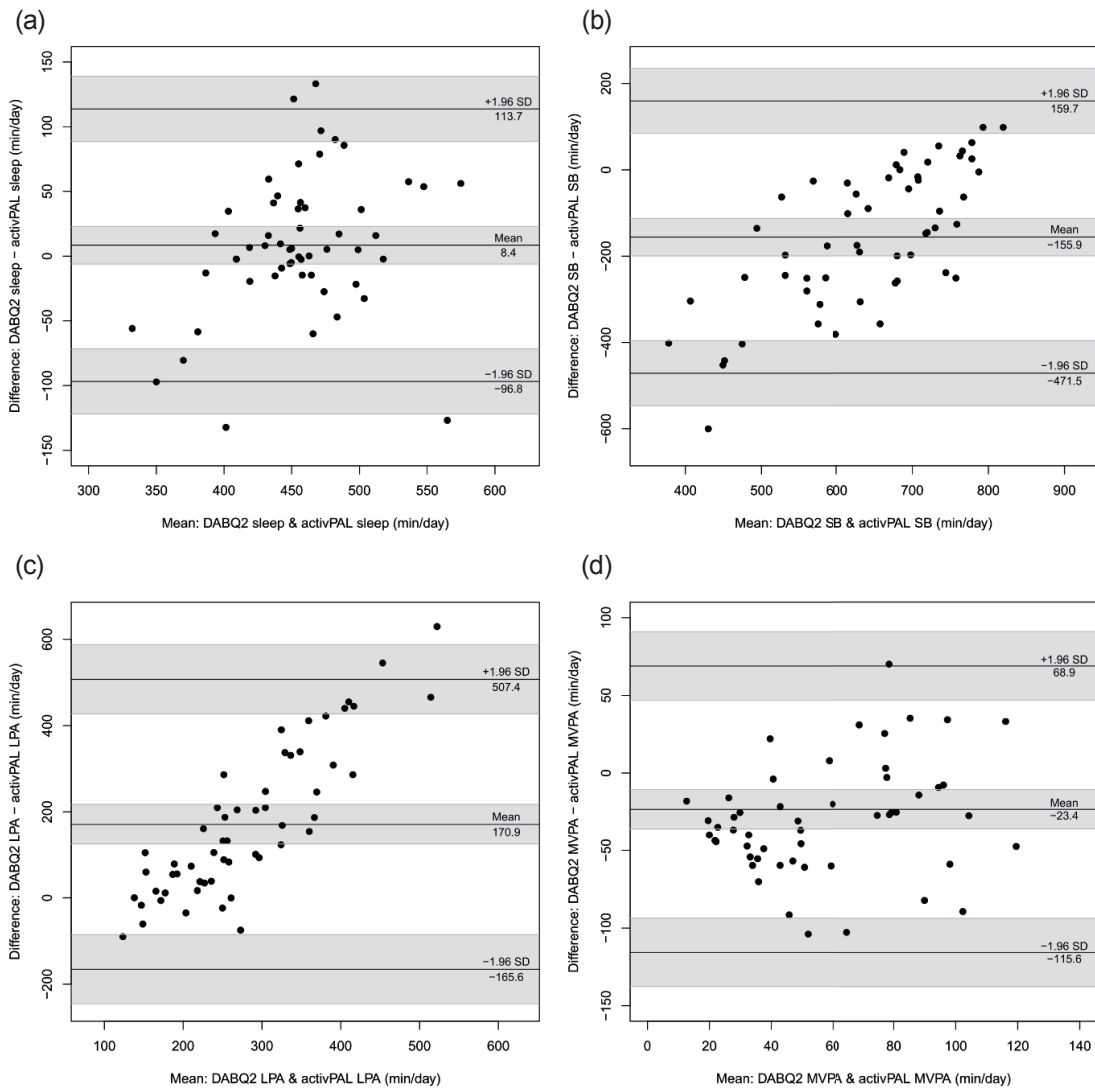


Figure 1. Bland-Altman plots on the time spent in (a) sleep, (b) sedentary behaviour (SB), (c) light physical activity (LPA), and (d) moderate-vigorous physical activity (MVPA) when comparing DABQ and activPAL estimates. Mean differences, lower and upper limits of agreement, and their 95% confidence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

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 ($\rho = 0.38$, 95% CI: 0.13, 0.59), and LPA ($\rho = 0.25$, 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 in Figure 1.

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 was found for some specific types of movement behaviours (e.g., sport participation, screen time). Convergent validity correlation coefficients for the duration 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 than 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, Gíslason, & Kristbjarnarson, 2002). That 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, Sekine, Chen, Hamanishi, and Kagamimori (2005) reported somewhat lower validity ($r = 0.38$). This discrepancy might be due to the response options (Matricciani, 2013); Gaina et al. (2005) used categorical response option, while continuous response option was used in the study by Wolfson et al. (2003) 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 showed 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 latter 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 respondent 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 (by 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 respondents to recall time spent in SB. Since activPAL is consid-

ered 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 the 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, 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. $LPA = 24-h - \text{sleep} - SB - MVPA$), 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 respondents to recall LPA ($\rho = 0.11$) (Chinapaw, Sloopmaker, 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 priori* 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 priori* 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 indicate 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., Belletiere, 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., Sloopmaker, 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: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. doi:10.1111/j.1479-8425.2005.00162.x
- 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. (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. (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., 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), 5362. 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. (2022a). Questionnaires measuring 24-hour movement behaviors in childhood and adolescence: Content description and measurement properties—A systematic review. *Journal of Physical Activity and Health*, 20(1), 50-76. doi:10.1123/jpah.2022-0399
- Rodrigues, B., Encantado, J., Carraça, E., Sousa-Sá, E., Lopes, L., Cliff, D., . . . , & Santos, R. (2022b). 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:10.1016/j.smr.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., . . . , & Zeileis, A. (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 and 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: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—World Health Organization. (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

Submitted: December 13, 2022

Accepted: July 28, 2023

Published Online First: December 11, 2023

Correspondence to:

Prof. Nejc Šarabon, Ph.D.

University of Primorska, Faculty of Health Sciences

Polje 42, 6310 Izola, Slovenia

Phone: +386 40429505

Email: nejc.sarabon@fvz.upr.si

Acknowledgements

The authors gratefully acknowledge the European Commission for funding the InnoRenew CoE project (Grant Agreement #739574) under the Horizon2020 Widespread-Teaming program and the Republic of Slovenia (Investment funding of the Republic of Slovenia and the European Union of the European Regional Development Fund). We also thank Petra Starbek (PS) for her help in data collection.