Physical activity is an important factor among the determinants of health due to it's protective factor and preventive role [1

IPAQ-HL questionnaires in self-administered form. Seven days after the first measurement was finished, participants were asked to complete the GPAQ-H and IPAQ-HL questionnaires a second time. The latter subsample contained 33 respondents.

Physical activity outcome measures

Global Physical Activity Questionnaire (GPAQ)

The GPAQ version 2 was developed by the WHO, this self-administered form comprises of 16 items that measure the physical activity levels of a normal active week (7 days) of adults. The Hungarian version was developed by a scientific research group alongside native English speakers and English language experts to ensure the cultural adaptation and efficient translation of the GPAQ.

The questionnaire contains three domains of PA: work, transportation, and recreational activities. The duration and frequency of physical activity [minutes, (min/day)] were recorded in case of all three abovementioned domains.

GPAQ Analysis Guide [23] was used for scoring and data cleaning. Our study indicates data in min/week format for easier comparison with accelerometer data. Total MVPA min/week (all vigorous + all moderate activities' mins), moderate and vigorous activities in min/week, and weekly sitting time in min/week values were calculated [23, 24].

International Physical Activity Questionnaire (IPAQ-HL)

The Hungarian long version of IPAQ was used to test the concurrent validity of the GPAQ-H alongside the objective measurement. The questionnaire contains 27 items formed to assess the frequency, duration, and intensity of the activities of the last 7 days. The examined domains in IPAQ-HL were work, transportation, household, leisure time activities, and time spent sitting. The data were expressed in min/week, for calculation of the different scores the scoring protocol of the questionnaire was used [14, 25]. We summarized PA in MVPA min/week, moderate and vigorous activities min/week, and sitting time in min/week also.

ActiGraph GT3X

Triaxial ActiGraph GT3X+ accelerometers (ActiGraph, Pensacola, FL) were used to collect data on PA with standard device initialization (sample rate of 30 Hz, 60 s epochs and normal filter option). Participants were asked to wear the devices for seven consecutive days during wakefulness on the right hip except for the following activities: water-based activities or contact sports. A run of zero counts lasting more than 60 min was defined as "non-wear time". A minimum of 480 min of wear-time was required daily and a minimum of 5–7 days with valid wear time (where at least 1 day was a weekend day) was required for inclusion into the analysis [26]. ActiLife 6 software was used to initialize the accelerometer and to download results.

Validity and reliability process

COSMIN checklist and Edinburgh Framework for validity and reliability were used for the validation process.

Statistical analysis

Data were entered in Microsoft Excel and analysed using IBM SPSS 22.0 program. To present the quantitative data, mean (standard deviation, SD) and median (inter quartile range, IQR) were computed. Normality of the data was tested using Kolmogorov-Smirnov test (data was considered normally distributed if $p < 0.05$). Mann-Whitney U test and Chi-square test were calculated to measure the gender differences in PA levels. Factor analysis was conducted using principal component analysis (PCA) and varimax rotation. The Kaiser–Meyer–Olkin (KMO) index was calculated along with Bartlett's test and anti–image correlation.

The convergent validity between the questionnaires (GPAQ-H and IPAQ-HL) and accelerometer-based measures was determined for all of the participants and examined using Spearman's rank correlation, where > 0.40 was considered as good, 0.30–0.40 as moderate and < 0.30 as poor validity [30]. We assessed Bland-Altman plots with 95% limits of agreement to evaluate the extent of agreement between the accelerometer and the GPAQ-H and GPAQ-H and IPAQ-HL. To measure the internal consistency reliability, Cronbach Alpha was calculated. Intraclass correlation coefficient (ICC) was used for test retest reliability analysis of the GPAQ-H, where above 0.75 means were interpreted as good, 0.50–0.75 as moderate and lower means as poor reliability [11, 24]. Confidence interval of 95% was applied, and p value of < 0,05 was considered statistically significant.

A total of 120 young adults were included in the validity and reliability study. Average age of the participants was 21.53 ± 1.75 years. The main characteristics of the sample were showed in Table 1. The female and male participants were differed by anthropometric measures (body fat, muscle, visceral fat, waist circumference) as it was previ-

Physical activity patterns of the sample based on accelerometer, self-administered IPAQ-HL, and GPAQ-H questionnaires

	Male ($N = 56$)				Female ($N = 64$)				p
	Mean	SD	Median	Percentiles	Mean	SD	Median	Percentiles	

found (0.538) with a significant Barlett's test of Sphericity (279.51; $p < 0.001$). The total variance was explained as 81.10%. We found five factors as follows: Factor 1 work vigorous activities, work and leisure time together (24.45% of variance), Factor 2 moderate leisure time activities (15.99% of variance), Factor 3 moderate work time activities (15.65%), Factor 4 active transportation (15.10%), and Factor 5 sitting time (9.91% of the variance).

Internal consistency and test retest reliability of the GPAQ-H

The reliability (Cronbach Alpha) of the GPAQ-H instrument with all domain's scores was 0.521 (confidence interval (CI) 0.371–0.644). In our study after 7 days of the first data collection a subsample of our baseline sample completed the GPAQ-H measurement tool. We found in all intensity scores and sitting time (moderate, vigorous, MVPA and sitting time) good reliability scores ($R = 0.899–987$, $p < 0.001$) between the baseline and follow-up scores.

Bland Altman plots demonstrated differences between the GPAQ-H and accelerometer mean values (Fig. 2). The plots showed that GPAQ-H overestimates vigorous activities by 212.75 min/week (331.82–757.42) and MVPA values by 104.93 min/week (– 1016.98–807.11). A high difference, 6336.79 min/week (CI 3638.18–9035.40) was revealed regarding sitting, as GPAQ-H largely underestimated the time spent sedentary. Furthermore, the plots indicated wide limit of agreements for all examined parameters.

This study showed the validity and reliability of the GPAQ-H measurement tool in comparison with accelerometer and IPAQ-HL data. Our results demonstrated fair to moderate validity of the Hungarian GPAQ compared to the accelerometer data and moderate and good correlation with IPAQ-HL questionnaire. We examined the correlation between accelerometer and questionnaires according to moderate, vigorous, MVPA activities, and sitting time values. Our results are consistent with other studies according to the intensity of the correlation coefficients.

The GPAQ-H vigorous data were showed significant moderate correlation with accelerometer-moderate and accelerometer-MVPA results, but there were no significant results with accelerometer-vigorous data. The GPAQ-H moderate values did not correlate with MVPA, only with accelerometer-moderate results. The GPAQ-H MVPA showed significant correlation with moderate and MVPA accelerometer values. The GPAQ-H sitting time did not correlate with the examined accelerometer parameters. In case of the subgroup analysis our results were similar according to genders. We noticed significant difference only by vigorous activities irrespective of the measurement method (GT3X $p = 0.048$, GPAQ-H $p = 0.046$, IPAQ-HL $p = 0.017$), and by objectively measured sitting time ($p = 0.018$). Otherwise, in case of the total sample, sitting time did not show a significant correlation between questionnaire and accelerometer data, but there was a significant negative correlation between accelerometer sitting time value, the GPAQ-H MVPA ($R = -0.296$, $p < 0.001$), and vigorous values ($R = -0.325$,

$p < 0.001$). The GPAQ-H and IPAQ-HL questionnaires showed moderate and good correlation and similar mean values, but the overestimation of the MVPA, moderate and vigorous activities was higher in IPAQ-HL.

In the French validation study of GPAQ, Riviere et al. applied similar study design as our research group: they measured PA patterns of staff members and students (N = 92, age 30.1 ± 10.7, 76.9% BMI 18.5–24.9) of the University of Lorraine, using IPAQ-LF for concurrent and ActiGraphs

Mumu et al. found fair to moderate correlation between objective and subjective monitoring, still claimed GPAQ as an acceptable measure, particularly among women with illustrated with Bland-Altman plots toward overestimation of higher levels of vigorous- and moderate-intensity activities, and underestimation for lower levels PA, parallel to similar studies in general. Reliability for MVPA revealed moderate correlations (self-report R = 0.61, with interviewer R = 0.63). To reduce bias in the GPAQ measurements they advised to incorporate accelerometers, particularly by the measurement of different intensity PA (A. H. Chu, Ng, Koh, & Muller-Riemenschneider, 2015).

Wanner et al. measured the validity of GPAQ in European context. They found significant results as other

MET: Metabolic equivalent of task; MVPA: Moderate to vigorous physical activity; PAQs: Physical activity questionnaires; PCA: Principal component analysis; SB: Sedentary behaviour; SD: Standard deviation; SRH: Self-reported health; WHO: World Health Organization; STEPS: STEPwise Approach to the Chronic Disease Risk Factor Surveillance

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